

The Financial Benefits of Biophilic Design in the Workplace: A Review and Summary of Current Research

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MIST

Introduction: Towards Designing with Nature

During a recent presentation, Bill Browning, a founding partner of the environmental design consultancy firm Terrapin Bright Green, LLC, asked everyone in the audience to imagine their favorite place to go when they wanted to de-stress and relax (Isle, 2014). He then asked everyone to raise their hands if the place they had pictured was located outdoors. Nearly every person in the room raised their hand. This simple exercise revealed both the inherent connection humans feel towards nature and the disconnection from nature that has been created within the modern built environment.

The movement towards sustainable design and construction practices has largely led to standardized methods of lowering energy consumption and using resources and building materials more efficiently. Building and business owners have benefited from these practices as ways to cut costs and boost their bottom lines. In recent years, however, there has been a growing belief that focusing solely on low-environmental-impact building designs ignores a fundamental factor necessary for long-term sustainability and future financial growth: people. The overwhelming majority of business costs are spent on staffing and human resource needs. Therefore, investing in the human side of business has great potential for recovering lost productivity and increasing profits while fostering sustainability.

Heightening the importance of investing in the people of businesses and institutions has led to a resurgence of the theory of *biophilia* and, more recently, *biophilic design*. These concepts give a name to the feelings evoked by the thought exercise described above. Psychologists and biologists have posited that not only are human beings innately drawn to natural settings and elements but that having contact with nature (whether it be direct, indirect, or symbolic) within the built environment results in increased productivity, health, and overall well-being.

The following report synthesizes a great extent of the research available through 2015 on biophilia and biophilic design, especially as it relates to observed effects on employees in the

workplace. The intent is to provide an additional layer of information that may inform strategic decision-makers and help to identify new priorities related to design, human resources, and financial allocations. After defining the terms, the significance and implications of biophilic design in the workplace will be discussed in depth, and several studies of its effects on employees and businesses will be presented.

Biophilia

A term first coined by social psychologist Erich Fromm in 1964 and later put into use by biologist E.O. Wilson in 1984, biophilia is defined from the Greek root meaning love of nature (Browning et al., 2012). At its base, the concept of biophilia is straightforward and explains that humans are innately drawn to associate with natural systems and processes. This is a direct result of how humans evolved. In fact, as Kellert, Heerwagen, and Mador (2008) write, the tendency for humans' desire to affiliate with nature is "biologically encoded because it proved instrumental in enhancing human physical, emotional, and intellectual fitness....People's dependence on contact with nature reflects the reality of having evolved in a largely natural, not artificial or constructed, world" (p. 3).

As shown in the simple timeline of human evolutionary history below, it is only within the last few thousand years that humans have begun to separate ourselves from our natural surroundings. In fact, for 99% of our species' history, humans' biological development has resulted as adaptive responses to natural environments which included features such as light, sound, color, wind, water, vegetation, and landscapes (Kellert & Calabrese, 2015). It is only within the last few decades that people have started to inquire as to how our detachment from the outdoors and natural environments has affected humans physically and mentally. Indeed, given that the time we have occupied the built environment accounts for only 1% of all human

history, there cannot be a great level of certainty about how this change has and will continue to biologically affect us.

The Evolutionary History of Human Beings

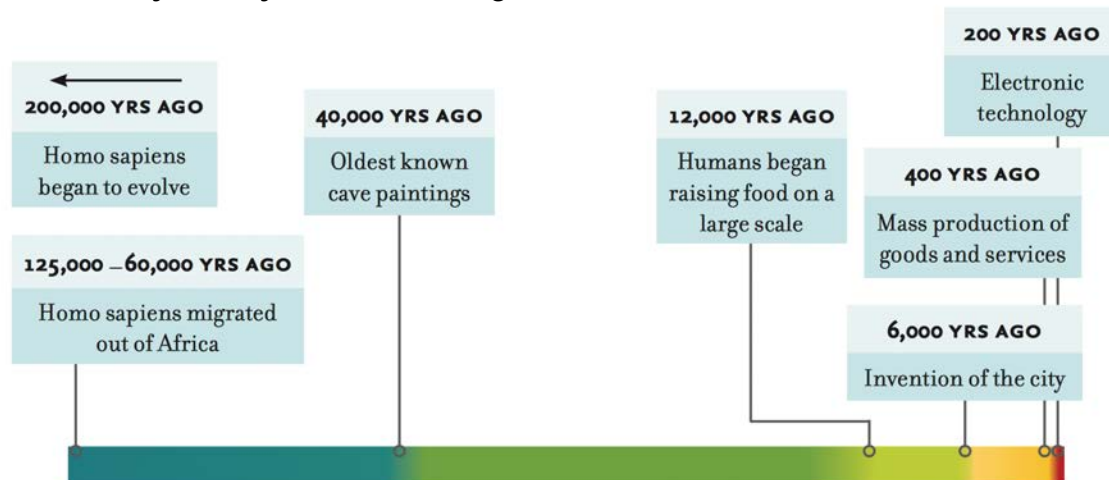


Figure 1- Kellert & Calabrese, 2015

Physiological Effects of Biophilia

While the modern built environment has largely separated humans from the natural elements in which we evolved, there is a growing body of research pointing to the benefits of returning to the basic tenets of biophilia as a means to increase health and productivity. Indeed, there have been measured physiological and neurological effects of nature on the human body and the brain. For example, neuroscientists have studied the effects of different types of scenery on the visual cortex in the brain. When subjects shown views of complex, dynamic, natural scenes, interactions of the mu (opioid) receptors processed in the rear portion of the visual cortex increased significantly which indicated a more pleasurable experience (Browning et al., 2012). Conversely, participants processed less dynamic images such as that of a treeless street or a blank wall in the front portion of the visual cortex and triggered far less mu receptor

interactions. Thus, these plain, artificial scenes were much less pleasurable to view than the natural views.

Scientists observed more physiological changes in the human body when immersed in natural versus artificial settings. A Japanese study on the practice of “forest bathing” compared subjects in multiple field experiments as they walked through both forests and urban landscapes. In the forest setting, individuals’ pulse rates decreased by 3.9-6.0%, systolic blood pressure levels were lowered, and salivary cortisol (a hormone released during periods of stress) decreased by 13.4-15.8%. Not only were isolated aspects of human physiology affected by being close to nature, but major bodily systems demonstrated significant improvement in the forest scape. Parasympathetic system activity, which serves to relax the body, increased by 56.1% in study participants while in the natural environment. Sympathetic system activity which stimulates the body when we feel stressed decreased by 19.4% while walking through the forest. (Park, Tsunetsugu, Kasetani, Kagawa, & Miyazaki, 2010)

There have also been recent studies demonstrating that cognitive functions can be improved and restored through contact with nature which helps build the case for linking biophilia to increased productivity in the workplace. Environmental psychologists Rachel and Stephen Kaplan developed the “Attention Restoration Theory (ART)” which posits that perceived or direct contact with nature can improve people's abilities to recover and refocus their mental capacities after working intensely for a period of time. In the Kaplans’ study, individuals were shown images of either natural or urban landscapes after just having completing a mentally demanding task. After several minutes of viewing these images, those subjects who viewed images of nature were found to have faster reaction times, more correct responses, and better overall memory recall than those who viewed images of urban settings. Further evidence to support this study was demonstrated when measurements were taken using an “Eye Position Detector System.” Using this tool it was discovered that when viewing

images of nature as opposed to urban scenes, the eye made far fewer fixations. Researchers suggest that fewer eye fixations equate to fewer blocked pathways to the brain. Therefore, the brain is required to do less work in order to process the images of nature. Taken together, these studies showing that nature and natural images can reduce strain on the brain and could help employees function more quickly and efficiently makes the theory of biophilic design a worthwhile topic of discussion for employers and building owners. (Nature-Based Design: The New Green, 2013)

The human body has also demonstrated positive responses to isolated aspects of biophilia such as daylight. For example, the balance of our circadian rhythm has been partially linked to the changing color of daylight (yellow light in the morning, more blue tones in mid-day, and turning to reddish hues in the afternoon). Exposure to this natural color and light pattern helps to control the equilibrium of our daily cycle of hormonal activity including serotonin, the hormone associated with mood, and melatonin, which regulates sleep (Browning et al., 2012). A study performed in 2013 sought to determine if the amount of natural daylight in the workplace affected employees sleep patterns. Groups of workers were assigned to either windowless work spaces or offices that had windows. It was found that those working in offices with windows were exposed to 173% more natural daylight and slept an average of 47 minutes more per night than their counterparts without windows (Cheung et al., 2013). Sleep can have a significant effect on a person's day-to-day and long-term productivity and well-being. From improving the amount and quality of sleep to reducing stress and heart rate to increasing brain functionality, biophilia has proven physiological benefits which are particularly valuable when considered in the context of employee health and productivity.

Biophilic Design

The biophilia hypothesis taken together with the positive physiological effects on the human body and brain observed during contact with nature have led many to suggest that biophilia could actually be used and applied to different sectors of the built environment and human life in order to improve health, well-being, and productivity. The application of connecting humans to nature within the manmade world has been termed biophilic design.

While this paper's intent is not to detail the many methods for incorporating biophilic design elements into buildings, a brief overview of its main categories may aid in further understanding the concept and its implications for use in the workplace. Many researchers have divided the multiple patterns of biophilic design into three main categories as shown in Table 2 taken from Terrapin Bright Green's *14 Patterns of Biophilic Design* (Browning et al., 2014). First, *nature in the space* or direct experience with nature entails both bringing nature indoors (i.e. water features, plants, courtyards, dynamic light, variable/natural ventilation etc.) and providing occupants the means to connect with the outdoors from within, typically via views through glass or fresh air from operable windows or doors. The second category includes *natural analogues* or the indirect experience with nature. This entails the use of natural materials and structural forms or artwork and patterns which represent or echo those found in nature. These natural analogues can elicit the same positive physiological

Nature in the Space



Figure 2 - Clark and Chatto, 2015

Natural Analogs



Figure 3

responses as direct contact with nature. Finally, the way in which spaces are configured can also evoke certain responses in people as a result of having developed biologically in certain types of landscapes. As research suggests, due to the fact that the human species evolved in savanna environments (open landscapes dotted with tree clusters), surroundings that provide people with both a “prospect,” the means to have wide views to many settings, and a “refuge,” areas that appeal as safe and secure, are ideal. (Browning et al., 2014)

Nature of the Space



Figure 4

Categories of Biophilic Design and Observed Physiological Effects

14 PATTERNS	•	STRESS REDUCTION	COGNITIVE PERFORMANCE	EMOTION, MOOD & PREFERENCE
NATURE IN THE SPACE	Visual Connection with Nature	<ul style="list-style-type: none">• Lowered blood pressure and heart rate (Brown, Barton & Gladwell, 2013; van den Berg, Hartig, & Staats, 2007; Tsunetsugu & Miyazaki, 2005)	Improved mental engagement/ attentiveness (Biederman & Vessel, 2006)	Positively impacted attitude and overall happiness (Barton & Pretty, 2010)
	Non-Visual Connection with Nature	<ul style="list-style-type: none">• Reduced systolic blood pressure and stress hormones (Park, Tsunetsugu, Kasetani et al., 2009; Hartig, Evans, Jammer et al., 2003; Orsega-Smith, Mowen, Payne et al., 2004; Ulrich, Simons, Losito et al., 1991)	Positively impacted cognitive performance (Mehta, Zhu & Cheema, 2012; Ljungberg, Neely, & Lundström, 2004)	Perceived improvements in mental health and tranquility (Li, Kobayashi, Inagaki et al., 2012; Jahncke, et al., 2011; Tsunetsugu, Park, & Miyazaki, 2010; Kim, Ren, & Fielding, 2007; Stigsdotter & Grahn, 2003)
	Non-Rhythmic Sensory Stimuli	<ul style="list-style-type: none">• Positively impacted heart rate, systolic blood pressure and sympathetic nervous system activity (Li, 2009; Park et al., 2008; Kahn et al., 2008; Beauchamp, et al., 2003; Ulrich et al., 1991)	Observed and quantified behavioral measures of attention and exploration (Windhager et al., 2011)	
	Thermal & Airflow Variability	<ul style="list-style-type: none">• Positively impacted comfort, well-being and productivity (Heerwagen, 2006; Tham & Willem, 2005; Wigö, 2005)	Positively impacted concentration (Hartig et al., 2003; Hartig et al., 1991; R. Kaplan & Kaplan, 1989)	Improved perception of temporal and spatial pleasure (alliesthesia) (Parkinson, de Dear & Candido, 2012; Zhang, Arens, Huizenga & Han, 2010; Arens, Zhang & Huizenga, 2006; Zhang, 2003; de Dear & Brager, 2002; Heschong, 1979)
	Presence of Water	<ul style="list-style-type: none">• Reduced stress, increased feelings of tranquility, lower heart rate and blood pressure (Alvarsson, Wiens, & Nilsson, 2010; Pheasant, Fisher, Watts et al., 2010; Biederman & Vessel, 2006)	Improved concentration and memory restoration (Alvarsson et al., 2010; Biederman & Vessel, 2006) Enhanced perception and psychological responsiveness (Alvarsson et al., 2010; Hunter et al., 2010)	Observed preferences and positive emotional responses (Windhager, 2011; Barton & Pretty, 2010; White, Smith, Humphries et al., 2010; Karmanov & Hamel, 2008; Biederman & Vessel, 2006; Heerwagen & Orians, 1993; Ruso & Atzwanger, 2003; Ulrich, 1983)
	Dynamic & Diffuse Light	<ul style="list-style-type: none">• Positively impacted circadian system functioning (Figueiro, Bruns, Pittnick et al., 2011; Beckett & Roden, 2009)• Increased visual comfort (Elyezadi, 2012; Kim & Kim, 2007)		
	Connection with Natural Systems			Enhanced positive health responses; Shifted perception of environment (Kellert et al., 2008)
NATURAL ANALOGUES	Biomorphic Forms & Patterns	•		Observed view preference (Vessel, 2012; Joye, 2007)
	Material Connection with Nature		Decreased diastolic blood pressure (Tsunetsugu, Miyazaki & Sato, 2007) Improved creative performance (Lichtenfeld et al., 2012)	Improved comfort (Tsunetsugu, Miyazaki & Sato 2007)
	Complexity & Order	<ul style="list-style-type: none">• Positively impacted perceptual and physiological stress responses (Salingaros, 2012; Joye, 2007; Taylor, 2006; S. Kaplan, 1988)		Observed view preference (Salingaros, 2012; Hagerhall, Laike, Taylor et al., 2008; Hagerhall, Purcella, & Taylor, 2004; Taylor, 2006)
NATURE OF THE SPACE	Prospect	<ul style="list-style-type: none">• Reduced stress (Grahn & Stigsdotter, 2010)••	Reduced boredom, irritation, fatigue (Clearwater & Coss, 1991)	Improved comfort and perceived safety (Herzog & Bryce, 2007; Wang & Taylor, 2006; Petherick, 2000)
	Refuge	<ul style="list-style-type: none">•••	Improved concentration, attention and perception of safety (Grahn & Stigsdotter, 2010; Wang & Taylor, 2006; Petherick, 2000; Ulrich et al., 1993)	
	Mystery	<ul style="list-style-type: none">••		Induced strong pleasure response (Biederman, 2011; Salimpoor, Benovoy, Larcher et al., 2011; Ikemi, 2005; Blood & Zatorre, 2001)
	Risk/Peril	•		Resulted in strong dopamine or pleasure responses (Kohno et al., 2013; Wang & Tsien, 2011; Zaid et al., 2008)

© 2014 Terrapin Bright Green / 14 Patterns of Biophilic Design

Table 1 - Browning et al., 2014

Biophilic Design in the Workplace: Implications for the Bottom Line

Review of current case studies and the potential benefits for real world application in the workplace can inform future decisions regarding facilities at the University of Chicago. It should be noted that there have been numerous studies conducted which have shown that windows and views of nature in hospital rooms have led to decreased patient recovery times and

medication needs which in turn have cut down on costs for hospitals and have allowed for a greater number of patients to be served (Clark and Chatto, 2014). Only recently, however, have researchers begun to study how biophilia might be applied to the workplace and what benefits may be realized by incorporating biophilic design elements into office settings.

It has quickly been discovered that there is a real and potentially very significant business case to be made for incorporating biophilic design into office spaces. While average businesses spend nine percent of their costs on renting space and one percent on energy, the overwhelming majority, 90%, of a business's costs are spent on staff including salaries and benefits (Alker, Malanca, O'Brien, & Pottage, 2014). Therefore, any change implemented to lower staff costs by even a small percentage could translate to major savings and profit increases for businesses.

Breakdown of Business Operating Costs

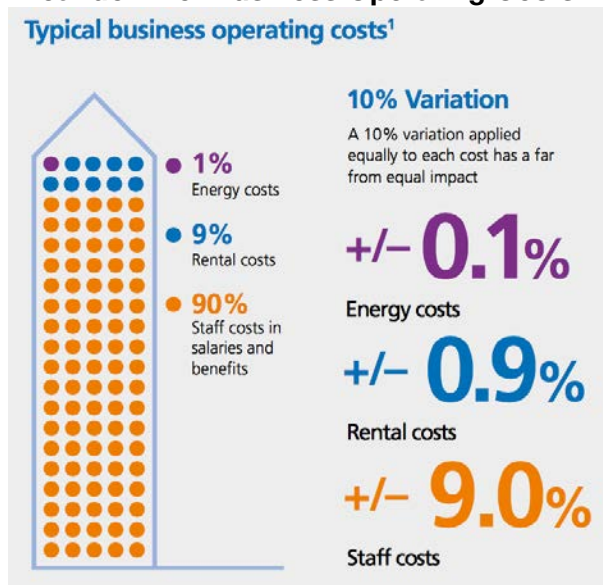


Figure 5 - Alker, Malanca, O'Brien, & Pottage, 2014

There are several aspects of employee behavior contributing to the high cost of staff management. For example, absenteeism is the rate of how often workers are not present at their jobs and presenteeism is the measure of how often employees are present physically but are not performing their duties due to lack of focus, fatigue, illness, or negative mood.

Absenteeism and presenteeism account for 2.7% and 1.3% of unproductive staff costs respectively (Browning et al., 2012). Table 2 below details how the overall private and public sectors' absenteeism rates as measured by the U.S. Department of Labor can impact businesses financially. While some level of absenteeism in the workplace is accepted as standard, researchers have hypothesized that a sizable percentage of current absenteeism rates could be avoided through biophilic improvements in the workplace. A recent case study from the University of Oregon highlighted in the next section of this report will present further evidence to support this hypothesis.

Rates and Costs of Absenteeism in the Private and Public Sectors

	Absenteeism Rate (annually)	Absenteeism Hours (per employee per year)	Annual Cost of Absenteeism (per employee)
Private Sector	3%	62.4 hours	\$2,074
Public Sector	4%	83 hours	\$2,502

Table 2 -Browning et al., 2012

Additionally, though presenteeism rates are not easily quantifiable, it has been found to cost employers \$938 per employee per year in the private sector and \$1,250 per employee per year in the public sector (Browning et al., 2012). In 2005, a report from Australia estimated that nationally businesses lost \$26 billion to presenteeism (Alker, Malanca, O'Brien, & Pottage, 2014). Given that four percent of business costs result in lost productivity due to absenteeism and presenteeism, research has turned to focus on how improving employees' working environments may help to recover these losses.

However, it is important to note that in much of the literature on biophilic design there exists a fair amount of uncertainty surrounding the true economic benefits of implementing design changes focused on improving employee productivity. Many researchers acknowledge that productivity benefits are not easily quantifiable or intuitively believable as opposed to cost reduction strategies. As explained in the *Economics of Biophilia*, "An investment in employee

workspace seems less fruitful than an investment in technology upgrades, where the rates of return are calculable” (Browning et al., p. 10).

The following section of this report will present several studies which begin to build the economic case for the use of biophilic design in the workplace. Some of these studies have gathered empirical data to demonstrate how biophilia can decrease rates of absenteeism and presenteeism and encourage increased employee productivity. Others rely on occupant surveys and self-reports of well-being to show how employee mood and self-perceived changes in performance are affected by changes in office design.

Case Study 1: Sacramento Municipal District’s Call Center

A 2003 in-depth study sponsored by the California Energy Commission on windows and offices set an early precedent for how biophilic design could affect worker productivity. Measurement of call time handling for individuals with views of nature versus those without resulted in faster processing of calls from individuals with views by 7% to 12% (Windows and Offices, 2003). Other office workers in the call center with views also performed 10% to 25% better than those without when given mental functionality and memory recall tests. View quality was not the main focus of this study. However, long before the current movement, evidence showed that some of the basic principles of biophilic design (simply looking at nature through windows) significantly affected employee cognitive performance and work productivity.

Case Study 2: Views of Nature and Absenteeism Rates

More recently, a study carried out by Ihab M.K. Elzeyadi, Ph.D., LEED AP (2011), measured the effect of lighting quality and types of views out on the number of sick days taken. The experiment was conducted at an administrative building at The University of Oregon with a typical open-plan spatial design. Within the building, 30% of the offices had access to views

with natural scenery outside, 31% of offices had access to views of urban settings, and 39% of the offices had no access to views outside. The images below taken from Elzeyadi's study (2011) depict the natural and urban views from within the different office locales as well as the floor plans of the building.

Figure 6 Natural View



Figure 6 - Elzeyadi, 2011

Figure 7 Urban View



Figure 7 - Elzeyadi, 2011

Figure 8 Cubicle Floor Plan



Figure 9 Open Floor Plan



Figure 9 - Elzeyadi, 2011

At the conclusion of a two-year data collection period, subjects used on average 63 hours of sick leave per year. It was found, though, that employees in the study groups with no views or mainly urban views were absent up to 16% more than those in groups who had access to views of nature. The figure below from Elzeyadi's (2011) study shows the percentage of days taken for sick leave increased significantly between the groups with the best views of nature (Groups 1 and 2) to those with no view at all (Group 5).

Percentage of Days Missed Due to Sickness Based on Differing View Group

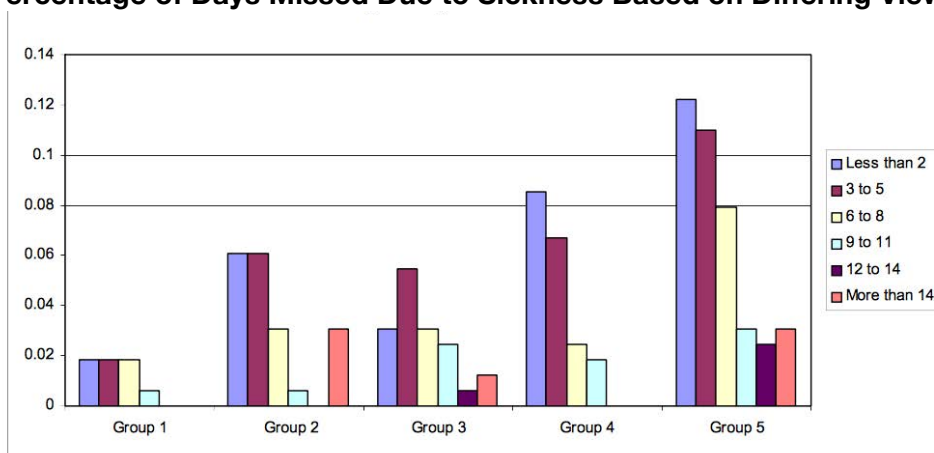


Figure 10 -Elzeyadi, 2011

Further statistical analysis was used to examine the correlation between expert ratings of lighting and view quality and the use of employee sick leave. As the study predicted, the poorer the lighting and view quality, it was predicted that more sick time would be used. For example, someone with a high quality view of nature from their workspace could be predicted to use only 57 hours of sick leave per year. A worker with no view at all, though, is predicted to be absent 68 hours per year (Elzeyadi, 2011).

Not only did this study demonstrate how varying views can affect the amount of sick time taken by employees, but it also determined that the variables of lighting quality and view explain 6.5% of the variation of overall sick leave usage. Elzeyadi (2011) explains that this

figure is statistically significant and that absenteeism in offices could be greatly impacted by increasing employees' views of nature and lighting quality, major patterns of biophilic design.

The Rocky Mountain Institute (RMI) took Elzeyadi's results one step further and used the 15% reduction in sick time taken to show what that cost savings might be in dollars and cents . For an employee with an average annual salary with benefits of \$75,000 who uses 250 gross sq. ft. of office space, about \$300/sq. ft. is spent by a business on that employee. Whereas employees take an average of eight sick days out of 250 total working days, the cost of absenteeism to the business will be about 3.2% of annual salary costs, or \$9.60/sq. ft. However, if by retrofitting offices with biophilic design elements such as more windows with better views, absenteeism decreases by 15%, then business can save up to \$1.44/sq. ft. per year. (Witherspoon, 2015)

Case Study 3: Vegetation and Productivity

Another study out of the United Kingdom, was conducted to measure the effect of plants on employees within office spaces. Authors Nieuwenhuis, Postmes, Knight, and Haslam (2014) designed three different field experiments to measure the effect of “lean” versus “green” offices on employees. The first experiment used an open office floor plan in which part of the space was outfitted with plants and greenery. Subjects were then asked to complete a survey at the end of the three week testing period to report their perceived change in workplace satisfaction, concentration, perceived air quality, and productivity. The second experiment was carried out over three months and the offices being tested were located on separate floors of a building where one floor was kept “lean” and the other was made “green.” The same subjective survey was administered to employees in either office but call time handling was also measured as a gauge of productivity. The third field test held similar testing conditions of separate green and lean offices but instead of subjective surveys, only objective productivity

was measured by giving workers specific tasks and measuring time to completion as well as error rate.

Overall, results of the three field experiments as shown in Table 3 below demonstrates employees' strong preference for greener office settings. In the "lean" office type, there was nearly¹ no statistically significant change (and even a negative change in one case) in

Employee Survey and Testing Results from "Green" vs. "Lean" Offices

Changes of Employees' Satisfaction, Concentration, Perceived Air Quality, and Productivity in Lean and Green Office Environments Across all Studies

Dependent variable	Study 1		Study 2		Study 3
	L	G	L	G	L vs. G
Workplace satisfaction	+	++	0	++	Not tested
Concentration	0	++	0	+	Not tested
Perceived air quality	0	+	0	++	Not tested
Productivity ^a	(-)	(+)	0	0	+ ^b

Note. L = lean condition; G = green condition. ++ = positive change at $p < .01$. + = positive change at $p < .05$. (+) = positive change at $p < .10$. (-) = negative change at $p < .10$. 0 = no change ($p > .10$). This table was based on simple effect analyses in Studies 1 (T1 vs. T2) and 2 (T1 vs. T2, T3) and the MANCOVA in Study 3.

^a Productivity was measured in different ways across the studies. ^b This effect refers to the difference between the lean and the green condition.

Table 3 - Nieuwenhuis, Postmes, Knight, and Haslam, 2014

employees' workplace satisfaction, concentration, perceived air quality, or productivity (Haslam et al., 2014). However, in the "green" offices, employees reported significant positive improvement in all categories surveyed. When measuring productivity of specified tasks in the third field study, employees' in offices with plants were able to complete these assignments faster and with no increase in errors. "Green" office employees demonstrated a 15% increase in productivity over their "lean" counterparts. This particular study is admittedly small in scale,

¹ Researchers explained that workplace satisfaction improvement for "lean" participants in Study 1 was attributed to unavoidable contact with green conditions as part of an open floor plan.

but shows evidence that aspects of biophilic design, namely having natural vegetation in offices, can lead to significant improvement in work performance and cognitive ability.

It is interesting to note that for similar experiments, different outcomes have been observed depending on the type of biophilic element being tested. One office's employee may become more productive with the introduction of vegetation while another responds better to increased exposure to natural light. Surveys of those who will occupy the space being built or renovated could inform facility operators of their design improvement preferences (increased daylight and views, personal lighting and ventilation controls, more vegetation, etc).

Effects of Natural and Increased Ventilation

Authors Alker, Malanca, O'Brien, and Pottage of the World Green Building Council (WGBC) released a paper in September 2014 compiling evidence from numerous studies showing how biophilic design elements can affect health, wellbeing, and productivity in the workplace. Some of the most compelling data presented measured productivity gains and losses in relation to indoor air quality and ventilation. One body of research identified 15 studies linking ventilation improvements with up to 11% increases in productivity (Alker, Malanca, O'Brien, & Pottage, 2014). Another group of studies from 2006 showed that poor air quality can lower performance by up to 10%. Adjustments made to indoor air quality through ventilation rates and type of air supply have been shown to affect the presence of VOCs (volatile organic compounds which are commonly used in building materials, finishings, and sealants) and CO₂ levels which, in turn, have had measured effects on employee fatigue, performance and absenteeism rates (Alker, Malanca, O'Brien, & Pottage, 2014). The table below lists those findings as compiled by the World Green Building Council's report.

Benefits to Employees/Productivity from Changes to Ventilation Standards

	Standard Level	Testing Level	Benefit
Air Ventilation Rate	8-10 litres/second	20-30 litres/second	10% performance increase
Air Ventilation Rate in the Presence of VOCs	5 litres/second	20 litres/second	8% performance increase
Outdoor Air Supply Rate	12 litres/second	24 litres/second	35% decrease in absenteeism
CO₂ Level	1000 parts per million	600 parts per million	11-23% improvement on decision-making tasks

Table 4 - Alker, Malanca, O'Brien, & Pottage, 2014

Biophilic Design and Well-Being

In addition to the measured effects biophilic design may have on productivity, many proponents of biophilia emphasize the importance of how it might affect individual's perceived sense of well-being, engagement, and sense of value in the workplace. These are even more difficult to quantify than productivity but could have marked effects on cutting costs and increasing profits for businesses. As Alker, Malanca, O'Brien, and Pottage (2014) write, "In many ways, perceptions may provide the missing link between the physical office environment and health, wellbeing and productivity outcomes." A global study in biophilic design released by Human Spaces and conducted by a research team led by Sir Cary Cooper in 2015 surveyed 7,600 workers in 16 different countries from North America, Europe, the Middle East, and Asia. Based on survey responses, it was found that 33% reported that the design of an office affects their decision to work at a certain company (The Global Impact of Biophilic Design in the Workplace, 2015). With the cost of employee turnover (including termination, temporary workers, recruitment, and lost productivity) calculated at approximately 150% of a position's salary and even as high as 250% for more executive level positions, biophilia in building design could play an important role in employee recruitment and retention (Bliss, 2015).

Of the 7,600 respondents of the Human Spaces survey, 47% said that they had felt stressed at work in the previous three months (The Global Impact of Biophilic Design in the Workplace, 2015). As evidenced in the chart below, work environments containing green space fosters increased positive feelings and decreased negative feelings. Stress, boredom, and anxiety can all hinder performance and lead to lost productivity through absenteeism or presenteeism.

Survey Responses of Employee Feelings Towards Their Workplace

GLOBAL RESEARCH FINDINGS			
The table below presents the percentage of respondents (N=7600) that report feeling happy, inspired, anxious or bored when entering workplaces that either do or do not provide internal green spaces.			
How do you feel when you enter the workplace’?		Internal Green Space	
		Yes	No
Positive Feelings	Happy	15%	9%
	Inspired	32%	18%
Negative Feelings	Anxious	2%	5%
	Bored	5%	11%
Comment from Steelcase, leading office furniture manufacturer: <i>“Well-being is made tangible through the workspace – this isn’t simply about work environments with better ergonomics or more comfort. We believe that the workplace can be a place where people actually leave healthier than when they arrive in the morning.”</i> Nancy Hickey (Senior Vice President and Chief Administrative Officer).			

Table 5 - The Global Impact of Biophilic Design in the Workplace, 2015

Some of the most compelling statistics related to well-being and self-perceived productivity come from the Genzyme Center in Cambridge, Massachusetts. Genzyme purported to design its current facilities with its employees in mind so that they could work more comfortably with “greater focus and efficiency” (“Value,” 2008). The building contains a 12-story atrium complete with heliostats which are large mirrors which rotate with the movement of the sun in order to provide the most light to offices throughout the day. There are also 18 indoor gardens

located throughout the building. Eighteen months after opening the building in 2003, Genzyme asked employees to complete a survey comparing their new workspace to their previous facilities. The responses were overwhelmingly positive as shown below:

- *72% said they felt more alert and productive.*
- *88% said having direct views and access to the interior gardens improved their sense of wellbeing.*
- *75% said the building's clear glass design has increased their sense of connection with colleagues.*
- *92% said the building has increased their sense of pride about Genzyme's commitment to the environment.*

Building owners and facility operators have become accustomed to managing their physical spaces with the ideas that reducing energy costs and resource efficiency management are the best practice means for sustainability and long-term profitability. However, the evidence above suggests that biophilic design is a financially beneficial way to invest in employees as increasing staff satisfaction and output while reducing costs. This report presented existing research on the concepts of biophilia and biophilic design, new and forthcoming research must be monitored. For example, Terrapin Bright Green, LLC will soon be releasing its first five-year study on the effects biophilic design had on occupants of the Bank of America Tower at One Bryant Park in New York City in which 90% of occupants were provided with outward views. Companies such as Google, Apple, and Facebook have all implemented biophilic design in the construction or renovation of their facilities, as well. While much of their planning data is not released to the public, it will be valuable to understand how employees react to their new working spaces.

The academic and research mission of educational institutions offers ripe environments to scientifically study campuses, facilities and the people who use them. The use of biophilic design could have great impact not only on faculty, staff, and students, but the future of the

institutions themselves. University administrators, just like any business owner, strive to eliminate inefficiencies and maximize the productivity of current staff. That alone could be strong financial motivation to consider designing with the principles of nature. At Universities, an additional, and perhaps even stronger, economic motivation is creating rich learning environments that support recruiting and fostering top level faculty and students. As the current research here shows, biophilic design is a financially worthwhile endeavor to include in the built environment. The extent of its benefit is arguable until further scientific study more deeply quantifies the financial returns due to improved health, productivity and satisfaction of employees working in biophilic environments. The conscious and subconscious biophilic desires of occupants revealed through studies and surveys to date (more natural light, brighter colors, access to private spaces, etc.) makes a compelling case that decision makers consider prioritizing biophilia in the built environment to create the most economically productive future version of their companies and institutions.

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