

Interior Design Strategies
for Nature-based Features to Support Stress Reduction
in Knowledge Workers

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Abstract

According to Duxbury and Higgins 57% of full time employees reported high levels of stress. Stress is impacting the productivity, health and well-being of individuals, and the bottom line of employers. A growing body of evidence suggests exposure to nature, nature-based features, and biophilic design may offer a solution to reducing stress in the office workplace. This thesis brings together a comprehensive body of information drawn from the neurosciences and environmental psychology, including attention restoration theory (ART), psycho-evolutionary theory, Kellert's biophilic design elements, and seven case studies, to propose key nature-based interior design strategies for stress reduction in office knowledge workers. Providing direct and indirect exposure to nature appears to have the strongest impact on mitigating the stress response. The importance of the integrated design process (IDP), post-occupancy evaluation (POE), and barriers to incorporating biophilia centred design practices are addressed and process strategies proposed.

Dedication

To my parents:

Beatrice (Haugen) Christopher

A true biophilic - ahead of her time
(1924-2013)

and

Alan Christopher

Who enabled biophilia in both of us
(1930-2013)

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1 Introduction

1.1 The Problem: Stress in the Workplace

Stress is negatively impacting the productivity, the health and well-being of employees and the bottom line of employers. According to a Canadian study of 25,000 full-time employees 57% reported high levels of stress (Duxbury & Higgins, 2012). It is estimated Canadian employers lose \$20 billion per year due to stress-related illness (Lem, 2013). Stress causes a loss of productivity and chronic stress can cause long term health issues (Posen, 2013).

A growing body of evidence suggests exposure to nature and nature-based features may offer a solution to reducing stress in the workplace (Berman, Jonides, & Kaplan, 2008). This thesis brings together a comprehensive body of information drawn from the neurosciences, environmental psychology, the applications of green building rating systems and design practice to determine strategies that would provide practitioners a cost effective and straightforward way of integrating nature-based features into workplace design to enhance well-being and reduce stress. In this thesis, I identify research that supports the inclusion of nature-based features in workplace environments for stress reduction and improved health and well-being, as well as propose strategies to assist interior designers with integrating these stress-reducing nature-based features into the workplace environment.

1.2 Research Questions

The research study explores the following two research questions:

1. What nature-based features can interior designers incorporate into workplace design to help reduce stress and improve health and well-being of office knowledge workers?
2. How can such nature-based features be implemented in design practice?

1.3 Definitions and Framework

This research explores the use of biophilic design in, and surrounding, office workplaces for knowledge workers, to reduce stress and improve well-being and productivity. The following terminology will be used in this thesis and the research questions above:

Biophilia incorporates elements of nature, and is defined as our innate need or love of nature (Wilson, 1984). *Biophilic design* is the translation of biophilia to the built environment (Kellert & Wilson, 1993). This thesis will also use Kellert's (2008) **biophilic design principles** as a framework for the nature-based features discussed. These principles consist of two dimensions: (1) organic and (2) place-based dimension, described respectively as our built environment that reflects our innate need or love of nature and "buildings and landscapes that connect to the culture" and location (Kellert, 2008, p. 8). Organic dimension is further subdivided into three biophilic experiences: direct, indirect and symbolic.

Direct biophilic experience includes self-sustaining features in nature such as: plants, woods, gardens, daylight, views, landscapes and scents. A typical work environment may not include these experiences, but that is the argument of this thesis - they should include nature-based features. When direct biophilic experience is not possible *indirect biophilic experiences* must be included. *Indirect biophilic experience* is defined as nature that requires on-going human intervention to survive, such as potted plants, which require watering and other maintenance to survive, whereas a plant in the forest is watered and maintained naturally.

While there are many potential direct and indirect biophilic design strategies, this thesis focuses on developing strategies around the use of direct and indirect biophilic experiences and less on the symbolic i.e., natural motifs such as leaves on column

capitals or organic shapes on finish materials which will be explained in further detail in section 2.2.2.

Nature is a term we are all familiar with yet is difficult to precisely define. Kaplan and Kaplan (1989) state that nature is not limited to relatively untouched or designated natural areas. Instead, they propose nature should include “parks, open spaces, meadows and abandoned fields, street trees and backyard gardens”, and that space may be “managed or unkempt”, spaces where “plants grow by human design or even despite it....referring to areas” that are often “described as green, but they are also natural when the green is replaced by white or brown or red and yellow”. Like Kaplan, this discussion of nature does not include fauna¹ (Kaplan & Kaplan, 1989). I have used Kaplan and Kaplan’s definition of nature, in its broadest sense to allow for the discussion on biophilia.

Knowledge worker is defined as “an employee whose job involves developing and using knowledge rather than producing goods and services” (Cambridge, n.d.). Knowledge workers typically spend some time working in an office environment. Knowledge worker is a common term used by designers, researchers, and business in corporate and office design. The use of the term is not meant to imply knowledge workers do not exist in other areas of work and strategies suggested for knowledge workers in office environment may apply to knowledge workers and workers in other fields and locations. This thesis will focus on knowledge workers who typically spend some portion of their time working in an office environment.

Evidence-based design has become increasingly important to the interior design industry in the past decades. Evidence-based design is basing design decisions

¹ Animals.

on peer reviewed evidence or research. Third party green rating systems², guidelines or strategies are especially important at the introduction of a new concept or approach to allow for easier adaptation by practitioners, a specific framework to work within a possibly vast array of information.

1.4 Organization of the Document

This report is divided into two major parts: (1) current theory and research on stress, office work environment, and biophilic design (2) strategies for designers to integrate biophilic design principles into workplace design for knowledge workers. Part 1 provides a background to nature-based features to support stress reduction in knowledge workers. Beginning with the nature of stress and its impact on workers, the thesis traces the history of biophilia in relation to enhancing health and reducing stress and presents current literature relating to the use of biophilia in workplaces. Specific interior design applications and examples are identified. Part 2 translates research into practice and reviews case studies (Chapter 3), and proposed strategies for including nature-based features in the workspaces of knowledge workers (Chapter 4).

Use of text boxes

Text boxes in this thesis provide anecdotal information from my experience as a practitioner for the past 30 years working in five different design firms/organizations.

² Third party green rating systems such as Leadership in Energy and Environmental Design (LEED) and Living Building Challenge (LBC) are examples of standards or a framework for practitioners to work within.

2 Literature Review

This chapter reviews the literature on human stress, biophilia and the integrations of biophilic design and nature-based features in the workplace. Chronic stress contributes to loss of productivity and health issues. The introduction of biophilic elements into the workplace design may reduce this stress, although there is limited research in this area. The first section looks at the psychological and physiological responses to stress stimuli; how chronic stress causes loss of productivity and health issues. The second section explains the history of biophilia, introduces the two psychological theories on nature's ability for restoration and the application of the theory to the built environment using Kellert's biophilic design elements.

Literature review methodology included key search terms of: biophilia, biophilic design, nature-based features, plants, wood, singularly and combined with stress, stress reduction, knowledge workers, office design as well as personal correspondence with a respected neurosurgeon. Over a hundred and thirty scholarly articles or texts on nature-based features and biophilic design topics were found, of which fifty were reviewed in detail. Interest and research in the topic is definitely growing. As a specific example the earliest "biophilic workplace studies" peer reviewed article was 2009, with only one article; increasing to nine in 2012 to 2013, and then 11 by 2014. Significantly more research was found on the topic of plants and stress reduction than wood and stress reduction. No research was found on stress reduction and wood specifically in an office workplace that was not in a healthcare setting.

2.1 Psychological and Physiological Responses to Stress

There is a significant amount of research on stress in the workplace. My initial search on the topic identified over 11,000 peer reviewed articles. The amount of research devoted to the topic reflects the seriousness of the problem. Stress causes loss of productivity and chronic stress (CSS) can cause long term health issues (Posen, 2013). According to a Canadian study more than half of full-time employees reported high levels of stress (Duxbury & Higgins, 2012). A 2011 study showed more than half of stressed workers (52%) called in sick, when they were not technically sick and remained off work for an average of three days (Posen, 2013), a significant lose in productivity. It is estimated Canadian employers lose \$20 billion per year due to stress-related illness (Lem, 2013).

It is important to note that there can be both psychological and physiological responses to stressors (stress stimuli). Understanding and addressing the stress response is complex because of the potential sources that cause stress are so diverse. The Canadian Centre for Occupational Health and Safety defines workplace stress as “harmful physical and emotional responses than can happen when there is a conflict between job demands on the employee and the amount of control an employee has over meeting these demands” (Stats Canada, 2001). Workplace stress is caused by too much work, poor relationships with coworkers and the fear of job loss (Stats Canada).

Stress is defined as a “condition of coping with events beyond an individual’s normal working capacity (in quantity and/or level of difficulty), and the negative psychological and physical ailments which can result from this.” (Dictionary of psychological testing, 2007). Credo (2015) defines stress as a “physical response to a threatening or challenging situation (a stressor)” and this physical response is called the stress response or the fight or flight response. The first definition is looking at stress

from a mental health perspective. The second is looking at the more physical form of stress. Both definitions are relevant to stress reduction and improved health and well-being.

A *stressor* is defined as “anything in the outside world that knocks you out of your homeostatic balance, and the *stress-response* is what your body does to re-establish homeostasis” (Sapolsky, 2004). A stressor can also simply be the anticipation “of being knocked out of homeostatic balance” (Sapolsky, 2004). Homeostasis is defined as “the maintenance of relatively stable internal physiological conditions (as body temperature or the pH of blood) in higher animals under fluctuating environmental conditions” (Merriam-Webster). Stress is caused by workplace situations we may have no control over i.e., coworkers and job security, but is also caused by our environment. Sapolsky emphasize the importance of homeostasis. Most literature on workplace stress focuses on mental health. Research suggests nature-based features and biophilia may help to return individuals to the state of homeostasis through restoration which will be discussed in section 2.2.2.

2.1.1 The brain and the neuroscience of stress

People are largely unaware of the stress they experience day to day, since much of the stress occurs in our sub-conscious. Neurosurgeon, Dr. Norman Hill describes how the brain coordinates all the chemical and electrical impulses, which it constantly receives. Whether consciousness is present or not, the brain must deal with a constant flow of sensory impulses, even during sleep. The majority of these sensory impulses are sorted in a subconscious state (N. Hill, personal communication, April 13, 2015). The brain only allows those sensory impulses to pass which are necessary to perform a specific task.

Our response to stressors has not evolved with our environment (M. Hill, 2013). Our response to tigers in the wild is physiologically similar to our response to non-life threatening work pressures (Hill, 2010). An alarm response, which releases cortisol, was appropriate and effective when faced with a saber-tooth tiger, but is, in our current environment is inappropriate. The release of cortisol, in response to stressors, was meant for the short term the “flight or fight response”. Too much stress causes problems with our physical health, and impacts memory loss as cortisol thins out the dendrites, the connections between our brain cells that are required for one cell to speak to other cells, which affect short term memory (Posen, 2013) (*Figure 1*). We do not perform well mentally when stressed and chronic stress can lead to depression (Posen, 2013). Today’s stress can become long-term, and with technology follows knowledge workers almost everywhere. Knowledge workers faced with no respite are less productive and unhealthy. Knowledge workers need respite or restoration time.

https://books.google.ca/books?id=cWtlm60oxUwC&pg=PT24&lpg=PT24&dq=posed+dendrites&source=bl&ots=9G1DzXG141&sig=5qo_UKUF6Uw0QUrL_Qkm4bUnspY&hl=en&a=X&ved=0CB4Q6AEwAGoVChMli6_tmJC_xwIVi1seCh3fygXd#v=onepage&q=posed%20dendrites&f=false

Figure 1. Thinning of dendrites. Stress impacts memory loss as cortisol thins out the dendrites or connections between our brain cells that are required for one cell to speak to other cells (Posen, 2013).

Improper or inappropriate stimuli in a work setting can interfere significantly with the functioning of these specific brain patterns. Other sensory stimuli which is

appropriate can make performing the task more effective by either providing the required information or by providing an environment that is more conducive to the task i.e., meditation or nature by providing a state of contentment or positive homeostasis (N. Hill, personal communication, April 13, 2015).

When respite is not provided stress can impact on workers' health. Hill outlined a variety of ways our bodies can be affected by environmental stress, even if people are unaware of that stress:

- (1) Failure to deliver proper stimuli within the particular brain areas controlling thought and feeling. This can result in anxiety and unexplained fears (apprehension), poor judgement, short temper, inability to relax, sense of loneliness and procrastination.
- (2) Failure to obtain appropriate stimuli to the muscular skeletal-structures can result in fatigue, lethargy, unexplained pain occurring in non-anatomic distribution and nervous habits such as nail biting or pacing.
- (3) Failure to deliver appropriate stimuli to visceral structures can result in palpitations, sweating, difficulty in breathing for no apparent reason, unexplained blood pressure changes with feelings of faintness, as well as diarrhea or constipation.
- (4) Failure to deliver appropriate stimulus to the endocrine glands can result in lack of appetite, insomnia, anorexia, and loss of libido.
- (5) Failure to deliver appropriate stimuli to the spleen and bone marrow (the immune system) can produce minor bacterial or viral infections.

(N. Hill, personal communication, April 13, 2015)

2.1.2 Response to stress - restoration

According to environmental psychologist Stephen Kaplan (1995), the directed attention of the human brain can be restored through exposure to nature. Berman, Jonides and Kaplan (2008) state: humans need to rest our brains and time in nature can help our brain rest, which helps restore our memory and attention through involuntary attention. Involuntary attention effortlessly engages us whereas voluntary or directed attention requires our mind to focus which can cause mental fatigue. Natural environments can be fascinating and thus hold our attention involuntarily, without our brain having to expend energy to maintain our focus. Thus, nature is restorative versus causing mental fatigue. Often, people in Western culture, 'rest' with television but research shows this is not restorative. Nature however can be restorative as it can help restore the brain in a "soft way", due to nature's ability to involuntarily hold our fascination versus television, which is considered a "hard" medium as it can cause mental fatigue (Berman et al., 2008; Hill, 2013). Nature can offer the necessary respite or restoration time stressed knowledge workers require. Environmental psychology and biophilic design theory of nature will be discussed further in section 2.2.

2.1.3 Stress testing methodologies

Stress reduction using nature-based features including time in nature, images of nature, plants and use of wood in an indoor space have been tested through various stress testing methodologies: heart-rate variability, blood pressure, pulse rate, total hemoglobin concentrations measured using near-infrared spectroscopy (NIRS), salivary cortisol and salivary amylase.

2.1.4 Summary

Stress causes memory and productivity losses. Continuous chronic stress causes health problems and can lead to mental health issues. It is estimated Canadian employers lose \$20 billion per year due to stress related illness. However, research

suggests that exposure to nature can help reduce stress, recreate the state of homeostasis and allow for the necessary restoration time.

2.2 Biophilia and Biophilic Design

“Study nature, love nature, stay close to nature. It will never fail you.”

Frank Lloyd Wright (as cited in Lind, 1992)

Proponents of biophilia suggest that introducing nature into the workplace may serve to mitigate the human stress response and aid in improving health, memory, and attention. The following section provides an overview of biophilia and current theory on nature-based features, stress reduction, and biophilic design drawn from literature.

2.2.1 History of Biophilia and Biophilic Design

The term biophilia was first used by Erich Fromm in 1973 (Britannica) and later developed by Edward O. Wilson (1984). Wilson defined biophilia as our innate need and affiliation for nature. The concept of biophilia is not new. Humans have spent the vast majority of our evolutionary time on earth living in and with nature. Our ties to nature suggest that humans evolved on the savannahs, and thus we have a genetic memory to prefer places with a similar environment (Orians & Heerwagen, 1992; Terrapin, 2012). Thus responses to nature are in our physiology, such as our fight or flight response to danger, (a stressor), our predisposition to fear poisonous snakes, spiders, plants and even certain animals that we have never been exposed to in our present environment (Hill, 2013). The stress response is in our physiology, as research suggests so is the restorative abilities and resulting health benefits of nature-based

features such as the direct biophilic experiences of woods, plants and views in mitigating stress (Hill, 2013; Berman, 2013; Berman et al., 2008; Kaplan, 1995).

The potential role of biophilia as a health benefit or source of healing is also not new. Although, the term biophilia was not introduced until 1973, and the term biophilic design, the translation of biophilia to the built environment was not introduced until 2008, historically nature and biophilia have been a part of daily living and even healing practices for centuries.

Traditional Chinese medicine, Indian Ayurveda, Roman philosophers, such as Cornelius Celsus all advocated nature in healing (Selhub & Logan, 2012), as did Aesculapion in ancient Greece in the 4th to 6th century BC (Gesler, 2003). During the Middle Ages monastic hospices in Western Europe typically included nature and gardens.

Nature was an important part of daily life, only in the last few centuries have we become more removed from nature. With the onslaught of the Industrial Revolution, many workers moved from farming communities to cities to find new work opportunities (Britannica; Connelly, 2013). However, due to the rapid growth, lack of sanitation and crowded conditions, diseases could spread rapidly and thus living in cities was considered unhealthy (Britannica; Connelly, 2013). In Europe, those who could afford to, maintained a home in the country. In North America, as cities expanded rapidly in the mid to late 19th century “nature as a mental healer” gained popularity. The rich could visit sanitariums and health resorts with names that evoked nature “The Pines, The Highlands, Lake View...” (Selhub & Logan, 2012, p. 12). For the average citizen without access to such resorts, the urban park could be a place of respite. According to Selhub and Logan (2012) Fredrick Law Olmstead, the designer of New York’s Central Park, “advocated that such urban escapes would promote mental relaxation for users” (p. 13).

In Germany and Scandinavia, the modern Volkspark Movement began in the early 1900's, developing urban green spaces for industrial workers and their families in dense urban environments (Worpole, 2000). Mid to late 19th century writers and naturalists, Henry David Thoreau and John Muir were also both advocates of the importance of nature for well-being (Selhub & Logan, 2012). Many were advocating for the importance of nature for well-being. In 1851, Dr. Kirkbride, at the request of his peers, prepared design guidelines for a restorative landscape approach for healthcare facilities, referred to as the Kirkbride Plan (Selhub & Logan, 2012). Kirkbride advocated for large windows, pleasant views and a half acre of land per patient. Kirkbride's peers unanimously endorsed the Kirkbride Plan and facilities were built in 28 US states (Marcus & Sachs, 2013). However, with the onset of antiseptics, antibiotics, pain killers, anesthesia, and efficiency combined with:

...improved surgical techniques; emotions were now studied in psychology, the physical body in anatomy and medicine thus severing any lingering belief in the mind-body connection: outdoor space was relegated to parking lots and delivery ramps; gardens disappeared and glimpses of nature were restricted to token areas of landscaping at the main entrance (Marcus & Sachs, 2013, p. 9).

From the 1870's onward, in both Britain and US, the trend was to move to the "new" suburbs. The shift to suburban living, with its larger gardens, suggests a desire for re-establishing a connection to nature, and a reaction against the densely built urban environment (Sparke, 2006). According to Wright, in the US, the new suburbs offered

“picturesque site planning and natural building materials” which “evoked a return to nature, to a lost innocence and an earlier stability” (Wright, 1981, p. 93).

In addition to this mid-Victorian interest in reconnecting with nature, by relocating their homes to the ‘new’ suburbs, nature was also collected and brought indoors in the form of potted plants and glass domes. Wardian cases (*Figure 2*), covering ferns and other plants, conservatories, flowers, aquaria and other natural elements such as pine cones and shells were collected and displayed (Sparke, 2006). The Victorian interest in nature was not consciously recognized or labelled as biophilia or a love of nature for health benefits, but may have been subconsciously.



Figure 2. Wardian case (with permission Creative Commons, 2014).

The Arts and Crafts Movement, inspired by the writings of Ruskin, was a reaction to industrialization. The movement involved a return to traditional craftsmanship, forms and natural materials (Triggs, 2014), the influence of Arts and Craft Movement extended into the 1930's.

More recently, a growing body of design research is encouraging designers to reintroduce nature-connectedness into health care settings. In the last two decades,

therapeutic gardens have been re-introduced in the design of hospitals, and long term care facilities, due to growing evidence of the benefits (Marcus & Barnes, 1999).

Biophilic research in health care settings reports decreased healing times after surgery, improved pain management and depression (Ulrich, 1984).

A good example of nature-connected healthcare setting design is the Planetree model. In the early 1980's in California, a patient Angela Thierot developed the Planetree model, named after the tree Hippocrates taught his students beneath. In the Planetree model, the hospital experience is refocused on the patient including: unrestricted visiting hours, welcoming family members, including children at all hours, encouraging family members to cook, to stay overnight, but also create a more homelike environment including plants, fish tanks and connecting to the outdoors through views and gardens (Marcus & Sachs, 2013). Designed using the Planetree model, the waiting areas in Lakeland Hospital in Michigan are situated to allow patients and families waiting for surgery to see the "calming and peaceful view provided by the natural setting of the St. Joseph River...as they mentally prepare for their procedure" (Frampton, Gilpin, & Charmel, 2003 in Marcus & Sachs, 2013, p. 11). The Planetree model "brought nature and gardens back into focus as important elements of a healing environment and a healthy workplace" (Marcus & Sachs, 2013, p. 11).

Healing or therapeutic gardens, were designed for patients and their families, however, based on the evidence presented so far, as researchers have found health benefits from gardens in hospital settings, it stands to reason the same benefits might also be realized in other workplace settings such as the knowledge workers office environment.

2.2.2 Environmental psychology and biophilic design theory

Environmental psychologists Stephen and Rachel Kaplan's and architectural scholar Roger Ulrich et al., pioneered the two key psychological theories on nature's ability for restoration (Section 2.2.2.1). These theories help to explain how the integration of nature-based features may mitigate the stress response. Social ecologist and research scholar, Stephen Kellert's biophilic design elements and architectural scholar, Grant Hildebrand's survival-advantage characteristics provide designers with the theory to translate biophilia to design strategies.

2.2.2.1 Attention restoration theory (ART) and psycho-evolutionary theory.

The two psychological theories that provide the background theory for literature on restorative environments are attention restoration theory (ART) (Kaplan & Kaplan, 1989; Kaplan, 1995) and psycho-evolutionary theory (Ulrich et al., 1991; Ulrich, 1993). ART and psycho-evolutionary theory provide a potential explanation of why nature is restorative. The two theories, according to Hartig, Bringslimark, and Patil (2008), have varying views on what occurs during restoration, deal with different forms of resource depletion and stress different results. Although there are differences in approaches, Hartig et al., (2008) suggest the Kaplans and Ulrich et al. provide similar views on the restorative process provided by nature. Both place importance on nature, specifically trees, water and other natural elements to promote restoration based on evolutionary assumptions. .

2.2.2.2 Kellert's biophilic design and survival-advantage characteristics.

Theorist and research scholar, Stephen Kellert translated biophilia, ART, and psycho-evolutionary theory into a framework of biophilic design (see Figure 3). Kellert's biophilic design principles, consisting of two dimensions, six elements and 70 attributes offer guidance in applying the theory of biophilia to the design of the built environment.

Kellert's work provides important pioneering theory in the relationship between the built environment and nature.

Architectural scholar, Grant Hildebrand has a similar framework, but it is much smaller in organizational scale. Hildebrand's five survival-advantage architectural characteristics, often aligns with one of Kellert's biophilic attributes (see also section 2.2.2.2.). Kellert and Hildebrand both suggest that humans are predisposed to prefer certain relationships with their environment, a satisfaction, or preference due to our evolution in nature, a survival based theory.

Kellert's work is a theoretical framework only, not a design strategy or application. Kellert states his theoretical framework is a work in progress (Kellert, 2008). Hildebrand describes his characteristics as a "defensible hypothesis" (Hildebrand, 2008, p. 264). Both Kellert and Hildebrand continue to work on the organizational structure of their frameworks. As a work in progress, Kellert's many different levels i.e., principles, dimensions, interactions or experiences, elements, and attributes, can be difficult to follow and keep straight (see Figure 3). The attributes overlap and there are varying levels of detail within the elements. However, the work does provide a common language and framework for organizing key ideas that have been translated by designers into actual design solutions (see also Chapter 3).



Figure 3. Kellert's Biophilic Principles, elements and attributes (with permission Kost, 2015; adapted from Kellert, 2008).

Kellert framework has two dimensions, organic and place-based. The **organic dimension** is “defined as shapes and forms in the built environment that....reflect the inherent human affinity for nature” (Kellert, 2008, p. 5). The organic dimension is divided into:

(1) **Direct** experience refers to contact with a natural environment such as daylight, plants, and animals (Kellert, 2008). This particular type of natural environment is one nature that can survive without human input, such as a forest. The Selgas Cano,

Pond Studios, and SC3 case studies in Chapter 3, provide examples of workplace design for direct biophilic experience offices.

(2) **Indirect** experience requires the natural element to have “ongoing human input” in order for the element to survive such as a potted plants or interior gardens that require human input to survive i.e. watering, heat, fertilization (Kellert, 2008, p. 5). The case studies, Path and CMHR offices (Chapter 3) provide examples of indirect biophilic experience.

(3) **Symbolic** experience involves no contact with real nature, but only the representation of nature through images or symbols (Kellert, 2008).

Research suggests direct and indirect experiences with nature have greater potential for stress reduction (Kahn, et al., 2008). Kahn, Severson and Rucker found interacting with images of nature, or to use Kahn’s et al., term - *technological nature* “provides some but not all the enjoyments and benefits of interacting with actual nature” (2009, p 41). The restorative benefits of the direct and indirect experience of nature is further supported by Kaplan’s ART and Ulrich’s psycho-evolutionary theories.

Kellert second biophilic design principle is “place-based” design. **Place-based**, , is defined as spaces that reflect the cultural and geography of an area and create a sense or “spirit of place” (Kellert, 2008, p. 6). Other design researchers as far back as Jane Jacobs and William Whyte have long pointed to the significance of landscape and parks in building communities by place-making (see also Schneekloth & Shibley, 1995). The Google offices - Moscow, Tel Aviv, and London in Chapter 3 are examples of biophilic place-based design.

Within Kellert's organic and place-based dimensions, there are six biophilic categories or "Elements". Each of the six elements consists of 11 to 14 attributes (a total of 70). Kellert states there is much overlap amongst the attributes (2008). Attributes also do not always categorize neatly as either direct or indirect dimensions i.e., plants can be either direct or indirect depending upon the situation.

2.2.2.1 Focusing on four of Kellert's Biophilic Elements

Based on the literature reviewed, four elements (and their associated attributes) from Kellert's framework, appear to provide the most potential for impact on stress reduction in the design of workplaces for knowledge workers: (1) Environmental features, (2) Light and space, (3) Place-based relationships and (4) Evolved human-nature relationships (see also Figure 4). These elements focus on being exposed to nature, either directly or indirectly. As previously mentioned, Kahn's work identifies that being in direct or indirect nature has "greater potential for stress reduction than imagery or symbolic nature" (2008). The remaining two elements "Natural shapes and forms" and "Natural features and processes" focus more on the symbolic dimensions of biophilia.

"Environmental features" includes attributes involving direct contact such as sunlight (or natural light), plants, natural materials, views and vistas and will briefly touch on air (operable windows) and animals. **"Light and space"** focuses on the qualities of light and spatial relationships. The research and case studies will focus on natural light which will be tied into views and vistas noted above. **"Place-based relationships"** reflect and combine the culture and geography to fulfill "locational familiarity – the yearning for home - remains a deeply held need for most people." This element consists

of eleven attributes: geographic connection to place, historic connection to place, ecological connection to place, cultural connection to place, indigenous materials, landscape orientation, landscape features that define building form, landscape ecology, integration of culture and ecology, spirit of place and finally avoiding placelessness (Kellert, 2008, p. 12). Google offices, in Chapter 3 - Case Studies, are excellent examples of place-based design. **“Evolved human-nature relationships”** attributes focus on the “fundamental aspects of the inherent human relationship to nature”: prospect and refuge, order and complexity, curiosity and enticement, and fear and awe are illustrated through CMHR case study (Kellert, 2008, p.13).

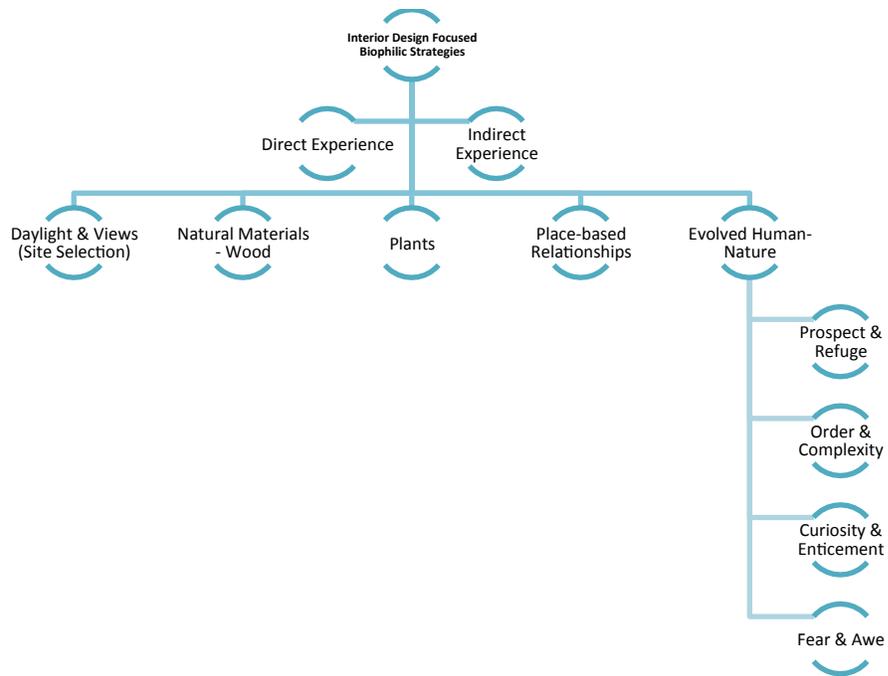


Figure 4. Interior design focused biophilic strategies

2.2.2.2 Evolved human-nature relationships

This last element “**Evolved human-nature relationships**” connection to office design is less obvious and thus will be addressed in detail. The attributes mentioned above: prospect and refuge, order and complexity and curiosity and enticement that connect to the central ideas of this thesis - that due to our evolutionary development in nature, humans are predisposed to prefer certain types of relationships with their environment. This predisposition or preference that theorist believe is rooted in evolutionary theory, a survival based theory, and is why nature and nature-based features can contribute to the restorative effects of nature and thus stress reduction (Hill, 2013; Kaplan, 1995). These attributes can contribute to successful spatial layouts and design based on our evolutionary environmental programming and thus our comfort and restoration in nature and the built environment (Hildebrand, 2000). These attributes explain the theory behind successful or unsuccessful spaces and thus guide designers to create spaces that are more effective. These key attributes of Element 6, Evolved human-nature relationships (Kellert, 2008) are similarly referred to as survival-advantageous architectural characteristics by Hildebrand (2008) and are expanded upon below.

Prospect and refuge evolved from our species historically spending 99 percent of our life entirely in nature. A secure and protected environment, refuge, with a view from that secure darker place into a brighter more expansive space, prospect, was evolutionarily desirable. Prospect allows us to identify danger while being in a secure, protected environment. From the small and darker confines of refuge, we must be able to see out into the light and expansive prospect; when in prospect we must be able to retreat to refuge (Kellert, 2008, p

13, Hildebrand, 2008; Hildebrand, 2000; Appleton, 1975). An example of prospect and refuge in nature, on the savannah, would be a cave, with four directions secured from predators but with a view out to the expanse beyond - prospect. A built example would be a tree-house with a view beyond, or lofts or mezzanines that look over other spaces. Google's new offices located in Dublin have provided interior cave like spaces. Or on a smaller scale, prospect and refuge theory explains why we do not like to sit with our back facing a door or entrance to a space. We are unprotected, and can be surprised.

Order and complexity (Hildebrand uses a similar term - complex order). Design needs balance. Too much or extreme order is boring, too much complexity can be overwhelming and lead to chaos. i.e., Canadian Museum of Human Rights (CMHR) Case Study exterior window mullions design has achieved the desired balance between order and complexity (Figure 31, section 3.7).

Curiosity and enticement (or enticement Hildebrand). "Curiosity reflects the human need for exploration, discovery, mystery and creativity ... enticement fosters curiosity" (Kaplan, Kaplan, & Ryan, 1998; Kellert, 2008, p. 13). Offering a view and access to a setting brighter than the one we occupy i.e., trails that meander are more interesting than a straight path or road, or a partial view to a sun filled clearing (Kaplan, 1987), or providing a sliver of a view into the next interior space fosters interest and curiosity in the space. CMHR uses a Frank Lloyd Wright technique of compression and expansion which I believe is an adaptation of this attribute to the built environment. In Figure 34 – a compressed

space, from which we have a view to the expansive and more open winter garden (Figure 32).

Fear and awe (Kellert) or peril (Hildebrand) Overhanging precipices or rushing water - combining reverence with fear can result in awe (Kellert, 2008). Mezzanines or open floor areas that allow occupants to look down from a height or large expanses of glass with spectacular views can also elicit fear and awe i.e., CMHR Case Study (Figure 31 and 32).

2.2.3 Biophilic design and the office knowledge worker

The following section discusses biophilia and nature-based features in relation to the knowledge worker using research examples of EBD (Evidence-based Design) to create work environments for stress reduction in knowledge workers. The section begins with the larger framework of site selection and the direct experience of nature, such as forests, and moves towards the narrower scope of the indirect experience of the natural materials of wood and plants within the knowledge workers environment for improved health and well-being.

2.2.3.1 Site Selection

As discussed earlier restorative and healing gardens have made a comeback in the health care system (Marcus & Sachs, 2013). Just as research provides evidence of restorative gardens increasing health and well-being for patient recovery from surgery or other ailments (Park, 2006); preliminary findings indicate positive cognitive benefits for office workers (Wight, 2007). In addition to gardens, research also shows the benefits of walking in nature, on paths and in urban parks and forests, versus walking in urban

settings without green infrastructure (Berman et al., 2008; Nisbet & Zelenski, 2011; Tsunetsugu et al., 2010). The reduction in stress participants experience while in the forest, not only improves the mood but also, enhances the functioning of their immune system. The essential oils emitted by evergreen trees are associated with improvements to the immune system and production of natural killer cells (Tsunetsugu et al., 2010). These effects can be long-term but vary based on gender, with immune function increased for up to 30 days in men and only seven in women (Li, 2010). Women also report higher levels of stress than men and are less likely to use outdoor nature during the work day (Lottrup, Grahn, & Stigsdotter, 2013), thus including access to indoor nature becomes even a greater priority for female knowledge workers. Outdoor nature³ is defined as “natural elements in the outdoor environment at the workplace, such as trees, shrubs, flowers and other vegetation” (Lottrup et al., 2013, p. 7). Indoor nature is these natural elements being brought indoors.

2.2.3.2 Scents

Nature, urban gardens, and forests can also be brought into the interior spaces through natural scents. It has recently been discovered that the reduction in stress and improvements to the immune system produced by forest visits can be replicated when evergreen oils are removed from trees, aerosolized, and infused into hotel rooms (Li et al., 2009). These are important findings and have significant, positive implications for businesses, knowledge workers and the health care system including enhanced performance, improved health and well-being, lower health care costs and reduction in sick days.

³ Lottrup et al. use the term workplace greenery, for clarity of terminology in this thesis I have used the term outdoor nature.

The Sense of Smell Institute in Chicago (SSIC) has a virtual library of research papers on the cognitive impacts of fragrance. One such study by Jo and Rodiek (2012) suggests contact with floral scents, such as plum blossoms, can improve mood and may foster increased brain functions in the areas of speech, memory, and movement. Lemon and jasmine have been linked with improved performance on mental tasks, peppermint with improved completion of tedious tasks and increased alertness, cinnamon-vanilla have been linked to improved creativity and rosemary to enhanced memory. Lime, marjoram, rose, lavender, bergamot and cypress have been shown to reduce anxiety and lavender to promote relaxation (Augustin, 2009).

2.2.3.3 Natural settings and movement

Interaction with nature might best be made unavoidable as opposed to being “tucked away” in parks, as people are unable to predict the importance of nature and its positive benefits, they are unlikely to seek it out (Nisbet & Zelenski, 2011). This suggests ensuring the environment and path between destinations includes nature to make the interaction with nature unavoidable.

One way of encouraging this interaction with nature is through challenges or friendly competitions. The Canada 30x30 Challenge, administered through the David Suzuki Foundation, conducted in May of 2013, encouraged Canadians to spend 30 minutes each day in nature, for the 30 days of May (Nisbet, 2013). Participants reported feeling more vitality and energy, and an increased sense of calm and peacefulness. Feelings of stress, negativity, and sleep disturbances were reduced by the end of the month. The more time participants spent in nature the more they reported being happier and connected with nature. The average weekly hours spent outdoors by the end of the survey, almost doubled to 8.5 hours. Participants also reduced their

television and internet (or email) time by about 2 to 2.5 hours. A number of Canadian workplaces publicized the challenge to employees, participants reported no change in job satisfaction or interactions with co-workers but participants did feel they were slightly more productive at the end of the 30 days (Nisbet, 2013). This research suggests time employees spend in nature and employers spend enabling employee's time in nature, can have a positive benefit to both employee and employer. In addition, movement within the office space must be considered as office workers are becoming more sedentary.

Derks and Bakker (2010) indicates that with the advance of technology, especially smart phones, the average office worker is working a longer week blending office time into what was once personal time. Office workers are also becoming more sedentary and sedentary impacts life expectancy, according to Hedge (2012), who suggests workers, should be unhooking from their technology and chairs and moving at least every hour. Software on laptops and other electronics can remind workers to move. An example of software alerts - a 10 week study by Cornell University found workers receiving computer alerts reminding workers to assume good posture, take a micro break and stretch were an average of 13 percent more accurate than coworkers who were not reminded (Lang, 1999). In addition, the "sit stand" workstations that have been touted as "the answer" have ergonomic issues. They put undue strain on the legs and 60% tend to not remain in use after the first month (Hedge, 2012).

Workers tend to think that the effects of sitting all day can be undone by an hour of activity at the gym in the evening, but this is not accurate. Hedge (2012) suggests that a pooling of fluids occurs in the legs unless a short walk, even just to the copier or printer, occurs at least every hour. Sitting slows our metabolism affecting good cholesterol, is tied to increase impact for heart disease, type 2 diabetes, breast, and

colon cancer (Lee et al., 2012). As time spent sitting increased, particularly watching television, the risk associated with cardio vascular disease also increased (Dunstan et al., 2010).

The technology that is partially responsible for the longer work week also frees the worker from the physical workplace and allows more movement and interaction with nature, and ties into Kellert's place-based design relationships element. Many corporate offices are placeless; the lack of connection to the exterior and the obsession by some corporations for homogeneity can be contributing factors. Combining the need for movement with the connection to nature could be a win-win scenario increasing place-based relationships, creating greater cultural and ecological connections. Thus, alternative and varied working spaces that encourage movement, interaction with nature and potentially increase place-based design could be beneficial, possibly rethinking the office and surrounding environment. Encouraging knowledge workers to move, to relocate to alternate locations; and considering planning that encourages movement could all be beneficial

2.2.3.4 Daylight and views

The stress-reducing benefits of providing daylighting and natural views in work environments are supported by Kaplan's Attention Restoration Theory (ART) and (Berman et al., 2008) (see also section 2.2.2), and various workplace research studies such as (Heerwagen, 2006; Heschong, 2003). Artificial views of nature such as photographs or plasma screen images (i.e. screen savers) also produce cognitive benefits, although not as strong as with an actual view to nature (Kahn et al., 2008).

Green building rating systems encourage views to the exterior, however, they do not specify that the view contains nature The benefits of having a view through a

window are strengthened if the view contains natural elements (Ulrich, 1984). Thus, when workers cannot be in nature, research suggests designers may consider views with natural content. Even views to nature during the commute to the office can be beneficial. According to (Cackowski & Nasar, 2003) drivers have a higher tolerance level for frustration during and after simulated drives through densely vegetated areas.

The research suggests a restorative work environment consider Kellert's biophilic design principles, individual preferences or personalization, locates in or near nature, incorporates natural scents, has views to nature, includes operable windows and ideally access to a park or path for walking meetings or opportunities for contemplation and stress reduction (Berman, 2008; Kaplan, 1995; Ulrich, 1993). Although being in direct nature is optimal, not all work environments have access to nature. In addition, Canadians spend an average of 88.6% of their time indoors (Leech et al., 1997). Thus, bringing nature indoors would be a beneficial option available to most interior design projects.

2.2.3.5 *Natural materials - wood.*

Natural materials such as wood have been shown to lower stress levels and improve health and well-being of occupants in indoor spaces (Raanaas, Evensen, Rich, Sjoström, & Patil, 2011; Tsunetsugu, Park, & Miyazaki, 2010). Japanese researchers, Tsunetsugu, Miyazaki, and Sato, (2007) suggest the ideal proportion of wood, as an interior finish on walls and floors, is between 30 to 45 percent of the combined surface area of the space. The 30 to 45 percent ratings lead to the greatest amount of relaxation and thus lower stress levels (Tsunetsugu et al., 2007). Depending on the function of the office space, if lower stress levels and relaxation is desirable, research suggests incorporating wood as a finish and furnishings material would be beneficial.

Tsunetsugu's research was conducted based on a typical Japanese living room, not an office environment. Most office spaces do not have the budget for 30 to 45 percent wood on floors and walls. Wood floors and walls are typically only used in meeting or reception areas, and rarely achieve the 30 to 45 percent ratio suggested. Wood floors can also negatively affect acoustics of the space. Tsunetsugu's research does not include wood furniture, which might be more advantageous from a budget and acoustical viewpoint for an office environment. Although Tsunetsugu's research was not conducted in an office setting, possibly revising the parameters of the research to more closely suit an office setting by including wood furniture and the strategic placement of wood may find similar results in an office setting. Strategic placement of wood may also result in achieving positive affects with less than the stated ideal 30 to 45 percent ratio.

Others have found similar results, although again not in office settings (Nyrud, Bringslimark, & Bysheim, 2014; Sakuragawa et al., 2005). Nyrud et al.'s study was administered on-line using 10 electronic images of a hospital patient room with varying degrees of wood. Sakuragawa et al., (2005) measured mood and blood pressure of participants exposed to hinoki wood or white steel wall panels, as well as surveying for preference (like and dislike) of both materials, as preferences can reduce stress (van den Berg et al., 2003). Both Nyrud et al., (2014) and Sakuragawa et al., (2005) found participants preferred moderate amounts of wood and in the Nyrud survey the least liked room was the room with wood on all surfaces.

In addition, Sakuragawa et al., (2005) found participants who liked wood, blood pressure decreased significantly (stress reduction), whereas participants who disliked wood had no increase or decrease in blood pressure, thus no stress was caused in participants who disliked the wood. Feelings of depression were also reduced when

exposed to the wood wall. Participants who liked the steel wall saw no change in blood pressure, and participants who disliked steel had an increase in blood pressure (stress) when exposed to the steel wall. Exposure to the steel panel also increased feelings of depression (Sakuragawa et al., 2005).

Wood paneling

In our own 2,700 sq. ft. office, we, the designers, added 30 to 36" wide full height wood veneer wall panels. In addition to paneling in the reception and boardroom, we added six of these panels in the general office area. The panels were installed singly, throughout the open office area, allowing each designer in the L-shaped general office area to have sight lines to at least one panel. One panel was also installed in each of the four enclosed offices. Thus, similar to green building rating systems, access to views (to the exterior) credits, we were able to provide views to wood (panels) for each occupant of the space.

Further research is required to determine:

- (1) If Tsunetsugu's findings can be adapted and replicated in an office setting,
- (2) If the strategic placement of wood, as noted in the text box example above, could lower the ideal wood percentage requirements
- (3) If refining exposure percentages in combinations with other materials i.e., wood and plants - what proportion and combination would be ideal? Wood also allows for further preference and personalization in the color, texture, and patterns which were not investigated in any of the wood research examples.

2.2.3.6 Plants

Considerable research suggests plants can have significant positive effects on workplace environments. Costa and James (1995) noted plants have been shown to reduce noise levels, increase privacy (Goodrich, 1986), improve air quality (Wolverton, Johnson & Bounds, 1989), absorb carbon dioxide (Wolverton, 1996), improve humidity

(Wolverton, 1996; Smith & Pitt, 2011) and absorb particles in the air (Lohr & Pearson-Mims, 1996). Workers with indoor plants in proximity to their desks took fewer sick leaves (Bergs, 2002; Bringslimark et al., 2007). Lohr et al. (1996), found participant's blood pressure was lower in areas with plants and reaction time was 12 percent faster. Offices were rated as more attractive with plants (Larsen et al. 1998). As discussed earlier, even individual preferences for a material can lead to stress reduction (Sakuragawa et al., 2005; van den Berg et al., 2003). Participants preferring wood panels, versus the white steel panels, showed greater reduction in stress when exposed to their preferred material, wood (Sakuragawa et al., 2005).

Raanaas et al. (2011) suggest that office spaces benefit from the introduction of plants. Memory recall and complex proofreading skills were improved when testing was conducted in individual offices containing four plants: two small flowering plants located on a window sill, a one-foot-high plant located on a desk, and a four-foot-high floor plant (Raanaas et al., 2011). In a separate study, female participants' mood and performance on creativity tasks improved when the space contained a four-foot-high corn plant (Shibata & Suzuki, 2004).

Nieuwenhuis et al. (2014) conducted three separate studies comparing lean versus green office environments. Each participant in the green office condition could see at least one to three large leaf plants (average height of 90 cm) from the workstation. Adding plants to a previously lean (or spartan) office environment resulted in significant increases in workplace satisfaction, self-reported levels of concentration, and perceived air quality. Adding plants to the lean space improved perceived productivity (Study 1) and actual productivity (Study 3). Study 3 results indicate a "green working environment is consistently more enjoyable for employees, more conducive to concentration, and more productive for the business than its lean equivalent....enriching a previously

spartan space with plants served to increase productivity by 15%” (Nieuwenhuis et al. 2014, p. 199-214). The plant quantities vary from minimum of one to four or five, but the results all suggest plants have a positive contribution to the work environment.

Three possible explanations for the psychosocial benefits of plants have been discussed by Nieuwenhuis et al.:

- 1) plants improve air quality by removing air-borne pollutants (Orwell, Wood, Tarran, Torpy, & Burchett, 2007) and by reducing CO₂ levels by 10% which increases productivity (Seppanen, Fisk, & Lei, 2006; Tarran & Burchett, 2007).
- 2) an evolutionary explanation of the benefits of plants and the ability of nature to restore our directed attention, Kaplan’s attention restoration theory (ART, Kaplan, 1995) as discussed earlier in this chapter.
- 3) relational and managerial consequences of enrichment – i.e., the enrichment of the workspace, with plants or by other means, communicates managements care and attention to employee well-being and contributes to increased levels of worker satisfaction, productivity and well-being (Ottosson & Grahn, 2005, Vischer, 2005).

The ongoing care and maintenance requirements of indoor plants does have some potential implications. Interior designers and facilities managers must carefully consider care and maintenance of natural elements within an office landscape. Hartig et al. (2008, p. 146) also discuss the differences in restoration times of males and females. According to Ahrentzen, Levine, and Michelson (1989), Canadian women working full-time spent twice as much time in the kitchen alone or with children in bedrooms than men working full-time. Rydenstam (1992) suggested that restoration time for women in dual income families is disrupted by tasks more frequently than their partners. This

raises the question would additional natural or biophilic elements, such as plants, add even more work to an already over worked individual and thus the restoration effects may be diminished (Hartig & Fransson, 2006). In some instances, women working full-time and already stressed or overworked at home, adding biophilic elements at work may cause a similar resentment at the office and negatively impact the desired restorative value. Thus, designers and facility managers must consider maintenance of nature-based features, such as plants, to ensure restorative values are not diminished by unwanted maintenance tasks.

2.3 Summary

Stress stimuli causes memory and productivity losses. Continuous chronic stress causes health problems and can lead to mental health issues. The literature reviewed reveals that there are potential psychological and physiological benefits of including nature in workplace design. Researchers theorize that exposure to nature mitigates stress stimuli and therefore has restorative effects on memory and attention for health, well-being and productivity benefits (Kaplan, 2008). . Providing direct and indirect exposure to nature appears to have the strongest impact on mitigating the stress response. According to the literature examined incorporating nature and nature-based features that have potential application into workplace design includes the following: site selection, locating in or near direct or indirect nature, maximizing daylight and views to nature, incorporates natural scents, encouraging movement in natural settings, and including natural materials such as wood and plants when direct nature is not possible. The case studies in Chapter 3 provide examples of the application of these strategies.

3 Biophilic Design Case Studies

This chapter presents a review of examples of biophilic workplace design strategies applied in current practice. The strategies represented herein include the subset of design approaches that were identified from Kellert's theoretical framework and supported by empirical evidence discovered as part of the literature review (section 2.2.2 and 2.2.3). These design strategies are intended to provide direct and indirect biophilic experiences and place-based relationships. Three primary criteria guided the selection of the case studies. The case studies must contain one or more of the empirically supported biophilic design strategies identified through the literature review, include office space for knowledge workers and provide both Canadian and global examples.

3.1 Case Study 1 – Johnson Wax office building

Frank Lloyd Wright's 1936 Johnson Wax office building is the first known example of biophilic workplace design. Wright not only brought plants inside, his combination of tapered columns and extensive skylights evoked a unique sense of the outdoors and the feeling of tree canopies. (Figure 5). Wright promised Johnson "a building that would make him feel as if he were bathing in sunlight among pine trees". The Johnson building is a strong example of direct (daylight), indirect (potted plants) and symbolic (tree canopies) biophilic design experience. Wright also later reported the workers "enjoyed the space so much that they often chose to spend their lunches in the building rather than leave to have lunch at home" (Docomomo US, 2012).



Figure 5. Frank Lloyd Wright's 1936 Johnson Wax office evoking a sense of outdoor tree canopy (with permission, Heitzman, 2015)

Although the term biophilic design was not developed until 1972, it can be said that Wright was an early adopter. Wright believed buildings should represent the area and landscape of the site, what Kellert would later describe as “placed-based relationships” (Kellert, 2008). Wright often used images of nature in his designs, such as the maple samara in his stained glass patterns in Samara House, or local natural materials such as the limestone of Wisconsin in Taliesin (Britannica, FLW, 2014).

“I believe in God, only I spell it Nature.”

Frank Lloyd Wright (as cited in Quote, 1966)

Wright was obviously unaware of the health benefits that would be revealed by today's daylighting and view studies, nor is there evidence that a post-occupancy evaluation study was ever done of the Johnson Wax building, he intuitively understood what impact the beauty of pine trees and filtered sunlight could have on the office workers,

3.2 Case Study 2 – Selgas Cano Architecture office

The *Selgas Cano Architecture* office, built in 2009, is an example of direct experience of nature, locating office workers in spaces adjacent to nature. The office is a 62' aerodynamic tube buried in the ground and set in a forest in the suburbs of Madrid (Selgas Cano) (Figures 6 to 13). The office was built without cutting a single tree, is passively ventilated using a modern version of tent flaps (Figure 13) and uses no artificial lighting during the day (Cohen, 2009).



Figure 6. Selgas Cano Architecture office set in suburban Madrid, Spain (with permission Cano, 2014).

Undoubtedly submersing the floor plane into the landscape provides an unusual perspective of nature at eye level. According to Kellert's biophilic attribute "prospect and refuge", the combination of the amount of glass and being partially below grade could

leave occupants feeling vulnerable. The space may have been more successful, from a biophilic design perspective, either at ground level or raised.

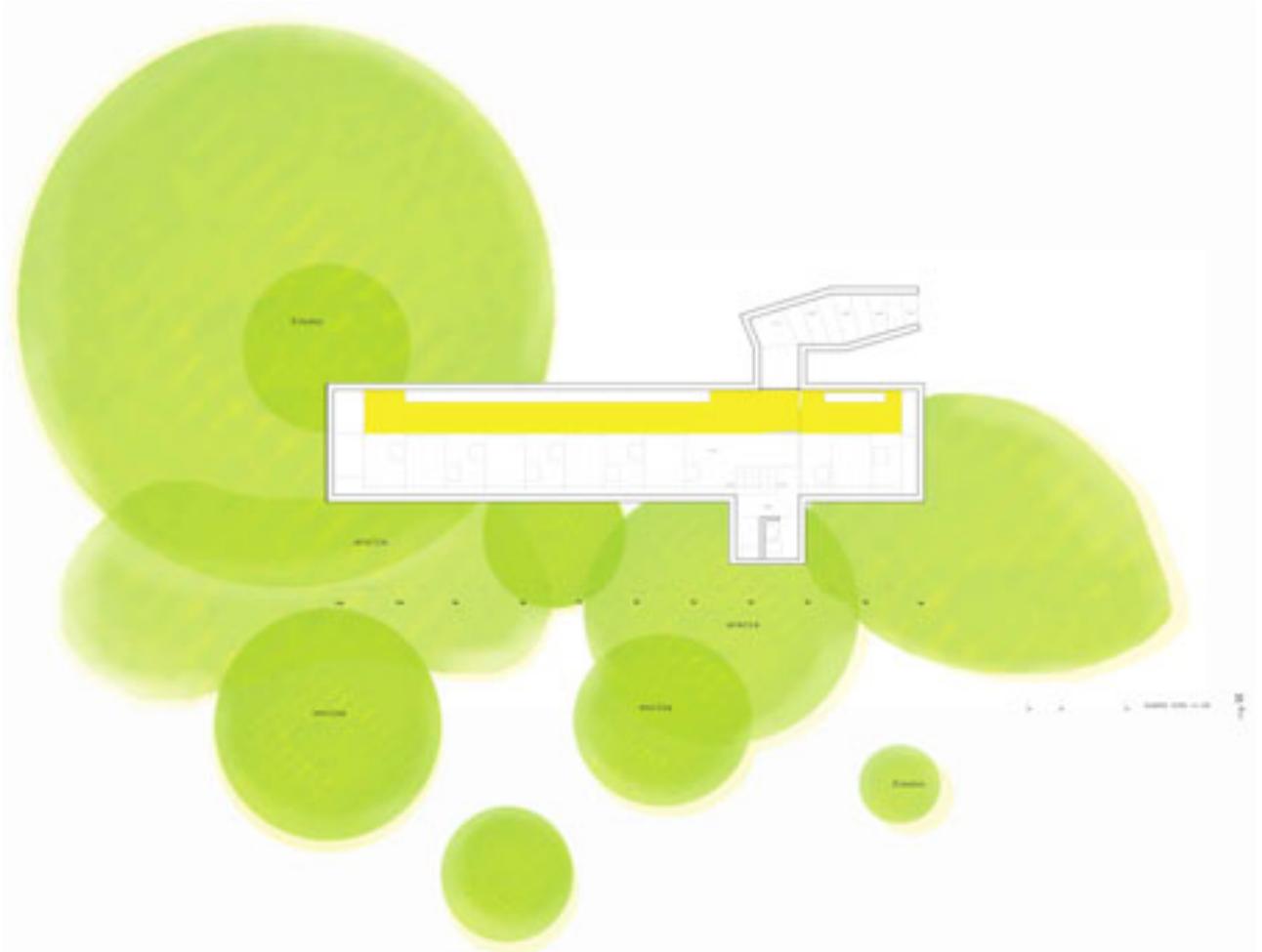


Figure 7. Site plan of Selgas Cano Architecture office set in suburban Madrid, Spain (with permission Cano, 2014).

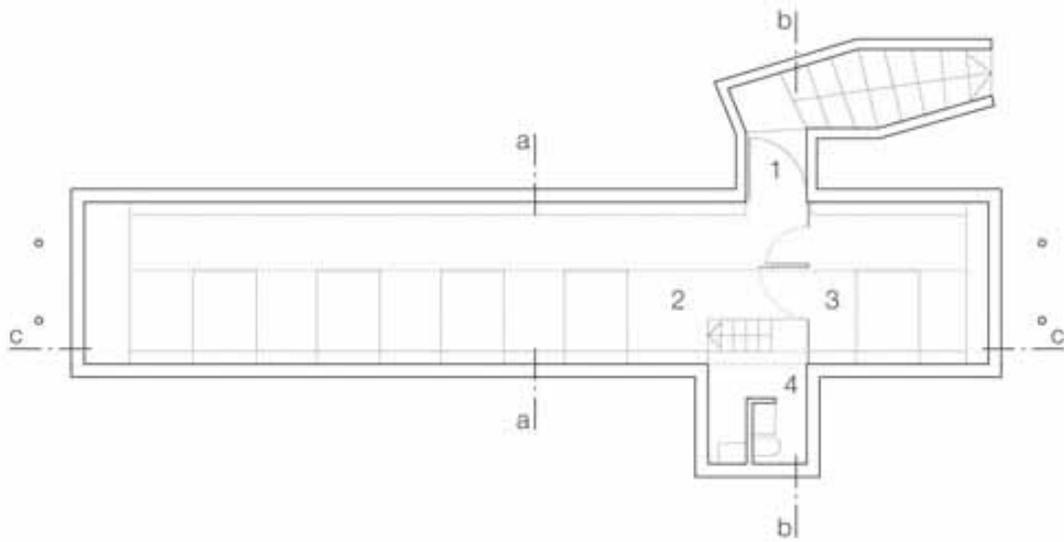


Figure 8. Floor Plan Selgas Cano (with permission Cano, 2014).

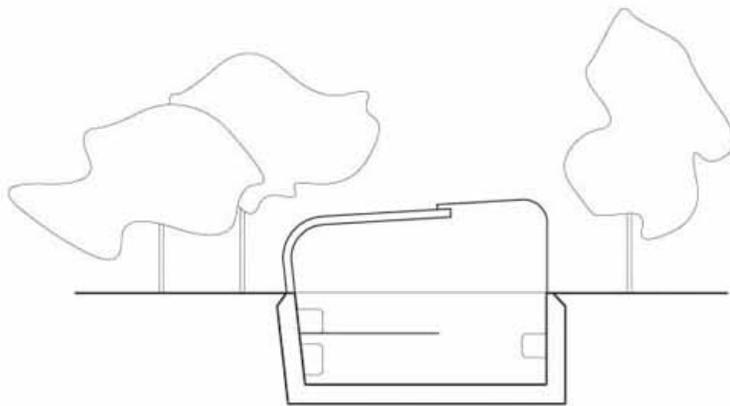


Figure 9. Section Selgas Cano (with permission Cano, 2014).

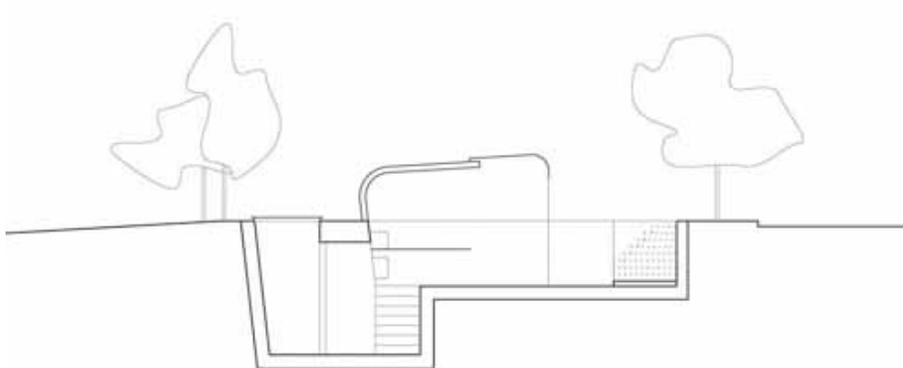


Figure 10. Section Selgas Cano (with permission Cano, 2014).

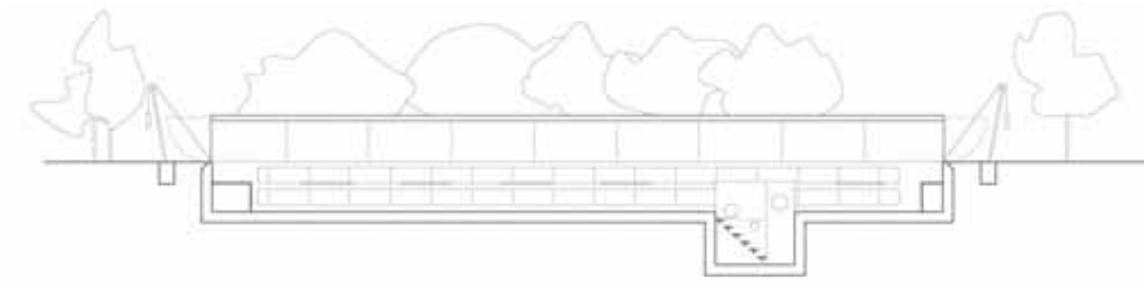


Figure 11. Section Selgas Cano (with permission Cano, 2014).

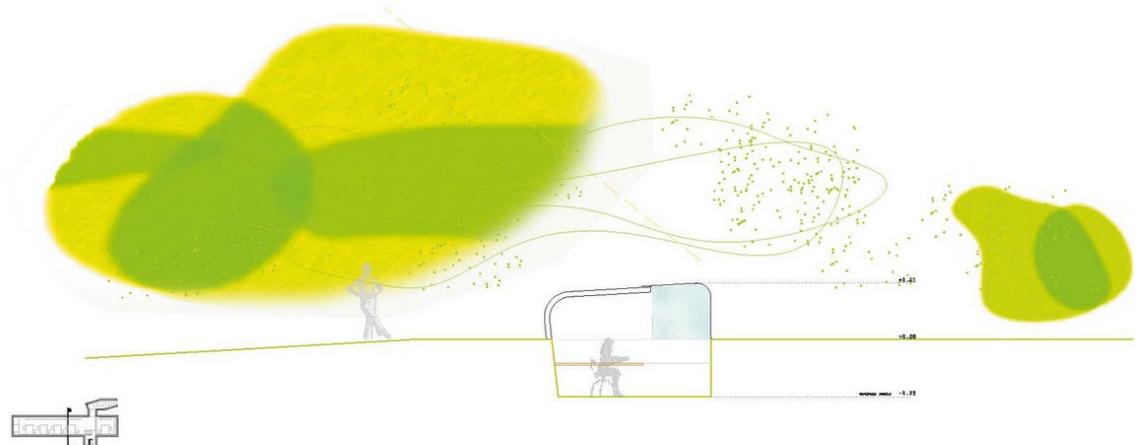


Figure 12. Section Selgas Cano (with permission Cano, 2014).



Figure 13. Operable windows Selgas Cano (with permission Cano, 2014).

Animals

A project located in the forest, like Selgas Cano, would naturally include animals. According to Beatley (2008) animals may occur naturally, or may be encouraged by addition of specially selected vegetation or feeders that attracts birds, butterflies, or even chipmunks. The importance of diversity of plantings versus monocultures must also be considered for interest, complexity and order (Kellert, 2008) and for the benefit of the ecosystem (Beresford-Kroeger, 2010).

On a recent trip to New York City, Sarah Sze's bird feeder sculpture in Highline Park is an example of art that also functions by providing shelter and food for birds in the area (Figure 14). The Highline, a park created on an abandoned elevated rail line, also provides example of diversity of plantings and integration of seating, which can increase time spent enjoying nature. Animals can occur naturally, or be encouraged through the selection of vegetation. Vegetation and animals add to the complexity and order, benefit the observers and inhabitants of the ecosystem. Animals can enrich the environment and provide the soft focus or fascination discussed earlier in ART even when viewed through a window.

<http://nyclovesnyc.blogspot.ca/2011/06/bird-feeder-art-at-high-line-park-phase.html>

Figure 14. Sarah Sze's bird feeder sculpture on the Highline Park, NYC

3.3 Case Study 3 – Pond Studios

Pond Studios is located in Lagrange, Georgia and designed by Elva Rubio for David Oakey Designs, a design and color textile consultancy firm (Oakey, 1997). The 15,000 sq. ft. building is located on the edge of large pond with the office space jutting over the pond as a peninsula; glazing on three sides provides a panoramic view of the

surrounding nature. “The idea was to be in, not just close to nature – as much as possible” (Rubio, n.d.). The space was also designed with a focus on natural lighting and use of local materials, which is atypical in 1996. The lower screen and storage heights, which are perpendicular to the walls, maximize light penetration into the office space (Figures 15 to 17).

Pond Studios site is located in nature, an example of Kellert’s direct experience, as well as maximizing daylight and views to nature. The space is reminiscent of a large tree house for adults. The office also uses natural and place-based local materials, such as wood in the ceiling and furnishings. Several expansive decks also encourage movement and the use of nature during office hours.

<http://davidoakeydesigns.com/pond-studios/>

Geran, M. (1997). Back to nature. *Interior Design*, 68(8), 116-121. Retrieved from

<http://search.proquest.com/docview/55212377?accountid=14569>

Figure 15. Pond Studios in Georgia.

Glazing on three sides of the small “peninsula” office provides a panoramic view of the surrounding nature. Note the low screen and storage heights, which are perpendicular to the east and west walls, we are seeing the north façade in this image. Refer to Figure 15 and 16 to see the “peninsula effect”.

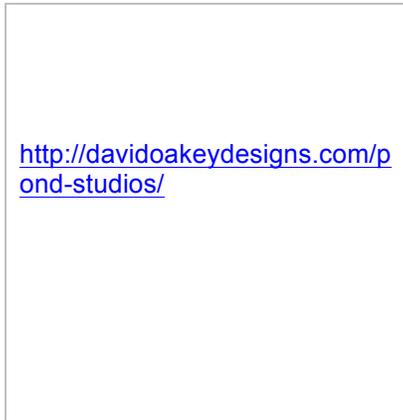


Figure 16. Pond Studios when first constructed.



Figure 17. Pond Studios as nature re-encroaches after construction.

Following the light – the importance of daylight

Pond Studios maximizes daylight through glazing on three sides of the office space. Rolf Disch's Heliotrope House, designed as a cylinder which rotates to maximize daylight in all spaces (Figure 18).

Early in my design career, I worked in a building with a 30,000 sq. ft. floor plate. The section of the space we occupied had one exterior window, buried in a distant workspace cubicle, screened by 65" high partitions. At the end of the day, I would leave with no idea what the weather had been for the entire day. The experience was disorienting. I also spent a year working in our large interior office boardroom, while awaiting renovations and a move to our new LEED office space in 2005. Working in the office area, without access to daylight for a year, took me a long time to recover from, despite moving into a corner office with beautiful views into the trees. I became a bit of a heliotrope and followed the sun around in my second workspace – my home office. Ten years later, I am still following the sun. The Heliotrope House, designed 1994 to rotate and follow the sun, as I believe we are innately programmed to do - other than in scorching weather. Following the sun does not require sitting in glaring hot sun. It means having the ability to connect with daylight in the manner most comfortable to the user at a given moment.

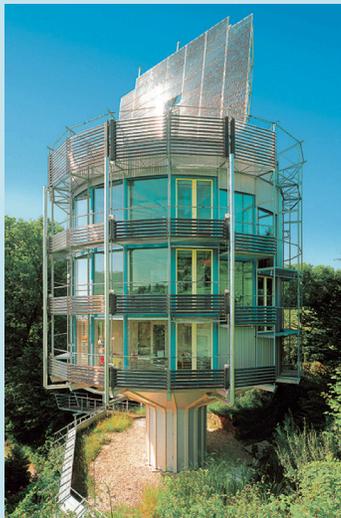


Figure 18. Heliotrope House, Freiburg, Germany (with permission Glazer, 2014).

3.4 Case Study 4 – SC3

The architectural office of SC3, located in Winnipeg, Canada is another example of locating in nature as Selgas Cano and Pond Studios. Whereas both Selgas Cano, also set in a city like SC3, and Pond Studios simply worked within existing nature, SC3, despite the city site, was able to significantly add to the existing nature. SC3 not only retained a preserved wood forest but also reintroduced tall prairie grassland (Figures 19 and 20). A deck surrounds much of the office building allowing meetings and individual work to occur set within nature. Mobile interior office furniture can also be moved to the deck. The deck is also used for yoga (Figures 22). Floor to ceiling exterior glazing and several doors permits views and access into the spruce forest (Figures 21 and 23). As a result, the scent of the forest permeates the indoor spaces. Employees also planted an additional 100 trees at the south end of the property and the city added additional shrubs and trees in the street boulevard. Walking paths were designed throughout and shared with the surrounding community. Although the busy street is less than 20 meters from the south end of the building (Figure 19), the site feels as if set in the prairies versus an urban area.

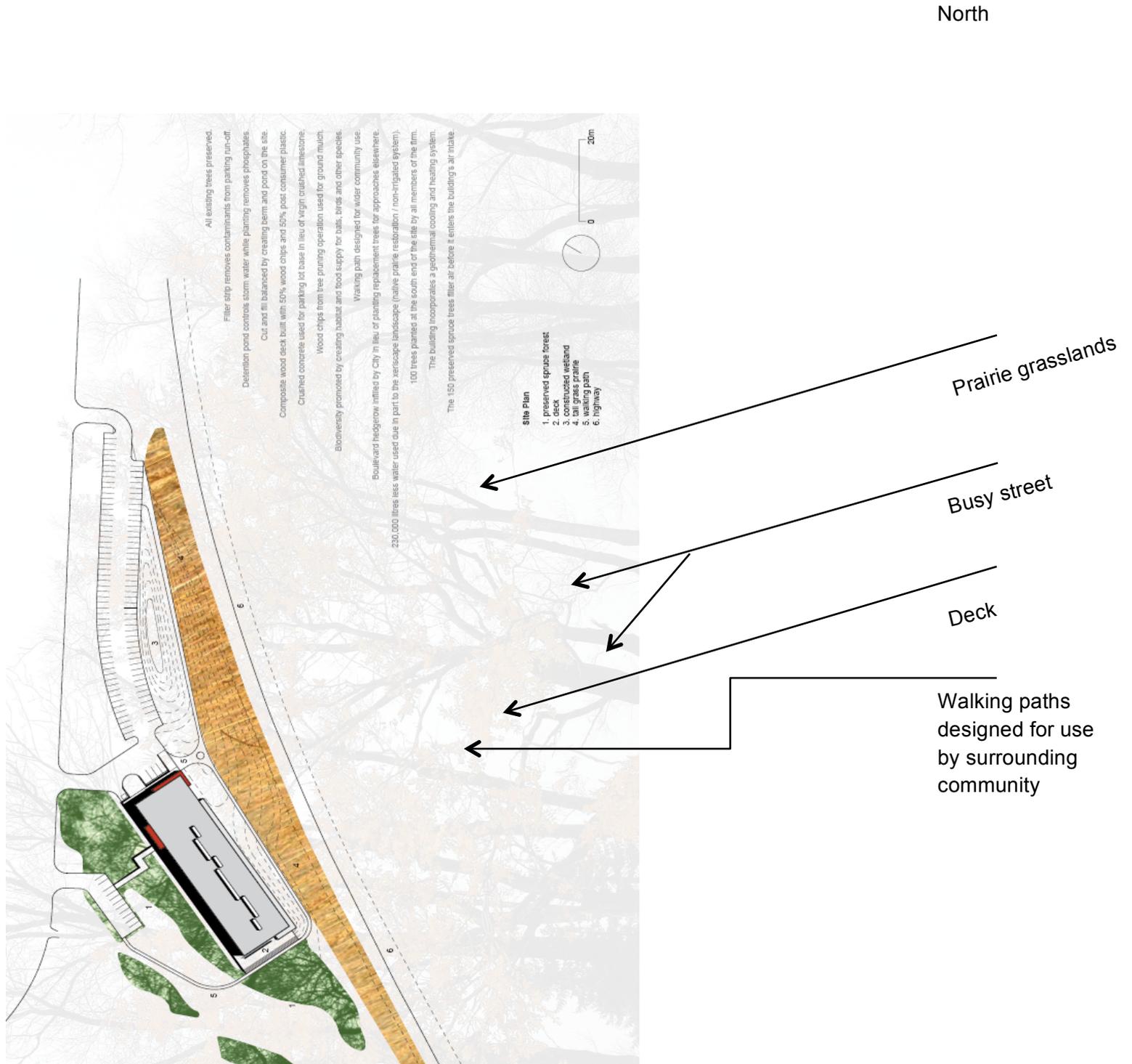


Figure 19. SC3 Site Plan (with permission Giles, 2014).



Figure 20. SC3 exterior. View of natural prairie grassland in the “front” yard view and tops of urban spruce forest in side and back area (with permission Giles, 2014).



Figure 21. SC3. View to urban spruce forest (with permission Giles, 2014).

Figure 22. SC3. Surrounding deck area set in urban forest (with permission Giles, 2014).



Figure 23. SC3. View to nature from open workstations (with permission Giles, 2014).

SC3 is an example of Kellert's direct experience of nature which maximizes daylight and views to nature, incorporates natural scents. In addition there is a complexity and order as well as a sense of awe provided by the view to nature. Movement within nature is also encouraged through the introduction of walking paths, decks and connection to the community or place-based relationships as well as supporting restoration time (Kaplan, 1995; Berman, 2013).

While SC3's deck is naturally shaded and sheltered by the spruce forest it does not provide an ideal workplace year-round in Winnipeg's extreme climate that can range from -40C in winter to +40C in summer. Working outside in direct contact with nature can be challenging where there are strong prevailing winds, bright sunshine, rain, uncomfortable temperatures, and insects. Therefore, additional measures may be required.

Use of outdoor space

Similar to SC3, our first corporate office included a summer, spring, fall boardroom, and a winter boardroom. The former boardroom consisted of a large hexagonal picnic table, that I built out of red cedar and seated eight in our backyard garden. We were a small group, only three to four people, at the time. The space served as a work area, meeting area and most lunches were either barbeques or picnics at this table. This tradition regained some traction in our new office space, but the garden setting was never as complete and the trekking, down two flights of stairs or into the elevator, with the fixings, meant it did not happen near as frequently. The outdoor spaces in the first office were more easily accessible which is important to maximize use.

The last three case studies, Selgas Cano, Pond Studios and SC3 are examples of knowledge worker's office spaces located in a natural setting – providing a direct experience of nature despite being located within a city in two of the instances. These spaces maximize the use of daylight, natural plants, animals, and views that form part of the environment directly surrounding the office space.

3.5 Case Study 5 – Google Inc.

Google Inc.'s workplaces provide an excellent example of the application of corporate workplace guidelines that contain a variety of biophilic design strategies. Google Inc. does not always locate their offices in nature, but they do incorporate or recreate nature indirectly and encourage outdoor activities in the surrounding natural amenities (parks, green spaces). Google's approach is supported by, and provides an example of, Kellert's direct and indirect experience as well as an effort to provide strong affiliation with the local context what Kellert refers to as place-based relationships.

Although access to direct nature is desirable for restoration and stress reduction in knowledge workers, it is not always possible and the use of indirect nature offers

additional opportunities. A proposed Google Campus in San Francisco Bay, California, designed by architects NBBJ as a series of bent rectangles (Figures 24 and 25).. The rectangles form a series of linked spaces and rooftops with scooter-riding, jogging, biking yoga classes, and even space to pitch a tent. Cars are hidden away. The bent rectangles and the outdoor spaces were created from data on how employees work and relate to maximize “casual collisions of the workforce” (Radcliffe, 2013). Corporate design guidelines require that employees must be no more than two-and-a-half minute walk from any other employee (Goldberger, 2013). Even on the ninth floor of its office building in London, Google manages to offer gardening opportunities use decks and balconies. There is even a waiting list for the gardening spots (Figure 26). In this way, Google’s workplace create spaces with nature and then strongly encourages the use of those spaces through their corporate culture and thoughtful site-specific, place-based design using both of Kellert’s direct and indirect experiences. Some of the park like setting at Google San Francisco may be self-sustaining, and not require human input for care, but most like Google London’s balcony gardens are indirect nature such as potted plants.

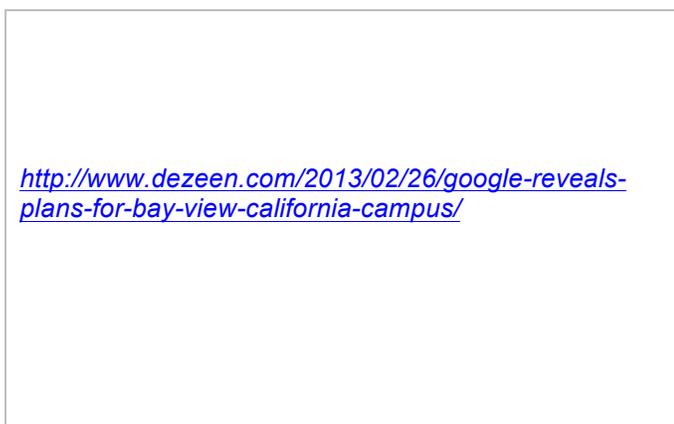


Figure 24. Proposed Google Campus with biking and walking paths.



Figure 25. Google detail. Clockwise from top left, outdoor Amphitheatre and spaces for classes, tents, boardwalks and docks, walking and bike paths.

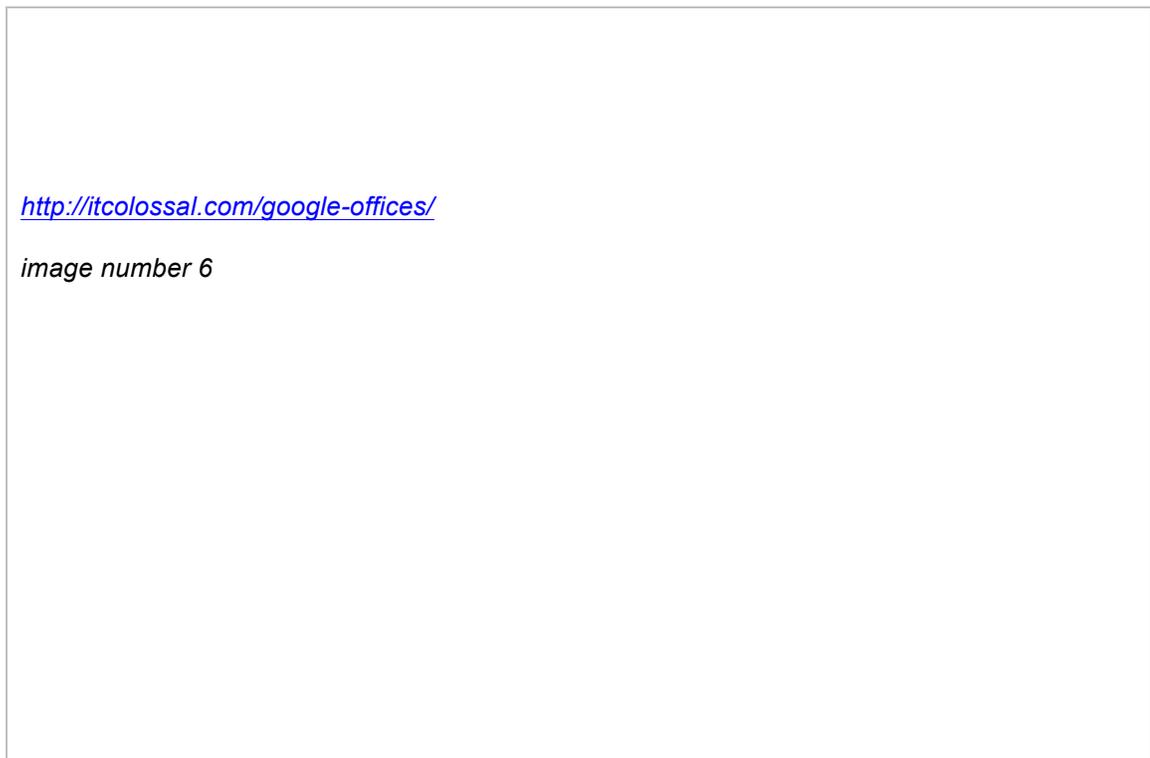


Figure 26. Google offices in London, England, on the 9th floor. Google has a waiting list for employees to plant seeds in special wooden containers (on the left of the image).

Google embraces place-based design, allowing a whimsical regional personalization. Google offices in Moscow are based on Russian folklore characters, which also include natural images and symbols on all surface planes, as well as a gathering space under a three dimensional “tree” complete with a lit canopy, branches, “leaves” on the “ground” and actual tree trunks embedded into the wall surface (Figure 27). The Google offices in Tel Aviv, however have a different approach with more than half of the interior space including an eco-friendly spirit, daylight and views, natural materials such as wood park benches, crates and flooring, and indoor trees which appear as if “planted” directly into the ground/floor. (Figure 28). Both Google Moscow and Tel Aviv are examples of Kellert’s place-based relationships. The work of van den Berg et al., (2003) also supports aesthetic preference or the more common design term of personalization which is linked to place-based design.

Google offices are excellent examples of place-based design. No two Google offices are the same. Employee preferences are included in each office location. Each location will have cultural, individual, and geographical preferences which contribute to place-based relationships. Personalization and preference can co-exist to fulfill the locational familiarity and yearning for home (Kellert, 2008).

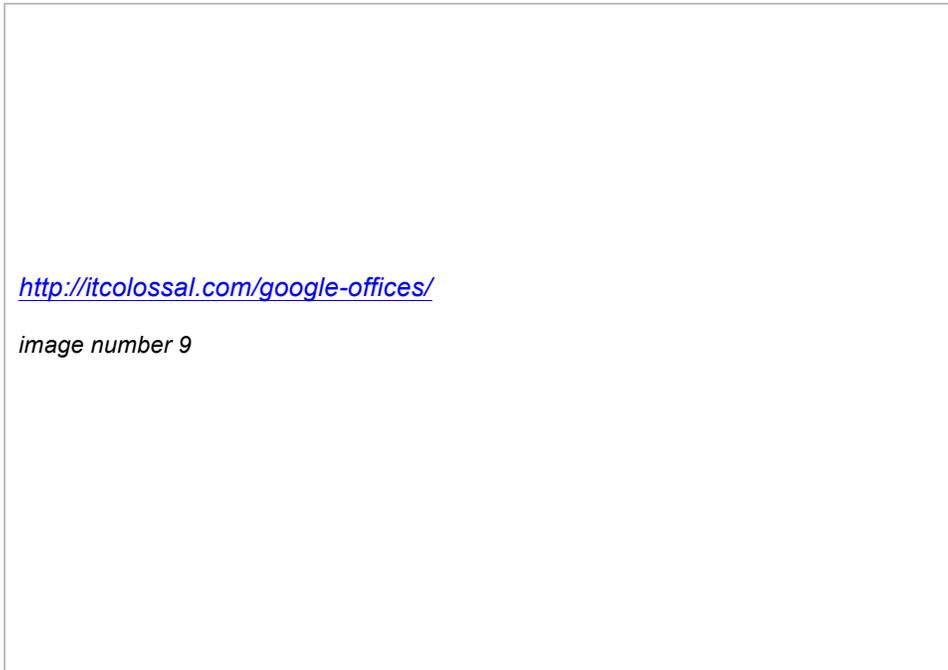


Figure 27. Google offices in Moscow show place-based design and whimsy based on Russian folk tales.

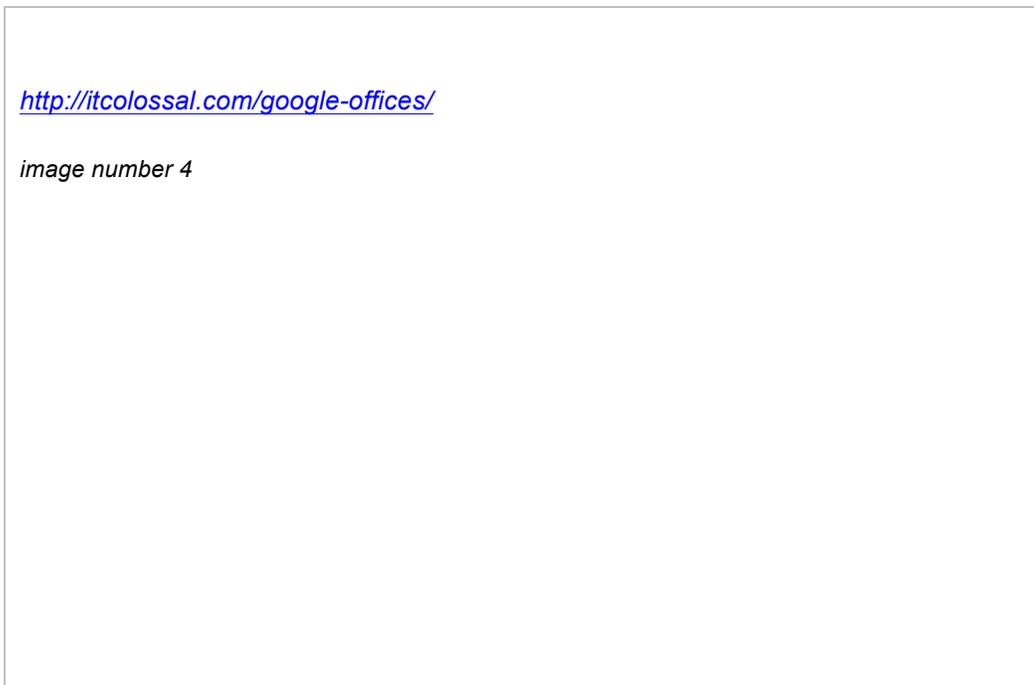


Figure 28. Google Tel Aviv office has an eco-friendly spirit.

3.6 Case Study 6 – Path

Path is a social networking app company with office space located in San Francisco and created by Geremia Design in 2011. Located in a dense urban site, the space maximizes daylighting but, does not provide direct experience and views to nature. Instead, the designers provide an indirect experience of nature through the use of well-placed plants, wood and other natural materials (see Figures 29 and 30).

<http://officesnapshots.com/2013/11/06/path/>

image 8 and 9 (cover image is image 1 and each image is counted singly)

Figure 29. Detail of Path office.

There is simplicity, a complexity and order inherent in the Path office design's use of plants that is sufficient to maintain interest while not becoming overwhelming. The research, of Raanaas et al., (2011) and Shibata and Suzuki (2004) in Chapter 2, suggests between one to five plants per workspace for stress reduction and improved health and well-being. Although Raanaas et al., and Shibata and Suzuki's work tends to focus on individual workspaces rather than meeting rooms, the Path image (Figure 30) is an example of a space that falls within the one to five plant range.

<http://officesnapshots.com/2013/11/06/path/>

image 1 – cover image

Figure 30. Path office in San Francisco illustrates use of indirect experience of nature through two well-placed plants and the use of wood and other natural materials.

Personalization - example of paint with potential application to plants

Over twenty years ago, I personalized the finishes for a 25 or 30,000 sq. ft. corporate client. I have always disliked finish selections with a limited color palette and avoided identical multi-floor office color selections. Multi-floors should be treated, at a minimum like fractals, a slight variation to each floor. The design team selected a palette of colors. To ensure efficiency, I applied the palette to the floor plan. However all users were given the choice - accept the color as presented - or swap out the selected finish for one of three or four other color options within the palette. All paint colors worked equally well in the space. The pattern created was interesting and random, a complexity, but with order. In this instance, users were simply selecting a paint color for one wall in their office. Users were delighted with being allowed this small choice. It required a little more time for our design team to change approximately 20 to 35 percent of the choices. Changes were either provided in the presentation meeting or emailed to the design team by a cut-off date. Once the selections were received, making the drawing changes took under an hour. This is an easy example of time efficient personalization.

This format could be applied, with some adaptations, to plant selection. Offer users a selection or palette of plantings to choose from, developed by a horticulturalist that considers the varied lighting levels. Administering on-line surveys allows for easy verification of preferred planting types and quantities based on individual users preferences. Research indicates personal preferences can reduce stress (Kahn et al., 2008).

3.7 Case Study 7 – Canadian Museum of Human Rights (CMHR)

The CMHR, located in Winnipeg, MB was designed by Antoine Predock, and opened in 2014. CMHR was selected as a case study because the building provides an example of evolved-human nature relationships, survival-advantage characteristics, and is one of the more prominent and recent examples of biophilic architecture in Canada.

The building is set in a downtown park, on the banks of the Red River. The building is primarily used as a museum, but it does have an office area for museum staff and curators located at its third mezzanine level. Figure 31, taken looking down on the offices from the 7th floor, provides an overhead view of the CMHR office area. The

cliff-like design of the office area, incorporates Kellert's biophilic attributes of "awe and peril" and "prospect and refuge." "Complexity and order" is experienced through the fractal form and patterning of the nearby exterior glazing and structural elements. Because of the slanted glass, work stations are setback from the exterior envelope, but there remains generous access to daylight and views to nature. Translucent screens are also used to maximize light penetration and views.

CMHR's corporate workplace policies allow for some personalization of individual workspaces. Plants have not been included within the office space, but indirect experience of nature is provided through the water and natural materials found in the adjacent Stuart Clark Contemplation Garden. The garden is constructed with basalt columns emerging from a slightly undulating slate floor with shallow, still water pools, wood benches, and healing plants honouring the First Nations sacred relationship to water, earth, and sky (Figure 32). Kellert's "place-based elements" are referenced in the use of locally sourced - Tyndall stone (Figure 32 to 34).



Figure 31. Office space in CMHR, Winnipeg.



Figure 32. CMHR winter garden.



Figure 33. CMHR winter garden detail. Basalt columns and slate floor (foreground), and medicinal plants (middle ground).



Figure 34. CMHR winter garden detail. Shallow pond and low ceiling in a portion of the winter garden.

Path and CMHR provide examples of indirect nature experience through plants (Path) and interior gardens (CMHR). Not all office settings can provide direct nature experience but most office settings can provide the knowledge worker with, at minimum, the experience of plants and in some instances the introduction of gardens, wood and other natural materials again providing application of Kaplan's ART.

3.8 Summary of findings

The case studies in this chapter provide Canadian and global examples of the successful application of a selection of biophilic design strategies. Not surprisingly, many of the early innovative projects are architectural offices or design studios (Selgas Cano, SC3 and Pond Studios). Biophilic design can be incorporated successfully into most projects, despite a constrained budget or dense urban location. These strategies are summarized in Figure 35.

No	Name	Description	Key Considerations
1	Johnson Wax	Historical context –first known office space with strong biophilic elements	-feeling of natural light and tree canopies
2	Selgas Cano	Tube buried in an urban forest in Spain	-located in nature, operable windows for natural ventilation -interaction with animals through location, vegetation or functional bird sculptures (Sarah Sze, Highline example)
3	Pond Studios	Design studio located in nature	-located in nature, maximizing daylight and views, low screens and storage, light colors to maximize daylight, use of local materials
4	SC3	Set in spruce forest and prairie grassland within city of Winnipeg	-located in nature, encouraging use and activity in nature (deck, paths, outdoor furniture, wireless connectivity, natural shade and consideration of wind and insects), augmenting existing nature and connecting with community - unexpected bonus of pine forest scent in interior space -operable windows
5	Google		-large corporation working within corporate guidelines but allowing personalization globally -place-based design
	San Francisco	Headquarters campus	-incorporates or recreates nature -encourages outdoor activity and use of nature
	London	Balcony gardens on 9 th floor of highrise	-encourages outdoor activity and urban gardening
	Moscow	Whimsical Russian folklore	-place-based design
	Tel Aviv	Eco-friendly spirit	-use of plants and trees, daylight, wood and other natural materials
6	Path	Simplicity and complexity of order	-daylight, wood and a few well-placed plants
7	CMHR (Canadian Museum of Human Rights)		-daylight and views -place-based design, human evolved and survival advantage characteristics: awe and peril, complexity and order, prospect and refuge -indoor gardens or spaces -use of local and natural materials

Figure 35. Case Study Summary

The case studies selected represent a number of successful and viable applications of biophilic nature-based features for inclusion in office workplace design. Key nature-based features include: locating in and near nature whenever possible (Selgas Cano, SC3, Pond Studios), maximizing the use of nature, encouraging movement in nature through creation of usable outdoor spaces (Google San Francisco), making nature unavoidable, incorporating natural scents and maximizing views to

nature and daylight (Pond Studios). When locating in nature is not possible, bring nature indoors in the form of plants and natural materials such as wood (Google Tel Aviv and Path). In addition place-based design (Google Moscow and CMHR) and evolved-human nature relationships (CMHR) are illustrated in the case studies.

4 Strategies for Change

Workplace stress is a serious health issue resulting in significant losses in workplace productivity. As we have seen in the previous chapters, research suggests nature-based features, by mitigating the stress response, help improve health and well-being in knowledge workers. Current literature suggests nature-based features that provide indirect and direct contact with nature are likely to provide the most psychological and physiological benefit to workers. There are several examples of how biophilic features have been successfully implemented into workplaces in Canada and around the world. Why are nature-based features and biophilic strategies not used in every workplace design project? The following chapter discusses the barriers and provides strategies for maximizing the use of nature-based features in workplace design.

4.1 Why is biophilic design and nature-based features not more commonly implemented?

The case studies in Chapter 3 provide leading edge examples of biophilic design, but unfortunately, despite innovation in specific projects, biophilic design practices are not always considered when designing office workplaces. Interactions with direct and indirect nature by most office workers are generally very limited. Based on Association of Registered Interior Designers of Ontario (ARIDO) 2013 and 2014 award winning projects and Canadian Interiors (Totzke, 2014) 15 of 16 corporate office projects included some form of wood. However, only one project included plants, only two projects included views featuring outdoor space, and only one project included access to outdoor “play” space, although surprisingly with absolutely no vegetation. (Note:

Seventeen projects were reviewed; one office was duplicated in two categories and thus only counted once.)

The award winning projects are an indication of approaches and materials utilized on the best projects and provide some indication of how the design profession is or is not incorporating nature-based features.

4.1.1 Education and awareness

There is a lack of awareness of Kellert's biophilic principles and of the research that supports nature-based features and stress reduction. Designers cannot cite research they are not aware of. Designers also cannot provide sound arguments and propose innovative research based solutions without the knowledge base. The link between practitioners and academia is not as strong as it could be. Although the calibre of seminars at conferences continues to improve, the CEU (Continuing Education Units) provider requirements are for industry representatives and not for academic researchers. The industry representatives often have product affiliations, although the material presented must be generic in content (IDCEC, 2012). Seminars are more technical in nature and less research-based. In addition, academic research techniques are not typically taught outside of Master of Interior Design (MID) programs, of which Canada currently only has one. Even the term research has different meaning for many practitioners than for academics (Karpan, 2005).

The bid process, which often awards the contract to the lowest bid, can further restrict time and money available for the delivery of projects and for research. Research based design is not practiced in all design firms, especially smaller firms with limited time and funds for research. A US study found practicing interior designers were experiencing moderate to high levels of burnout and were second only to nurses in level

of exhaustion (Hill, Hegde, & Matthews, 2014). The lack of time and funds for research will be discussed in further detail in section 4.2.2.

4.1.2 Recent changes in North America to promote biophilia

Interior Designers of Canada (IDC) has just announced two initiatives to increase awareness and the use of research-based information through funding for InformedDesign and secondly the creation of a Canadian Research Collective to “promote the benefits and value of research, to identify research methods used in interior design” (IDC, 2015).

The restructuring of the Professional Development (PD) requirements to IDCEC (Interior Design Continuing Education Council) and the addition of the mandatory HSW (Health, Safety and Welfare) CEU's will strengthen the connection between research and practitioners; as well as focus on the health and wellness aspects of interior design, which clearly include biophilia and nature-based features, and thus more implementation in future projects. I would suggest the interior design profession consider making a portion of the CEU's research based and mandatory not just HSW based.

As of January 1, 2015, a four year bachelor's degree will be the minimum requirement for National Council of Interior Design Qualification (NCIDQ) examination and certification (ARIDO, Membership, 2015). In the past, a three year diploma was acceptable, with an additional year of work experience, for a total of six years combination of education and work experience. Increased awareness and continued growth of MID programs will further advance research in Interior Design.

4.1.3 Third party rating systems

Kellert's biophilic design principles provide a theoretical framework for the translation of biophilia to the built environment; however, the elements do not provide a framework for application. Existing third party green rating systems such as LEED (Leadership in Energy and Environmental Design) and LBC (Living Building Challenge) as well as the simplicity of the Malmo's Green Point system (Kruuse, 2011; Persson, 2005) offer some of the required framework for process (Appendix B).

Rating systems offer guidance and direction to designers, and increased awareness and uptake of sustainable design and biophilia for both designers and clients. Ratings systems provide a framework for application, education, and provide objectives that are measurable and marketable. LEED certified sustainable design projects have risen from one project in 2004 to a total to date in 2014 of 1,756. LEED has grown significantly over the past 10 years with a total over 5,000 projects registered or certified as of end of 2014 (CaGBC, 2014).

Although the Living Building Challenge (LBC) was introduced in 2006 by Cascadia Green Building Council, the first three projects were only certified in 2010. LBC is still not well known among clients and the design community, but it is gaining momentum with 12 projects certified as of April 2015 (ILFI, 2015). LBC consists of only 20 imperatives, which are similar to credits in LEED. One of the imperatives is biophilia and several other imperatives have biophilic design connections. LBC is beyond LEED Platinum and is a more stringent third party rating system. To date LBC has not been adapted as a mandatory rating system by government or corporate entities as LEED has, but I believe it will at some point in the future, as interest and the practice of sustainable design is becoming more mainstream. The increased growth and awareness of LBC will also increase awareness of biophilic design. The growth of all

third party rating systems also encourages expanded process of Integrated Design Process (IDP), POE, research based design, and promotes the awareness of nature and biophilic design. However, although third party rating systems are growing – not all projects are rated. One of the impediments to rating systems, research based design, the expanded process of IDP, POE and biophilic design is time and money. I refer collectively to research based design, IDP (starting early and expanded scope), including programing for personalization and preference, and following up with POE as *expanded process*.

Integrated Design Process (IDP) is an important process component of LEED and LBC, and a “door opener” for starting early with the entire team and advocating for the involvement of all stakeholders as opposed to working in silos, often referred to as the waterfall approach (McLennan, 2004).

Expanded process is not consistently happening on all projects because of time (Vischer, 2001), burnout (Hill, Hegde, & Matthews, 2014) and in addition in the case of POE, ego and professional pride (Vischer, 2001). Most practitioners do not have time or budget for POE (Vischer, 2001) and other forms of research (Hill et al., 2014). As discussed in Chapter 2, research based design started in healthcare and has gradually spread to other disciplines, partially assisted by LEED and LBC. However, research based design is not practiced in all design firms, especially smaller firms with limited time and funds for research. Many large architectural firms and projects have researchers on staff and a fee structure that allows for more elaborate programming, POE and other research. Smaller and mid-size firms often have more limited resources. POE is often not conducted by design firms at the completion of a project, a year after occupancy, and again in later years. Vischer (2001) discusses four types of POE: building-behaviour research, or the accumulation of knowledge; feeding into pre-design

programming; strategic space planning and capital asset management. Vischer (2001) states the most common barriers of POE are cost, defending professional territory, time, and skills. Sometimes the possibility of admitting “mistakes” has liability and ego complications (Vischer, 2001). POE is an important tool for practitioners, overlooked or just not “got around to” due to time constraints and more urgent project issues – usually on the next project.

4.2 Proposed Biophilic Workplace Design Strategies

The following section proposes eleven workplace design strategies to increase the use of nature and nature-based features for stress reduction and improved well-being in knowledge workers. The proposed strategies are divided into two parts: (1) design and (2) process. These strategies build on the theoretical work of Kellert and others that are supported by empirical evidence found in the literature review (Chapter 2) and realized in real-life design applications like the Case Studies shown in Chapter 3. It is important to note that the eight design and three process-based strategies recommended herein are representative of a much larger number of potential biophilic design features and processes. Budgetary, location, and other constraints will obviously, play a role in determining what approaches will be most appropriate for any particular project

4.2.1 Design strategies

4.2.1.1 Locate in or adjacent to nature

Whenever possible locate work environments in or adjacent to nature. Can the office environment be set in nature and/or have a view to nature (i.e., Pond Studio Case Study)? Actively look for office space and buildings with adjacencies to nature and increase vegetation on pathways and streetscapes to existing green spaces (SC3 Case Study). Create new green spaces (SC3). The owner or design team can lobby the city and the local Business Improvement Association for more greenery and green space such as Agritecture (n.d.) roof top farming and SC3.

4.2.1.2 Guidelines

Incorporate Kellert's biophilic design elements and strategies from third party rating systems such as LEED and LBC. Strategies to facilitate the important first step of locating workplaces in or near nature, such as expanded process, starting early, POE and IDP are covered under the strategies process section that follows.

4.2.1.3 Use nature and make access to nature as easy as possible

Use these green spaces; add appropriate outdoor furniture for ease of use (Google, California Case Study). Consider setting up a variety of furnishing scenarios in the exterior setting that requires minimizes relocation time and effort by users. Having to wheel a chair out the door is one more thing to do, and means you may require two trips if you wish a beverage and pushing a chair, opening doors and general maneuvering typically requires two hands. Consider automatic door openers and the same floor level between interior and exterior areas to maximize ease of access. Consider mimicking the "in" office collaboration and individual spaces provided, in the exterior space i.e. soft or lounge seating, meeting space, stand-up or perches, individual work areas, quiet and collaborative, work and social gatherings, after hours, beer and pizza on the deck.

Once in nature – maximize the use of this nature.**Make nature unavoidable**

One approach is to not simply encourage meetings in outdoor spaces or walks at breaks, but to intentionally design the facility to both encourage and mandate use of natural facilities. Instead of the enclosed link between building A and B, ensure a view to vegetated areas. Consider slightly under-providing meeting areas and lunch facilities so that workers have no choice but to get out of the office. However, slightly under-providing lunch facilities must be carefully considered to ensure workers do not simply work through lunch rather than getting outdoors. It may be good to rethink the common corporate policy of working equates to sitting at a desk or at least being present in the office. Educate and encourage the use of alternate facilities and areas (both indoor and outdoor). Encourage walking meetings. Meetings can be recorded using smart phone technology. Wi-Fi and 3G connections allow for easy access to reference material.

4.2.1.4 Movement in nature

Think beyond the normal scope of an interior design project, beyond the often typical four walls of the office environment. Ways to include nature in our daily activities could be biking or walking through a park instead of driving, or yoga in the park at lunch, gardens, edible or visual. Consider the importance of movement, walking meetings and providing individual and collaborative outdoor spaces.

4.2.1.5 Daylight and views

Design projects that incorporate nature, either directly or indirectly, need to carefully control and use the view to their advantage. Ensure no one has the right to block the view to nature, daylight, or fresh air of other occupants (ILFI, n.d.).

Incorporating operable windows for natural ventilation and moving enclosed offices off

exterior walls and into the interior of the building floor plate will provide knowledge workers some access to nature. Appropriate glazing will allow daylight penetration to interior and consider use of light shelves to maximize daylight penetration. The use of low (under 42 or 48”) partitions and overhead storage units, which block daylight and views, will also allow for increased access to natural light. If higher partitions must be used, run the partitions perpendicular to the exterior glazing to minimize obstruction of daylight penetration. Design that incorporates light color furnishings and finishes will also maximize light penetration.

4.2.1.6 Natural scents

Natural scents are a method of bringing nature indoors and can reduce stress, promote relaxation (lavender) and can improve brain functions such as memory (rosemary), creativity (cinnamon-vanilla), and alertness (peppermint) (Augustin, 2009). Refer to section 2.2.3. Consider designing spaces which allow individuals to personalize their scent based on the task, or possibly providing spaces identified with terminology or graphics to signal the scent or goal of the space. Designers may be missing an opportunity and could consider providing individual knowledge workers with the option of scents within their office environment and collaborative spaces to increase worker cognitive abilities and health and well-being.

The introduction of scents is not without issues. The recent movement toward scent-free public spaces (such as doctors’ offices and hospitals), allergies, and the variation in individual scent preferences all present challenges to the use of scents in an office environment. Natural scents are a way of bringing nature into the office environment. It may be possible to provide individuals with choices within their own spaces, the creation of zones and/or scent-free work and collaborative areas.

4.2.1.7 Wood

Research suggests the ideal proportion of wood, as an interior finish on walls and floors is between 30 to 45 percent of the combined surface area of a living space (Tsunetsugu, Miyazaki, & Sato, 2007). If lower stress levels and relaxation is desirable in the workspace, consider incorporating wood as a finish or furnishing material.

4.2.1.8 Plants

Offer users a selection or palette of plantings to choose from, developed by a horticulturalist. Refer to section 3.2. text box titled: Personalization for an example. Choice will allow personalization, place-based and cultural input as well as order and complexity, as discussed in Kellert's biophilic design principles. Based on research in Chapter 2 and the case studies such as Path and Google Tel Aviv, consider between one and five plants per workspace (Raanaas, et al., 2011; Shibata & Suzuki, 2004). Based on the research of van den Berg et al. (2003) and Kahn et al., (2008) allowing additional input by individual users, incorporating personalization and preferences are important considerations. Administering online surveys can efficiently allow for verification of the preferred planting types and quantities based on individual user preferences.

4.2.2 Process strategies

In order to successfully implement biophilic design features in workplace design, interior designers must also use a number of new and expanded design processes. Designers need to start the process earlier than a typical design project or they will lose critical opportunities to include biophilic elements. The knowledgeable interior designer

has greater influence in these important early stages than most realize. Biophilic design potentially impacts all levels of a design and life-cycle of a particular project. Design team decision-making requires the collaborative input from a wide variety of perspectives. Therefore, the Integrated Design Process (IDP), which is a process that requires the participation of all consultants and stakeholders at the “project table” from the onset of the project, is particularly effective. The following sub-sections look at IDP and a number of other key processes that could be used to support the biophilic design of workplaces.

As defined in section 4.1.3, I refer collectively to research based design, IDP (starting early and expanded scope), including programming for personalization and preference, and following up with POE as *expanded process*.

4.2.2.1 Expanded Process – IDP

The **Integrated Design Process** (IDP) of LEED and LBC can be used as a starting point. Ideally, designers want to be involved early, before a site is selected. The Sustainable Site credits of LEED and LBC can be used to start a discussion but the discussion must move further to incorporate the current research on nature-based features and stress reduction and knowledge workers. Knowledge and evidence-based research are important. Cite the latest literature on important nature-based features and stress reduction. Provide a synopsis or link to the research. Circulate the information to other team members. Not all design team members are at the same level of interest, passion, and knowledge. Determine where the project team is at and what motivates and interests them (Carnegie, 1982). Based on scope of project discuss the possible importance and feasibility of engaging a landscape architect or horticultural consultant in the project.

Use the IDP process of LEED and LBC to maximize adjacency to nature and to include nature-based features in the project. As stated in Chapter 2, time in nature, a view to nature, a walk or drive to work, all can contribute to the well-being and stress reduction (Berman et al., 2008; Cackowski & Nasar, 2003; Hedge, 2012; Kellert, 2008; Tsunetsugu et al., 2010).

Start early

Start before the client is even aware of the need.

One of my memorable moments was competing for, and being awarded a contract for a deep green consulting firm's head office in 2010. Four design firms had been chosen to present to the potential clients management team. The client wanted to pursue LEED accreditation. I suggested LBC and carefully explained the limitations involved: that I had not done an LBC project before; no LBC projects had actually been certified to date, but three were registered; that I could obviously not guarantee we could achieve even petal certification but I would really like to try and that this goal fit well with their corporate goals. Being explicitly direct and honest about goals and limitations is imperative to maintaining excellent client relationships. I was passionate about this project and passion is imperative. If you are not passionate about this, your chances of success are diminished substantially.

4.2.2.2 Expanded Process - Programming and POE

Programming interviews are method of gathering information from the end users of the project. Programming, in design terms, is used to describe the specific requirements necessary to be included in the project. Programming interviews is one way of gathering this information and are usually completed with every project; just the degree varies. Although, not every project can include a complete survey and interviews. Online surveys using nature-based images can be a cost effective programming tool for designers to gather and verify preference and thus personalization,

which can reduce stress (van den Berg et al., 2003) and increase a sense of place-based design (Kellert, 2008). Incorporating an online survey process also allows for personalization of the design solution and a more successful buy-in by users and management. This is especially important for projects with committee approval process. If, when presenting a design solution, the design team can not only cite relevant research but also individualized corporate preferences as a basis for the design solutions - the approval process and the final project are typically more successful. I suggest a palette of specific nature-based features with cultural, geographical, individual, and corporate goals be determined through a combination of town hall meetings, interviews with management, survey, past project and design experience.

Verify this possible palette with the users through any combination of the above methods suitable to the project scale and complexity, budget and timeframe. As an example: one possible nature based feature - plant selection. If a final interior palette in a small office may consist of five to ten different types of plants. Select the initial plants based on research, horticultural consultant, light levels, building, site location and aesthetics. Then use online survey to allow users to be a part of the process and individualize their common and personal spaces. Personalization may sound time consuming but it can be efficiently completed as noted in the text box below and in text box in Section 3.2 titled Personalization – example of paint with potential application to plants.

An example of programming interviews, research and survey

Based on Heerwagen's (2006) research on the benefits of daylight and on (Kahn et al., 2008) views, all enclosed offices are located on the interior with floor to ceiling glazing panels on a minimum of one wall. A variety of workstation modules have been developed based on online surveys with all of your users and focus interviews with 75 percent of your users. Do the interview process, LISTEN and incorporate input. Have a reason for everything you suggest. You will not be able to provide everything for everyone, but you can explain why you have done what you have. You must carefully manage expectations throughout the entire process. During the interview process, you may ask questions, prefaced by "in a perfect world" and "if there were no budget constraints". These statements allow users to think outside the box, to think big, to brainstorm, but to also manage expectations from the start. The user expectations can be further managed in the presentation by referring, in a positive manner, to what you have been able to include and also ensure to address requested items that are not included and why. Users are realistic and understand that not everything can be incorporated, but it is important that users can trust that all information was received and if not included, why the item was not included - must be addressed.

Post-occupancy Evaluation (POE)

Post occupancy evaluation (POE) is the evaluation of the project after the user occupancy to determine successes and areas for improvement. POE can be done at any time after occupancy; the most typical is one year after occupancy. Conducting POE a few months after occupancy, repeating in a year, and a third review in several years can also be beneficial but is not common practice. POE is often not conducted by design firms, yet POE is an important tool for practitioners.

Some fundamental POE is required for LEED credits and for LBC. As evidence-based design increases, so will the frequency of POE by practitioners. However, incorporating nature-based features into the programming phase as well as POE are important strategies allowing personalization, place-based design, evaluating nature-based features and increasing the use of research in design projects.

Designer's, design associations, and insurance companies need to work hard to try and change some of the road blocks to POE that would improve the design solutions we provide our clients. LBC encourages a sharing of information, allowing professionals to reach sustainable design goals more quickly versus the tendency of design firms to clutch information and consider it proprietary intellectual property. If designers as a profession are willing to share successes and failures the profession and our clients will benefit, our design solutions will be research based.

4.2.2.3 Advocacy and Education

Advocacy and education are inspired by LBC and LEED where advocacy for change and mandating the use of the project as a sustainability educational tool. Designers must develop an in-house education program for biophilic elements and continue to update and add new components i.e., start with Kellert's biophilic design elements incorporated into the project, and add bird identification or biomimicry components. *Natural History* by Runtz (2012) is very accessible source for education of users. Designers must be advocates for the inclusion of nature-based features and biophilia to reduce stress and improve well-being of knowledge workers. LBC provides sample letter templates for project teams to issue to trade associations advocating for the development of standards for industries without third party certification. This advocacy concept is critical to change and can be used to incorporate biophilic design into city planning, parks, gardens and workplace design.

4.2.3 Design and process strategy summary

The research and case studies suggests the ideal biophilic office work environment considers: Kellert's biophilic design principles, locates in or near nature, maximizing daylight and views to nature, incorporates natural scents, encouraging movement in natural settings, including natural materials such as wood and plants when direct nature is not possible, and considers individual preference or personalization and place-based design.

Process is one of the reasons nature-based features and biophilia are not included in more projects. The adoption of expanded process which includes IDP, programming interviews, research based design and personalization, following up with POE, and advocacy and education are important processes to assist with the application of biophilic design. Based on the research cited, the ideal nature-based work environment should consider the proposed design and process strategies summarized in Figure 36.

	Design Strategy	Theorist/Research	Case Study
1.	Provide access to nature , (in or near nature)	Berman; Kaplan;	Selgas Cano, Pond Studio, SC3, Google – San Francisco (SF)
1.a	Incorporate guidelines : biophilic elements, survival-advantage characteristics, (LEED and LBC to facilitate locating in or near nature through IDP also included in Process Strategies 4.2.2)	Kellert; Hildebrand	All - but especially CMHR
1.b	Use nature – make access easy or unavoidable	Nisbet & Zelenski	SC3, Google
	Design to encourage movement (ideally in nature) i.e., walking and outdoor meeting areas, consider stair location and software to remind workers to move	Hedge; Lee et al.; Lang	SC3, Google – SF, London
1.c	Maximize daylight and views to nature . Use low screens, light finishes, and operable windows	Heerwagen; Heschong	Pond Studios, CMHR
1.d	Incorporate natural scents	Li et al.; Jo & Rodiek; Tsunetsugu et al.; Sense of Smell Institute of Chicago	SC3
2	Include natural materials such as:		
2.a	Wood – 30 to 45% of the floor wall and ceiling area	Tsunetsugu, Miyazaki & Sato; Nyrud et al.; Sakuragawa et al.	Pond Studios, Google - Tel Aviv
2.b	Plants – one to five plants within sight of worker. Consider personalization and place-based selections.	Raanaas et al., Shibata & Suzuki; van den Berg et al., & Kahn et al.	Google - Tel Aviv, Path
3	Consider individual preference or personalization and place-based design	Kellert; van den Berg et al., & Kahn et al.	Google, CMHR
	Process Strategy	Theorist/Research	Guideline or Rating System
1	Adopt and promote expanded process	I refer collectively refer to research based design, IDP (starting early and expanded scope), including programming for personalization and preference, and following up with POE as expanded process.	LEED, LBC, Malmo green points system
1.a	Use IDP (Integrated Design Process) – starting early to promote locating in and time in nature	Kellert; Kaplan; Berman; Berman et al.; McLennan	LEED, LBC, Malmo green points system
1.b	Use POE (post-occupancy evaluation) and programming interviews to promote personalization, research based design to further research in nature-based features	van den Berg et al.; Kellert; Vischer; Hill, Hegde & Matthews	LEED, LBC
2	Include education and advocacy to increase inclusion of nature and nature-based features	Kellert; Kaplan; Berman et al.	LEED; LBC (advocacy)

Figure 36. Design and process strategies summary

5 Conclusion

Stress has been a natural part of human response to dangerous or threatening situations, but the human biological response has not appropriately adapted to sources of stress in today's work environments. Office workers, are now working longer hours than workers did during the industrial revolution, are being exposed to increasing levels of stress stimuli. Stress causes a loss of memory and productivity. Chronic long term stress can cause more severe health and mental health issues.

Initial research suggested that nature-based, or biophilic design features might help to mitigate environmental stress stimuli and provide restorative attention rest periods . Therefore, this thesis research set out to address the following research questions: (1) What nature-based features can interior designers incorporate into workplace design to help reduce stress and improve health and well-being of office knowledge workers? (2) How can such nature-based features be implemented in design practice?

The literature research revealed that nature and nature-based features potentially have a very significant impact on human health and well-being. It was also revealed that direct and indirect exposure to nature has the greatest impact over symbolic nature experiences. The implication of this finding is that designers should strive to locate workspaces in, or adjacent to, nature, maximize the use of nature through paths and movement, optimize the provision of daylight and views and consider place-based design and evolved-human nature elements. Where direct contact is not possible, exposure to indirect nature, such as wood and potted plants, can also be

effective. The case studies show how the theory can be applied in practice in a viable manner.

Despite the identified benefits of biophilic workplace design, a number of barriers were identified including: the lack of knowledge, evidence-based design and the current limited scope of interior design practice. It is suggested that interior designers will therefore, need to take a more proactive approach and advocate for more direct and indirect nature-based features in and surrounding the workspaces of knowledge workers. Beyond design strategies, process is also important. IDP (Integrated Design Process) is a process that involves more consultants, earlier in the design process and therefore provides an opportunity to ensure all aspects of the design including landscape, orientation, form, and interior, all support biophilic design.

Knowledge-generation and the inclusion of stakeholders through preference-based programming and POE (Post Occupancy Evaluation) are also important. These knowledge-generation tools will not only assist with efficient approval and decision-making processes with clients, but increase client satisfaction, increase the professional body of knowledge and further the development of EBD (Evidence-Based Design) within the interior design profession.

Additional research is required to determine the precise difference in the amount stress is reduced with exposure to different nature-based features i.e., indirect versus direct nature. Is there a cumulative factor to stress reduction by combining several biophilic elements, both indirect and direct i.e., wood plus other nature based features such as plants? Additional research is also required on wood finishes and stress reduction, especially in an office setting.

Interior Designers have more influence on the health and well-being of building occupants than we, or others, believe. Through research and advocacy at all levels of the design process, the greater use of nature-based features will serve to improve and health, well-being, and stress reduction in office workers into the future.

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Appendix A Research Summary

Research Summary				
	Theorist	Theory	Summary	Limitations or arguments against
Stress	Posen	Stress in workplace	Stress in the workplace is detrimental to our health and productivity.	
	Hill		Evolutionary reaction to stress no longer appropriate.	
	Duxbury	Work life balance	Require balance – current work expectations with advances in technology are not balanced.	
	Flynn	Flynn Effect	IQ falling due to connectivity – contrary to past where IQ increased every decade.	
	Hedge	Office workers need to move	Office workers should be moving every hour to avoid blood pooling in legs.	
Historical	E.O. Wilson; Tooby & Cosmides	Sociobiology Evolutionary Psychology/Biology	-Affinity with nature is embedded -Our behaviour and biological systems developed for life in nature (not cities).	
	Selhub, & Logan; Marcus & Sachs; Marcus & Barnes		-EBD and healthcare design re-introducing nature based features to other areas of design.	
Biophilia & Biophilic Design	Kellert	Biophilic Principles	Direct and Indirect Experience, Place-based	
	Hildebrand	Survival-advantage characteristics	Enticement, peril, prospect and refuge, complexity and order.	
	Kaplan	Attention Restoration Theory (ART)	Soft focus as in nature required for restoration	
	Ulrich	View and Health	Decreased use of drugs and improved healing times when views to nature	
	Mahone et al.	Views and cognitive benefits	Views to nature have cognitive benefits (p 23)	
	Berman	Forest bathing	Benefits of forest bathing and stress reduction	
	Kahn et al.	Views of hardcopy or screens	Nature views of hardcopy images and plasma screen may produce cognitive benefits	
	Lottrup et al.		High satisfaction with view to outdoor window with natural elements is related to higher job satisfaction. View satisfaction is also related to job satisfaction and work ability.	
	Movement through nature: Cackowski & Nasar	Simulate nature view during commute	Higher tolerance for frustration	

	Theorist	Theory	Summary	Limitations or arguments against
	<p>Nisbet & Zelenski</p> <p>Nisbet et al. Mayer et al.</p>	<p>Nature- relatedness, nature connectedness</p>	<p>Connection to nature or “nature relatedness” and happiness. Suggests make nature unavoidable as people are unable to predict the importance of nature and positive benefits and thus unlikely to seek nature out More interaction and connection with nature the greater the sustainable activities and behaviours</p>	
	<p>Louv</p> <p>Raleigh</p>	<p>Nature deficit disorder</p>	<p>Growing evidence lack of time in nature is linked to rising rates of depression, attention deficit disorder and other health conditions Possible link between increased exposure to nature as a child and increased restorative effects later in life</p>	
	<p>Tsunetsugu, Park & Miyazaki</p> <p>Li; Duffy; Manikandan, Jo and Rodiek; Finkel Sense of Smell Institute of Chicago</p>	<p>Forest-bathing / Scents</p> <p>Scents</p>	<p>Tsunetsugu, Park & Miyazaki– spending time in forests either walking or contemplating improves mood, functioning of the immune system and production of anti-cancer ‘natural-killer’ cells. (p 19 draft 13) Li – aerosolized scents of nature</p>	<p>Morita, Naito, Hishida, Wakai, Mori, Asai, Okada, et. al Found no association between forest walking and reduction in blood pressure levels. (p 26)</p>
	<p>Tsunetsugu, Miyazaki, & Sato</p>	<p>Natural Materials</p>	<p>Ideal proportion of wood for stress reduction in residential setting.</p>	
	<p>Raanaas et al.</p>	<p>Interior Landscapes/Plants</p>	<p>Memory recall and complex proofreading skills improved when offices contained four plants.</p>	
	<p>Shibata & Suzuki</p>		<p>Improved mood and performance on creativity tasks in space with one large corn plant.</p>	
	<p>Berman, Jonides & Kaplan</p>	<p>Gardens and Nature</p>	<p>Cognitive benefits of interacting with nature</p>	
	<p>Nisbet & Zelenski;</p>		<p>Underestimating nature and forecasting errors</p>	
	<p>Tsunetsugu, Park, & Miyazaki</p>		<p>“Shinrin-yoku” Forest bathing</p>	

	Theorist	Theory	Summary	Limitations or arguments against
	van den Berg et al.	Preferences	User preference selection can lead to stress reduction	Limitation: Possible cueing dissatisfaction in on-line surveys. Asking participants about ideals and preferences could trigger negative mood or frustration that participants do not have these items and thus cueing participants to be dissatisfied.
	Kahn et al.	Hardcopy or plasma screen images	Nature views using hardcopy images or plasma screen may produce cognitive benefits.	
Third party rating systems	CaGBC	LEED	3 rd party green rating system – suggests views and IDP.	Does not go far enough – view not specified.
	McLennan	LBC	3 rd party green rating system – mandates views, biophilia, IDP and advocacy.	Does not go far enough.
	Beatley Persson	Malmo Green Points system	Simplistic guidelines developed for project in Sweden	

Appendix B Malmo’s Green Points system

Malmo’s Green Points system. Developers or designers building in the Western Harbor chose a minimum of 10 of the above 35 green measures

Malmo’s Green Points system.	
1. A nesting box for every dwelling unit.	19. In the courtyard or adjoin apartment buildings, at least 5 m2 of orangery and greenhouse space per dwelling unit.
2. One biotope for specified insects (plant biotopes) excluded per 100 m2	20. Bird food in the courtyard all the year round.
3. Bat boxes inside the plot boundary	21. At least 2 different traditional cultivated fruit and soft fruit varieties per 100 m2 courtyard space.
4. No hard standing in courtyards-all surfaces permeable to water.	22. House fronts to have swallow shelves.
5. All non-hard surfaces in the courtyard, to have soil deep enough and good enough for vegetable growing.	23. The whole courtyard to be used for growing vegetables, fruit and soft fruit.
6. The courtyard includes a traditional cottage garden, complete with all its constituent parts.	24. The developer/landscape architect to cooperate with ecological expertise and to shape the overall idea and the detailed solutions together with the associate. First the choice of associate has to be approved by Bo)1/the City of Malmo before it can be counted as a green point
7. Walls covered with climbing plants whenever possible/suitable.	25. Grey water to be purified in the courtyard and reused.
8. 1 m2 pond for every 5 m2 hard standing in the courtyard.	26. All biodegradable domestic and garden waste to be composted and the entire compost output to be used within the property, in the courtyard or in balcony boxes and suchlike.
9. Courtyard vegetation specially selected to be nectar-yielding and to serve as a butterfly take-away.	27. All building material used in constructing the courtyard-surfacing, timber, masonry furniture, equipment, etc., - must have been used before.
10. Not more than 5 plants of one and the same species among the courtyard.	28. At least half the courtyard to have a certain color as the theme for its plants, equipment, and material.
11. All courtyard biotopes designed to be fresh and moist.	29. At least half the courtyard to be water.
12. All garden biotopes designed to be dry and lean.	30. The courtyard to have a certain color as the theme for its plants, equipment, and material.
13. The whole courtyard made up of biotopes modeled on the biotopes occurring naturally.	31. All trees in the courtyard to be fruit trees, and all bushes to be fruit bushes.
14. All storm water captured to run above ground for at least 10 m before being led off.	32. The courtyard to have topiary plants as its theme.
15. Green courtyard, but no lawn.	33. Part of the courtyard to be allowed to run wild.
16. All rainwater from buildings and courtyard paving to be collected and used for watering vegetation or for laundry, rinsing etc., inside the buildings.	34. At least 50 wild Swedish flowering plants in the courtyard.
17. All plants suitable for domestic use, one way or another.	35. All roofs on the property to be green, i.e. vegetation-clad.
18. Batrachian biotopes in the courtyard, with hibernation possibilities.	

Malmo’s Green Points system. Developers or designers building in the Western Harbor chose a minimum of 10 of the above 35 green measures (Beatley, 2008, p.290; adapted from and used with permission Kruuse, 2014; Kruuse, 2011, p.6; Persson, 2005, p.51).