The Practice of Biophilic Design

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The Practice of Biophilic Design

Stephen R. Kellert, Elizabeth F. Calabrese

"The relationship between humankind and nature can be one of respect and love rather than domination…The outcome…can be rich, satisfying, and lastingly successful, but only if both partners are modified by their association so as to become better adapted to each other…With our knowledge and sense of responsibility… we can create new environments that are ecologically sound, aesthetically satisfying, economically rewarding"

René Dubos, ***The Wooing of the Earth***

1943 - 2016

In memory of Stephen Kellert — my dear friend, colleague and co-author. The world is a better place because of you, your passion, your dedication and love of life.

COVER PICTURE: The facades of these two adjacent buildings in Paris, France, illustrate the direct and indirect application of biophilic design, one through the use of vegetation, while the other through shapes and forms characteristic of the natural environment and the use of natural materials.

The Practice of Biophilic Design

Stephen R. Kellert, Elizabeth F. Calabrese

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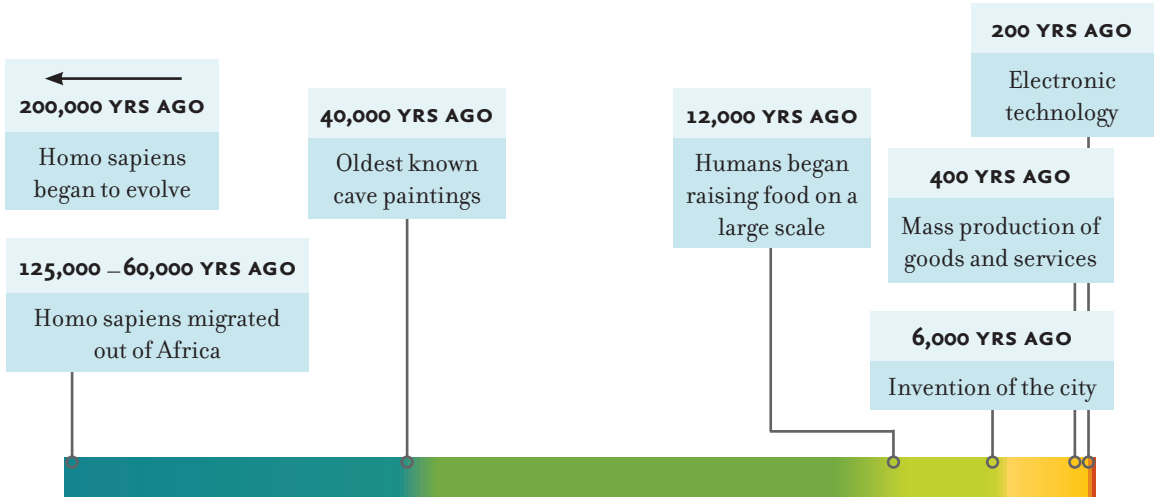
Reference:

Kellert, S. and Calabrese, E. 2015. *The Practice of Biophilic Design*. www.biophilic-design.com

I.

What is Biophilia and Biophilic Design?

Biophilia is the inherent human inclination to affiliate with nature that even in the modern world continues to be critical to people's physical and mental health and wellbeing (Wilson 1986, Kellert and Wilson 1993, Kellert 1997, 2012). The idea of biophilia originates in an understanding of human evolution, where for more than 99% of our species history we biologically developed in adaptive response to natural not artificial or human created forces. Most of what we regard as normal today is of relatively recent origin—raising food on a large-scale just in the last 12,000 years; the invention of the city, 6000 years old; the mass production of goods and services, beginning 400 years ago; and electronic technology, only since the 19th century. The human body, mind, and senses evolved in a bio-centric not human engineered or invented world.



Our species' inherent inclination to respond to natural forces and stimuli is illustrated by the results of a classic Swedish study conducted by the psychologist Arne Öhman (1986). In this research, the subjects were subliminally exposed to pictures of snakes, spiders, frayed electric wires, and handguns. Almost all the study participants aversively responded to the subconsciously revealed images of snakes and spiders, yet remained largely indifferent to the handguns and exposed electric wires. The results of this research both illustrate and suggest caution regarding the significance of our inherent inclinations to respond to nature in the

People possess an inherent inclination to fear snakes, even today the most common phobia found among humans.

modern world. The findings reveal the continuing influence of our evolved responses to nature, but also indicate that some of these reactions may have become "vestigial" – once adaptive in the distant human past, but largely irrelevant in today's built and increasingly urban world, and likely to atrophy over time.

Despite this possibility, a growing body of scientific study increasingly reveals that most of our inherent tendencies to affiliate with nature continue to exercise significant effects on people's physical and mental health, performance, and wellbeing. While the data is limited and the research often methodologically weak, the breadth of the findings across a wide range of sectors – work, education, health, recreation, housing, community – support the contention that contact with nature still has a profound impact on human fitness and quality of life (Kellert 2012, Browning et al 2014). For example, in the healthcare field, a wide range of studies have reported exposure to nature can reduce stress, lower blood pressure, provide pain relief, improve illness recovery, accelerate healing, enhance staff morale and performance, and lead to fewer conflicts between patients and staff (Annerstedt and Währborg 2011, Beck and Katcher 1986, Bowler et al 2010, Cama 2009, Friedmann 1983, Frumkin 2001, 2008, Katcher 1993, Kellert and Heerwagen 2007, Kuo 2010, Louv 2012, Marcus and Sachs 2014, Taylor 2001, Townsend and Weerasuriya 2010, Ulrich 1993, 2008, Wells and Rollings 2012).

The benefits of contact with nature often depend on repeated experience. People may possess an inherent inclination to affiliate with nature, but like much of what makes us human, this biological tendency needs to be nurtured and developed to become functional (Wilson 1986, Kellert 2012). People's reliance on learning and experience is what has allowed our species to reach beyond our biology to become inventive and distinctive as individuals and societies. This capacity to learn and choose a particular course of action is, however, a two-edged sword. It can spur beneficial and creative choices, but it can also lead to self-destructive behaviors. In the case of biophilia, we can either choose to engage our inherent tendencies to affiliate with nature, or to separate from and impoverish our connections to the natural world. Unfortunately, modern society has erected many obstacles to the beneficial experience of nature. Most problematic

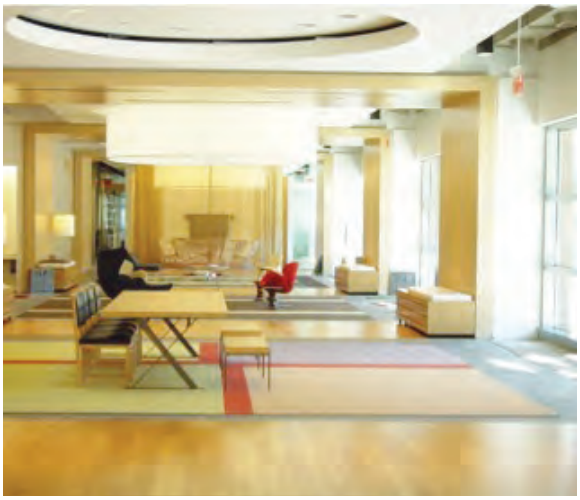
Many hospital rooms are dominated by technology and devoid of any connection to nature.

Research has indicated a view of nature can enhance recovery from illness and surgery, and reduce the need for potent pain medication.

is an increasing disconnect from the natural world, often viewed as merely a resource to be exploited or a nice but not necessary recreational amenity. This increasing separation from nature is reflected in modern agriculture, manufacturing, education, healthcare, urban development, and architecture.

One of the most significant impediments to the positive experience of nature today is the prevailing paradigm of design and development of the modern built environment. This is especially problematic, because while humans may have evolved in the natural world, the "natural habitat" of contemporary people has largely become the indoor built environment where we now spend 90% of our time. The need for beneficial contact with nature continues to be critical to people's health and fitness, but its satisfactory occurrence in today's built environment has become highly challenging. The dominant approach to modern building and landscape design largely treats nature as either an obstacle to overcome or a trivial and irrelevant consideration. The result has been an increasing disconnect between people and nature in the built environment reflected in inadequate contact with natural light, ventilation, materials, vegetation, views, natural shapes and forms, and in general beneficial contact with the natural world. Much of the built environment today is so sensory deprived, it is sometimes reminiscent of the barren cages of the old-fashioned zoo, now ironically banned as "inhumane" (Heerwagen in Kellert and Finnegan, 2011).

The majority of offices in the United States are windowless and often sensory-deprived settings.



Offices with natural light, materials, and vegetation have been found to increase productivity, improve morale, and reduce absenteeism.

II.
The Principles and Benefits of Biophilic Design

The challenge of ***biophilic design*** is to address these deficiencies of contemporary building and landscape practice by establishing a new framework for the satisfying experience of nature in the built environment (Kellert et al 2008, Kellert 2005, Kellert and Finnegan 2011, Browning et al 2014). Biophilic design seeks to create good habitat for people as a biological organism in the modern built environment that advances people's health, fitness and wellbeing.

The successful application of biophilic design necessitates consistently adhering to certain basic principles. These principles represent fundamental conditions for the effective practice of biophilic design. They include:

1. Biophilic design requires repeated and sustained engagement with nature.

2. Biophilic design focuses on human adaptations to the natural world that over evolutionary time have advanced people's health, fitness and wellbeing.

3. **Biophilic design encourages an emotional attachment to particular settings and places.**

4. **Biophilic design promotes positive interactions between people and nature that encourage an expanded sense of relationship and responsibility for the human and natural communities.**

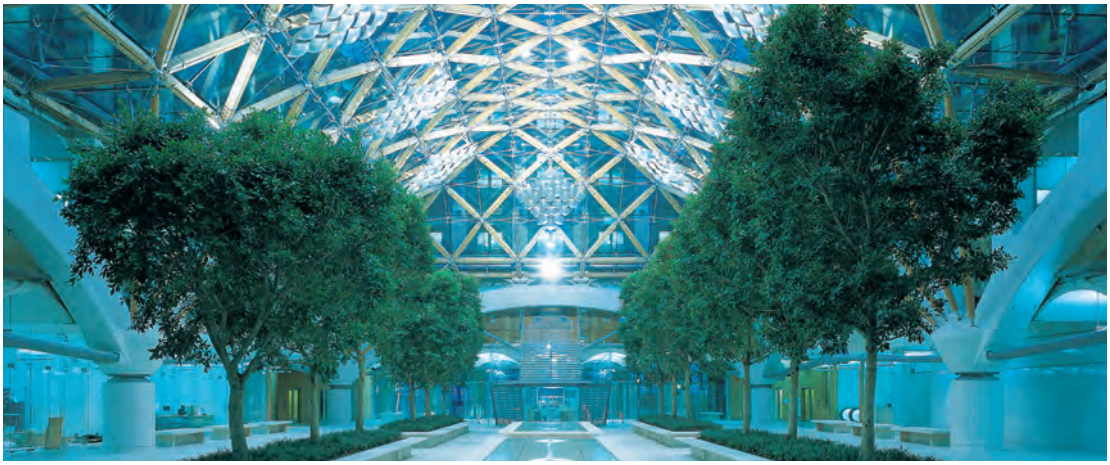
5. **Biophilic design encourages mutual reinforcing, interconnected, and integrated architectural solutions.**

Biophilic design further seeks to sustain the productivity, functioning and resilience of natural systems over time. Alteration of natural systems inevitably occur as a result of major building construction and development. Moreover, all biological organisms transform the natural environment in the process of inhabiting it. The question is not whether ecological change occurs, but rather will the net result over time be a more productive and resilient natural environment as measured by such indicators as levels of biological diversity, biomass, nutrient cycling, hydrologic regulation, decomposition, pollination, and other essential ecosystem services. The application of biophilic design can alter the environmental conditions of a building or landscape in the short term, but over the long run, it should support an ecologically robust and sustainable natural community.

The successful application of biophilic design should also result in a wide spectrum of physical, mental and behavioral benefits. Physical outcomes include enhanced physical fitness, lower blood pressure, increased comfort and satisfaction, fewer illness symptoms, and improved health. Mental benefits range from increased satisfaction and motivation, less stress and anxiety, to improved problem solving and creativity. Positive behavioral change includes better coping and mastery skills, enhanced attention and concentration, improved social interaction, and less hostility and aggression.

The integration of the biophilic elements of water, vegetation, organic shapes and forms, information richness, prospect and refuge, the patina of time, and organized complexity all contribute to this scene's powerful sense of place.

III.
The Application of Biophilic Design



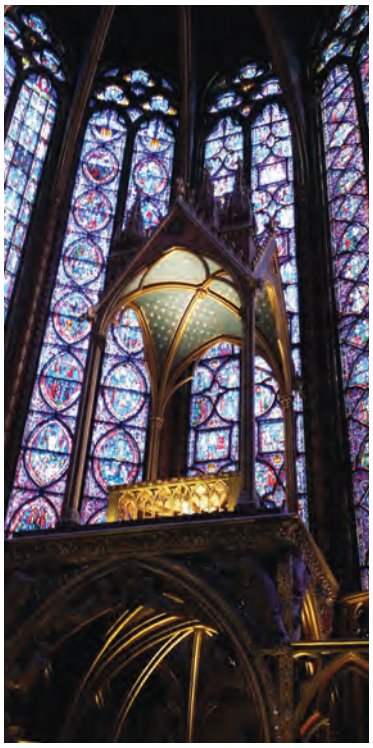
The practice of biophilic design involves the application of varying design strategies, what we refer to as experiences and attributes. The choice of which design applications to employ inevitably varies depending on a project's circumstances and constraints including particular building and landscape uses, project size, varying economic, logistical and regulatory factors, as well as cultural and ecological conditions. As emphasized, the effective practice of biophilic design requires adhering to the previously noted principles. Most important, biophilic design should never occur in piecemeal or disconnected fashion, but rather in a manner whereby the diverse applications mutually reinforce and complement one another, resulting in an overall integrated ecological whole.

Three kinds of experience of nature represent the basic categories of our biophilic design framework. These include the direct experience of nature, the indirect experience of nature, and the experience of space and place. The ***direct experience of nature*** refers to actual contact with environmental features in the built environment including natural light, air, plants, animals, water, landscapes, and others that will be described. The ***indirect experience of nature*** refers to contact with the representation or image of nature, the transformation of nature from its original condition, or exposure to particular patterns and processes characteristic of the natural world. These include pictures and artwork, natural materials such as wood furnishings and woolen fabrics, ornamentation inspired by shapes and forms occurring in nature, or environmental processes that have been important in human evolution such as aging and the passage of time, information richness, natural geometries, and others. Finally, the ***experience of space and place*** refers to spatial features characteristic of the natural environment that have advanced human health and wellbeing. Examples include prospect and refuge, organized complexity, mobility and way finding, and more. Within these three categories of experience, 24 attributes of biophilic design have been identified. A simple listing of these biophilic design experiences and attributes is noted on the following page, although each attribute is described in the pages that follow:

Experiences and Attributes of Biophilic Design

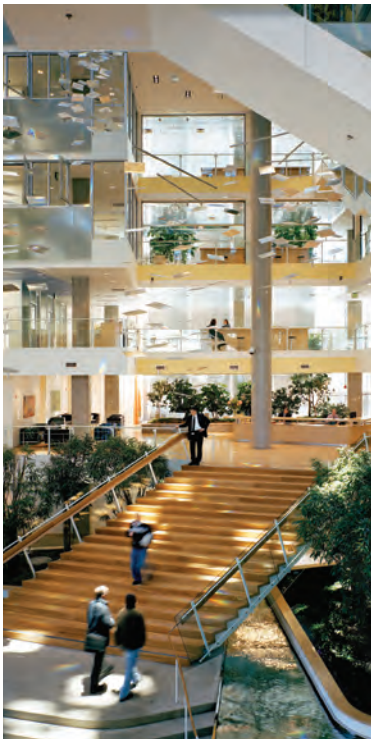
Direct Experience of Nature

- Light
- Air
- Water
- Plants
- Animals
- Weather
- Natural landscapes and ecosystems
- Fire



Indirect Experience of Nature

- Images of nature
- Natural materials
- Natural colors
- Simulating natural light and air
- Naturalistic shapes and forms
- Evoking nature
- Information richness
- Age, change, and the patina of time
- Natural geometries
- Biomimicry



Experience of Space and Place

- Prospect and refuge
- Organized complexity
- Integration of parts to wholes
- Transitional spaces
- Mobility and wayfinding
- Cultural and ecological attachment to place

All these biophilic design qualities are experienced through a variety of human senses including sight, sound, touch, smell, taste, and movement. The visual sense is by far the dominant way people perceive and respond to the natural world. When we see plants, animals, water, landscapes, and other natural features, a variety of physical, emotional and cognitive responses are triggered. People also react to indirect visual contact with nature, especially the sight of striking pictures, natural materials, organic shapes and forms, and more. Aesthetically attractive nature particularly arouses our interest, curiosity, imagination, and creativity. By contrast, when we lack visual contact with the natural world, such as a windowless and featureless space, we frequently experience boredom, fatigue, and in extreme cases physical and psychological abnormality. Despite our human tendency to favor the visual sense, other sensory responses to nature are of great significance to us, particularly touch, sound, smell, taste, time, and motion. Hearing water, touching plants, smelling flowers, sensing the movement of the air often moves us both emotionally and intellectually. Multisensory encounters with nature in the built environment can greatly contribute to comfort, satisfaction, enjoyment, and cognitive performance, and when feasible, should be encouraged.

What follows are brief descriptions of each of the biophilic design attributes.

Attributes of Biophilic Design

I. Direct Experience of Nature

LIGHT. The experience of natural light is fundamental to human health and wellbeing, enabling an orientation to the day, night and seasons in response to the sun's location and cycles. An awareness of natural light can also facilitate movement and wayfinding, and contribute to comfort and satisfaction. Beyond simple exposure, natural light can assume aesthetically appealing shapes and forms through the creative interplay of light and shadow, diffuse and variable light, and the integration of light with spatial properties. Natural light can be brought deep into interior spaces by such means as glass walls and clerestories, the use of reflecting colors and materials, and other design strategies. The experience of light in motion can be achieved through the contrast of lighter and darker areas and changes of daylight over time.

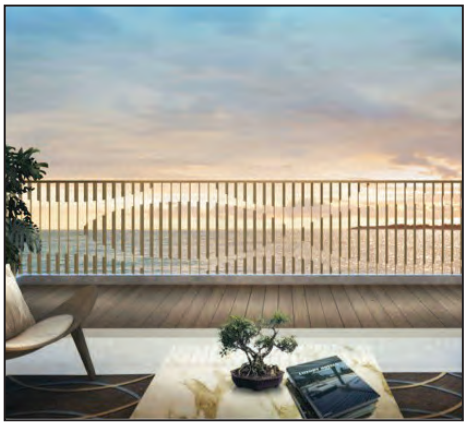
AIR. Natural ventilation is important to human comfort and productivity. The experience of natural ventilation in the built environment can be enhanced by variations in airflow, temperature, humidity, and barometric pressure. These conditions can be achieved through access to the outside by such simple means as operable windows, or by more complex technological and engineering strategies.

WATER. Water is essential to life and its positive experience in the built environment can relieve stress, promote satisfaction, and enhance health and performance. The attraction to water can be especially pronounced when associated with the multiple senses of sight, sound, touch, taste, and movement. Varying design strategies can satisfy the desire for contact with water including views of prominent water bodies, fountains, aquaria, constructed wetlands, and others. Water in the built environment is often most pleasing when perceived as clean, in motion, and experienced through multiple senses (although at muted sound levels).

PLANTS. Vegetation, especially flowering plants, is one of the most successful strategies for bringing the direct experience of nature into the built environment. The presence of plants can reduce stress, contribute to physical health, improve comfort, and enhance performance and productivity. The application of single or isolated plants, however, rarely exerts much beneficial effect. Vegetation in buildings and constructed landscapes should be abundant, ecologically connected, and tending to focus on local rather than exotic and invasive species.

ANIMALS. The presence of nonhuman animal life has been an integral part of people's experience throughout human history. Still, its occurrence in the built environment can be challenging and occasionally contentious. Positive contact with animal life can be achieved through such design strategies as feeders, green roofs, gardens, aquaria, aviaries, and the creative use of modern technologies such as web cameras, video, binoculars, and spotting scopes. Isolated and infrequent contact with animal life tends to exert little impact. When feasible, contact with animal life should include a diversity of species, and emphasize local rather than non-native species.

WEATHER. An awareness and response to weather has been an essential feature of people's experience of nature throughout history, and critical to human fitness and survival. The perception of and contact with weather in the built environment can be both satisfying and stimulating. This may occur through direct exposure to outside conditions, as well as by simulating weather-like qualities through manipulating airflow, temperature, barometric pressure, and humidity. Design strategies include views to the outside, operable windows, porches, decks, balconies, colonnades, pavilions, gardens, and more.



NATURAL LANDSCAPES AND ECOSYSTEMS. Natural landscapes and ecosystems consist of interconnected plants, animals, water, soils, rocks, and geological forms. People tend to prefer landscapes with spreading trees, an open understory, the presence of water, forested edges, and other features characteristic of a savannah-type setting important in human evolution. Still, even ordinary natural scenery is preferred by most people over artificial and human-dominated landscapes. The experience of self-sustaining ecosystems can be especially satisfying. Functional ecosystems are typically rich in biological diversity and support an array of ecological services such as hydrologic regulation, nutrient cycling, pollination, decomposition, and more. Self-sustaining ecosystems in the built environment can be achieved through such design strategies as constructed wetlands, forest glades and grasslands; green roofs; simulated aquatic environments; and other means. Contact with natural systems can be fostered by views, observational platforms, direct interaction, and even active participation.

FIRE. One of humanity's greatest achievements has been the control of fire that allowed the harnessing of energy beyond animal life, and facilitated the transformation of objects from one state to another. The experience of fire can be both a source of comfort and anxiety. The satisfying presence of fire in the built environment may be achieved through the construction of fireplaces and hearths, but also simulated by the creative use of light, color, movement, and materials of varying heat conductance.

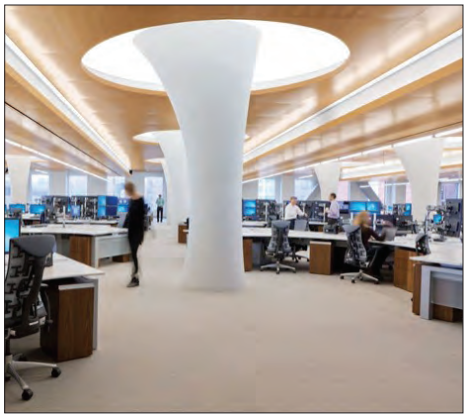
II. Indirect Experience of Nature

IMAGES OF NATURE. The image and representation of nature in the built environment—plants, animals, landscapes, water, geological features—can be both emotionally and intellectually satisfying. These images can occur through the use of photographs, paintings, sculpture, murals, video, computer simulations, and other representational means. Single or isolated images of nature typically exert little impact. Representational expressions of nature should be repeated, thematic, and abundant.

NATURAL MATERIALS. Natural materials can be especially stimulating, reflecting the dynamic properties of organic matter in adaptive response to the stresses and challenges of survival over time. The transformation of materials from nature frequently elicits positive visual and tactile responses, which few artificial materials can duplicate. Prominent natural building and decorative materials include wood, stone, wool, cotton, and leather, used in a wide array of products, furnishings, fabrics, and other interior and exterior designs.

NATURAL COLORS. Humans evolved as a daytime animal, and color has long served as an important means for locating food, water, and other resources, as well as facilitating movement and wayfinding. The effective use of color in the built environment can be challenging, given the modern ability to generate artificial, especially bright colors. The effective biophilic application of color should generally favor muted "earth" tones characteristic of soil, rock, and plants. The use of bright colors should be cautiously applied, and emphasize such appealing environmental forms as flowers, sunsets and sunups, rainbows, and certain plants and animals. The occurrence of highly artificial, contrasting, and "vibrating" colors should be avoided.

SIMULATING NATURAL LIGHT AND AIR.
Indoor lighting and processed air have been made possible by advances in building technology and construction. The trade-off has often been the occurrence of static conditions that can be physically and psychologically debilitating. Artificial light can be designed to mimic the spectral and dynamic qualities of natural light. Processed air can also simulate qualities of natural ventilation through variations in airflow, temperature, humidity and barometric pressure.

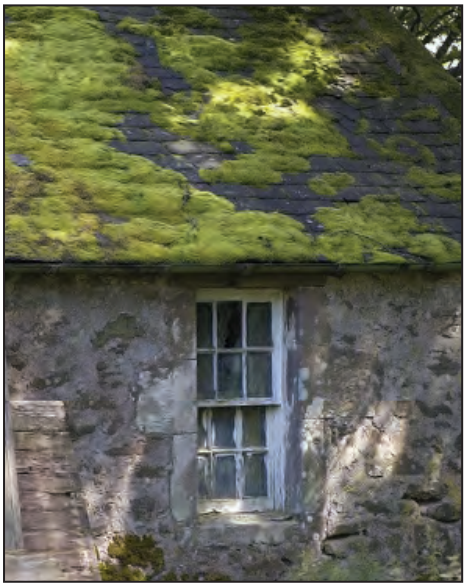


NATURALISTIC SHAPES AND FORMS.
The experience of shapes and forms characteristic of the natural world can be especially appealing. These naturalistic forms can be extraordinarily diverse from the leaf-like patterns found on columns, the shapes of plants on building facades, to animal facsimiles woven into fabrics and coverings. The occurrence of naturalistic shapes and forms can transform a static space into one that possesses the dynamic and ambient qualities of a living system.

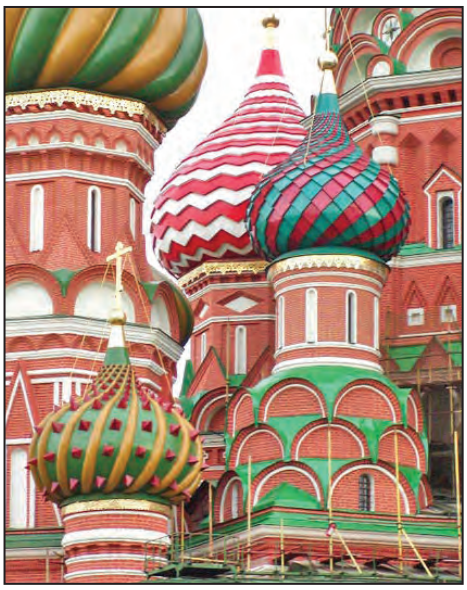
EVOKING NATURE. The satisfying experience of nature can also be revealed through imaginative and fantastic depictions. These representations may not literally occur in nature, but still draw from design principles prominently encountered in the natural world. For example, the "wings" of the Sydney Opera House suggest the qualities of a bird; Notre Dame's stained glass windows, a rose-like flower; while, the skyline of some cities mimic the vertical heterogeneity of a forest. None of these designs actually occurs in nature, but they all draw from design principles and characteristics of the natural world.

INFORMATION RICHNESS. The diversity and variability of the natural world is so pronounced, it has been described as the most information-rich environment people will ever encounter. Whether natural or built, people tend to respond positively to information-rich and diverse environments that present a wealth of options and opportunities, so long as the complexity is experienced in a coherent and legible way.

AGE, CHANGE, AND THE PATINA OF TIME. Nature is always changing and in flux, life especially reflecting the dynamic forces of growth and aging. People respond positively to these dynamic forces and the associated patina of time, revealing nature's capacity to respond adaptively to ever changing conditions. These dynamic tendencies are often most satisfying when balanced by the complementary qualities of unity and stability. Change and a patina of time can be achieved through such design strategies as naturally aging materials, weathering, a sense of the passage of time, and in other ways.



NATURAL GEOMETRIES. Natural geometries refer to mathematical properties commonly encountered in nature. These include hierarchically organized scales, sinuous rather than rigid artificial geometries, self-repeating but varying patterns, and more. For example, fractals are a geometric form often encountered in the natural world, where a basic shape occurs in repeated but varied and predictable ways that contribute both variety and similarity to a setting. Other prominent natural geometries include hierarchically ordered scales such as the "Golden Ratio" and "Fibonacci Sequence."



BIOMIMICRY. Biomimicry refers to forms and functions found in nature, especially among other species, whose properties have been adopted or suggest solutions to human needs and problems. Examples include the bio-climatic controls of termite mounds, the structural strength of spider webs, the heat-trapping ability of certain animal hairs. Technologically capturing these characteristics of nonhuman nature can result in direct utilitarian benefits, as well as provoke human admiration for the ingenuity of other life and the creativity of the natural world.

III. Experience of Space and Place

PROSPECT AND REFUGE. Humans evolved in adaptive response to the complementary benefits of prospect and refuge. Prospect refers to long views of surrounding settings that allow people to perceive both opportunities and dangers, while refuge provides sites of safety and security. These complementary conditions can be both functional and satisfying in the built environment. This biophilic outcome can be achieved through such design strategies as vistas to the outside, visual connections between interior spaces, and the occurrence of secure and sheltered settings.

ORGANIZED COMPLEXITY. People covet complexity in both natural and human settings, which signify places rich in options and opportunities. Yet, excessive complexity is often confusing and chaotic. The most satisfying settings tend to possess qualities of complexity, but experienced in an orderly and organized way. Complex spaces tend to be variable and diverse, while organized ones possess attributes of connection and coherence.

INTEGRATION OF PARTS TO WHOLES. People covet settings where disparate parts comprise an integrated whole. This feeling of an emergent whole can often be achieved through the sequential and successional linking of spaces, as well as by clear and discernible boundaries. This satisfying integration of space can be enhanced by a central focal point that occurs either functionally or thematically.

TRANSITIONAL SPACES. Successfully navigating an environment often depends on clearly understood connections between spaces facilitated by clear and discernible transitions. Prominent transitional spaces include hallways, thresholds, doorways, gateways, and areas that link the indoors and outdoors especially porches, patios, courtyards, colonnades, and more.

MOBILITY AND WAYFINDING. People's comfort and wellbeing often relies on freely moving between diverse and often complicated spaces. Clearly understood pathways and points of entry and egress are especially critical to fostering mobility and feelings of security, while the absence of these features often breeds confusion and anxiety.

CULTURAL AND ECOLOGICAL ATTACHMENT TO PLACE. Humans evolved as a territorial creature, because it promoted the control of resources, enhanced safety and security, and facilitated movement and mobility. An affinity for familiar places reflects this territorial inclination that can be enhanced by both cultural and ecological means. Culturally relevant designs promote a connection to place and the sense that a setting has a distinct human identity. Ecological connections to place can similarly foster an emotional attachment to an area, particularly an awareness of local landscapes, indigenous flora and fauna, and characteristic meteorological conditions. Cultural and ecological attachments to place often motivate people to conserve and sustain both natural and human built environments.

IV.

The Ecological and Ethical Imperative

Biophilic design is about creating good habitat for people as a biological organism in the built environment. Like all species, humans evolved in adaptive response to natural rather than artificial forces, and these adaptations became embedded in our species biology over evolutionary time. Biophilic design seeks to satisfy these inherent adaptations to nature in the modern built environment and, in doing so, enhance people's physical and mental health and fitness.

Good habitat means ecologically sound and productive environments where people function to their optimal potential. Ecosystems are comprised of webs of mutually reinforcing and complementary relationships where the resulting whole is greater than the sum of its parts. As with all organisms, effective human functioning depends on ecologically connected rather than disaggregated environments. Successful biophilic design should encourage connections that contribute to an overall coherent whole. The risk of specifying specific strategies of biophilic design is the potential to encourage their separate and piecemeal application. Biophilic design should instead promote ecologically interrelated design solutions at multiple scales from distinct interior spaces, the building as a whole, the surrounding landscape, to the urban and bio-regional scale.

Biophilic design is more than just a technical tool. The framework advanced here is certainly intended to be a practical methodology for the more effective design of the built environment. Its successful application will ultimately depend, however, on adopting a new consciousness toward nature as much as implementing a new design technique. Biophilia and biophilic design necessitate recognizing how much human physical and mental wellbeing continues to rely on the quality of our relationships to the world beyond ourselves of which we remain a part. As the landscape architect, Ian McHarg, remarked:

> ***"The problem of man and nature is not one of providing a decorative background for the human play, or even ameliorating the grim city: it is the necessity of sustaining nature as a source of life, milieu, teacher, sanctum, challenge and, most of all, of rediscovering nature's corollary of the unknown in the self, the source of meaning."***

Practical issues are clearly important in effectively adopting and applying biophilic design. But, nature offers us far more than just physical and material sustenance, contributing as well to our capacities for emotional and intellectual growth and wellbeing, and even attaining a just and satisfying existence. Biophilia and biophilic design are about our values and ethical responsibility for the care and sustainability of the natural world. A commitment to maintain and even enrich our relationship to nature necessitates a greatly expanded understanding of human self-interest that includes material benefits, but also a host of emotional, intellectual, and even spiritual rewards as well.

The modern age has precipitated a sustainability crisis reflected in enormous loss of biological diversity, natural resource depletion, environmental pollution, and atmospheric degradation. The conventional design of the built environment has greatly contributed to this crisis. The remedial response to this challenge has emphasized reducing our environmental impacts through energy and resource efficiency, the use of less polluting materials, recycling, and other important strategies. Yet, this low environmental impact approach, while essential, by itself, is insufficient for achieving true and lasting sustainability. Conserving and maintaining our buildings and landscapes also requires an attachment to and affection for these creations that originates in the realization of their contribution to our physical and mental health and wellbeing through an array of beneficial connections to nature. This sense of positive relationship to nature ultimately motivates us to become good stewards and sustain these places over time.

This is the promise of biophilia and biophilic design. The distortion of our values of nature in the modern age has precipitated widespread environmental degradation and a growing alienation from the natural world. Sustainability will remain an elusive goal until a fundamental shift occurs in our values and ethical relations to the natural world. The successful application of biophilic design will depend on recognizing how much nature remains the basis for a healthy, productive, and meaningful human existence. As the writer, Henry Beston, eloquently concluded:

"Nature is a part of our humanity, and without some awareness and experience of that divine mystery man ceases to be man. When the Pleiades and the wind in the grass are no longer a part of the human spirit, a part of very flesh and bone, man becomes, as it were, a cosmic outlaw, having neither the completeness and integrity of the animal nor the birthright of a true humanity."

References

Annerstedt, M and P. Währborg. 2011. Nature-assisted therapy: systematic review of controlled and observational studies. Scand. J. Public Health:1-18.

Beston, H. 1971. The Outermost House. New York: Ballantine.

Bowler, D.E., Buyung-Ali, L.M, Knight, T.M., Pulin, A.S. 2010. A systematic review of evidence for the added benefits to health of exposures to natural environments. BMC Public Health 10.

Browning, W.D., Ryan, C., Kallianpurkar, N., Laburto, L., Watson, S., Knop, T. 2012. The Economics of Biophilia, Why Designing with Nature in Mind Makes Financial Sense. New York: Terrapin Bright Green.

Browning, W.D., Ryan, C., Clancy, J. 2014. 14 Patterns of Biophilic Design, Improving Health & Well-Being in the Built Environment. New York: Terrapin Bright Green.

Cama, R. 2009. Evidence-based Healthcare Design. Hoboken, NJ: John Wiley.

Friedmann, E. 1983. Animal-human bond: health and wellness. In A. Katcher and A. Beck, eds., New Perspectives on Our Lives with Companion Animals. Philadelphia: University of Pennsylvania Press.

Frumkin, H. 2001. Beyond toxicity: human health and the natural environment. American Journal of Preventive Medicine 20.

Frumkin, H. 2008. Nature contact and human health: building the evidence base. In, Kellert et al, Biophilic Design.

Heerwagen, J. 2011. As quoted in the video, Kellert, S. and B. Finnegan, Biophilic Design: the Architecture of Life. www.bullfrogfilms.com.

Kellert, S. 2012. Birthright: People and Nature in the Modern World. New Haven: Yale University Press.

Kellert, S. 2005. Building for Life: Understanding and Designing the Human-Nature Connection. Washington, DC: Island Press.

Kellert, S. 1997. Kinship to Mastery: Biophilia in Human Evolution and Development. Washington, DC: Island Press.

Kellert, S, J. Heerwagen, M. Mador, eds. 2008. Biophilic Design: the Theory, Science, and Practice of Bringing Buildings to Life. Hoboken, NJ: John Wiley.

Kellert, S. and E.O. Wilson, eds. 1993. The Biophilia Hypothesis. Washington, DC: Island Press.

Kellert, S. and B. Finnegan. 2011. Biophilic Design: the Architecture of Life. A 60 minute video. www.bullfrogfilms.com

Kellert, S. and J. Heerwagen. 2007. Nature and healing: the science, theory, and promise of biophilic design. In Guenther, R. and G. Vittori, eds. Sustainable Healthcare Architecture. Hoboken, NJ: John Wiley.

Kuo, F. 2010. Parks and other green environments: essential components of a health human habitat. Washington, DC: National Recreation and Parks Association.

Louv, R. 2012. The Nature Principle: Reconnecting with Life in a Virtual Age. Chapel Hill: Algonquin Press.

Marcus, C.M. and N.A. Sachs. 2014. Therapeutic Landscapes: an Evidence-based Approach to Designing Healing Gardens and Restorative Outdoor Spaces. Hoboken, NJ: John Wiley.

McHarg, I. 1969. Design with Nature. Hoboken, NJ: John Wiley.

Öhman, A, 1986. Face the beast and fear the face: animal and social fears as prototypes for evolutionary analyses of emotion. Psychophysiology 23.

Taylor, A. 2001. Coping with ADD: the surprising connection to green places. Environment and Behavior 33.

Townsend, M and R. Weerasuriya. Beyond blue to green: the benefits of contact with nature for mental health and wellbeing. www. Beyondblue.org.au.

Ulrich, R. 2008. Biophilic theory and research for healthcare design. In Kellert et al, Biophilic Design.

Ulrich, R. 1993. Biophilia, biophobia, and natural landscapes. In Kellert and Wilson, Biophilia Hypothesis.

Wells, N. and K. Rollings. 2012. The natural environment: influences on human health and function. In Clayton, S., ed. The Oxford Handbook of Environmental and Conservation Psychology. London: Oxford University Press.

Wilson, E.O. 1986. Biophilia: the Human Bond with Other Species. Cambridge: Harvard University Press.

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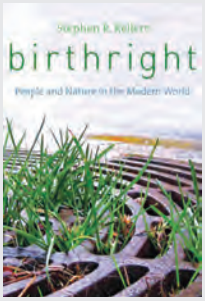
About the Authors

Dr. Stephen R. Kellert (1943 - 2016) was a Professor Emeritus at Yale University. He was also a member of the Board of Directors of Bio-Logical Capital, a firm that invests in sustainable land uses on large landscapes. His work focuses on understanding the connection between nature and humanity with a particular interest in the human need for nature, and sustainable design and development. His awards include the George B. Hartzog Award for Environmental Conservation, the American Publishers Best Book of Year Award in Architecture and Urban Planning for Biophilic Design, the National Conservation Achievement Award from the National Wildlife Federation, and others. He is also listed in "American Environmental Leaders: From Colonial Times to the Present." Dr. Kellert served on committees of the National Academy of Sciences, as a board of director of many organizations, and authored more than 150 publications, including 11 books.



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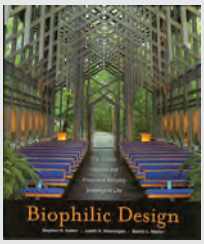
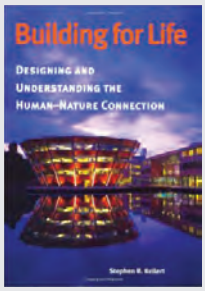
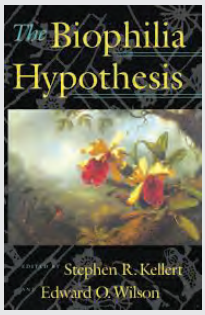


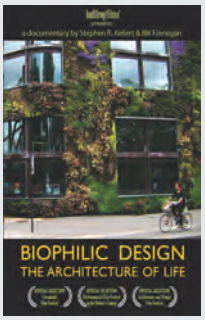
Biophilic Design: The Theory, Science, and Practice of Bringing Buildings to Life (John Wiley, 2008)



Building for Life: Designing and Understanding the Human-Nature Connection (Island Press, 2005)



The Biophilia Hypothesis (Island Press, 1993)



Biophilic Design: the Architecture of Life with Bill Finnegan—A 60-minute documentary video (www.bull-frogfilms.com)

Elizabeth Freeman Calabrese, AIA, LEED AP, has been in the design industry for 30 years. She is principal of Calabrese Architects, Inc. located in Burlington, Vermont, with national and international projects to her credit. Elizabeth is a leading educator in the growing field of biophilic design and believes that ecology and biophilia belong at the foundation and core of professional design programs. As a consultant, she encourages a holistic, integrated, "eco-system" approach when incorporating biophilia into projects, including those seeking Living Building Challenge and WELL Building certifications. *Liz@CalabreseArchitects.com*