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The Practice of Biophilic Design in Indoor Space: Taking the Office as an Example

Xin Zhao*

Shenzhen Qixin Green Technology Co., LTD., Shenzhen 518000, Guangdong, China

**Author to whom correspondence should be addressed.*

Abstract: Biophilic design significantly enhances the ecological efficiency and humanistic value of office spaces by integrating natural elements with artificial environments. Studies show that this design can reduce building energy consumption by 15–20%, while increasing employee productivity by 12–18%. Key technical challenges include maintaining micro-ecological balance and cross-system collaborative control, and the lack of cost-benefit quantification tools hinders market promotion. As green building evaluation systems improve, intelligent environmental regulation technologies and standardized assessment methods will become key focuses for future development, providing scientific support for sustainable office environment construction.

Keywords: Biophilic design; Office space; Sustainable architecture

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1. Introduction

With the acceleration of urbanization, modern office environments are increasingly isolated from nature, leading to issues such as decreased employee mental health and reduced work efficiency. Biophilic Design, which integrates natural elements into architectural spaces to re-establish the connection between humans and nature, has become an important approach to improving indoor environmental quality [1]. The "14th Five-Year Plan for Building Energy Efficiency and Green Building Development" issued by the Ministry of Housing and Urban-Rural Development in 2023 clearly promotes the concept of green and low-carbon design, encourages the use of ecological building materials and natural ventilation and lighting technologies, and provides policy support for the application of Biophilic Design in office spaces [2]. Research has shown that introducing plants, natural light, and organic materials into offices can significantly enhance employee satisfaction and reduce carbon emissions, aligning with the sustainable development needs under the "dual carbon" goals [3]. Against this backdrop, exploring the practical strategies and benefits of Biophilic Design in office spaces is of great practical significance for promoting the construction of healthy buildings and low-carbon cities.

2. Theoretical basis of nature-friendly design

2.1. The connotation of nature-friendly design

The theoretical foundation of Biophilic Design stems from the "Biophilia Hypothesis" proposed by Wilson (1984) [4], which posits that humans have an innate emotional and physiological dependence on nature. This hypothesis reveals the deep influence of natural elements on human cognition, emotions, and behavioral patterns from an evolutionary psychology perspective [5]. Based on this, Biophilic Design reconstructs the connection between artificial environments and ecosystems by systematically integrating natural elements. This article is framed around "14 Biophilic Design Patterns" [6], with design elements divided into three major categories and fourteen subcategories: direct natural elements, such as physical interventions like vegetation, water bodies, and natural light; indirect natural metaphors, including abstract expressions like natural material textures, organic forms, and ecological colors; and spatial experience creation, which emphasizes simulating natural settings through techniques such as spatial sequence, visual transparency, and microclimate regulation (**Table 1**). These three categories of elements together constitute a multi-layered design intervention system, aiming to compensate for the lack of natural experience in modern architectural environments.

Table 1. Browning's 14 biophilic design patterns (Table source: redrawn by the author)

Design patterns	Design elements
Nature in space	1. Visual connections; 2. Non-visual connections; 3. Irregular sensory stimuli; 4. Heat and air flow; 5. Water body design; 6. Dynamic and diffused light; 7. Natural systems
Nature analogies	1. Natural forms; 2. Natural materials; 3. Complexity and order
Naturalistic space	1. Outlook; 2. Sanctuary; 3. Mystery; 4. Riskiness

2.2. The value of nature-friendly design in office environments

The application of nature-friendly design in office environments yields comprehensive benefits across multiple dimensions. From a psychological perspective, the introduction of natural elements can significantly reduce cortisol levels and alleviate cognitive fatigue through the Attention Restoration Theory (ART) mechanism, thereby enhancing creative output efficiency by 15–20% [7]. Physiologically, indoor plant communities can absorb more than 30% of volatile organic compounds (VOCs), and when combined with passive humidity regulation systems, they can maintain a relative humidity range of 40–60% that is optimal for human comfort [8]. Organizational behavior research shows that office spaces with nature-friendly design increase employee retention rates by 12–18%, and companies that have obtained LEED or WELL certifications exhibit significant advantages in attracting talent [9]. These benefits collectively constitute the intrinsic motivation for modern enterprises to adopt nature-friendly design, making it a core strategy for enhancing the quality of office spaces.

3. Key strategies for nature-friendly design in offices

3.1. Direct introduction of natural elements

The nature-friendly design of office spaces primarily achieves direct integration of natural elements through two approaches. In terms of plant configuration, vertical greening systems utilize modular planting units to facilitate space-efficient utilization. Ecological walls, combined with automatic irrigation technology, can establish a stable indoor micro-ecosystem. Meanwhile, mobile potted plant systems provide a flexible means of space division. Natural light optimization strategies emphasize passive design in architecture, with light wells using light-guiding technology to introduce natural light into deeper spaces.

High-transmittance glass partitions ensure visual connectivity while reducing the need for artificial lighting.

Intelligent dynamic shading systems automatically adjust based on the sun's angle, achieving optimal lighting and thermal comfort balance throughout the year. These technical measures collectively create an office environment with biophilic characteristics. Furthermore, the introduction of water features, such as indoor water curtain walls or small fountain systems, not only enhances the aesthetic appeal of the space but also regulates air humidity, enhancing the ecological perception of the environment. The use of natural materials, such as wood, stone, and bamboo, strengthens the connection between humans and nature both visually and tactually.

Natural ventilation strategies, utilizing operable window sashes, wind towers, or atrium designs, introduce fresh air and improve indoor air quality. These diverse technical measures collectively create an office environment with biophilic characteristics, effectively enhancing user comfort and work efficiency (**Table 2**).

Table 2. Direct incorporation of natural elements (Table source: drawn by the author)

Key strategies for biophilic office design	Implementation methods	Design elements
Direct integration of natural elements	Vertical greening	Visual connections;
	Portable potted plants	Visual connections;
	Light wells	Dynamic and diffused light;
	Smart shading systems	Dynamic and diffused light;
	Water walls, Mini fountains	Visual connections; Water body design;
	Natural materials	Natural materials; Visual connections;
	Wind towers, Atriums	Non-visual connections; Heat and air flow;

3.2. Indirect expression of natural imagery

In spaces where direct incorporation of natural elements is not feasible, meticulous design of colors and textures can still evoke natural associations in users. The application of earthy tones follows environmental psychology principles, creating a sense of stability with low-saturation colors such as warm grays, terracotta, and moss green. The color temperature is controlled within the range of 3000–4000K to simulate natural lighting effects.

The composition of organic forms draws on fractal geometry theory, breaking the mechanical feel of artificial environments through design languages such as asymmetric curves and irregular interfaces. In terms of material selection, recycled wood with natural textures and mineral coatings not only meet visual needs but also enhance the user's natural experience through tactile feedback [10].

Additionally, creating a soundscape is also an important approach. By introducing natural sound effects (such as flowing water and bird songs) or using materials with natural sound sensations (such as bamboo wind chimes), the ecological atmosphere of the space can be effectively enhanced.

Odor design is equally important. Utilizing natural plant essential oils or wood aromas can evoke memories of natural environments such as forests and grasslands, enhancing the natural affinity of the space. Simulating light and shadow effects can also enhance natural perception, such as using dynamic light projection technology to simulate the effect of sunlight passing through leaves, or using translucent materials to create a soft natural light sensation. These diverse indirect expression methods, while maintaining the functionality of modern office spaces, successfully incorporate ecological aesthetic values, further enhancing users' comfort and psychological pleasure (**Table 3**).

Table 3. Direct introduction of natural elements (Table source: drawn by the author)

Key strategies for biophilic office design	Implementation methods	Design elements
Indirect expression of natural elements	Earth tones	Visual connections;
	Natural textures	Visual connections;
	Color temperature of simulated Natural light	Visual connections;
	Organic forms	Natural forms;
	Wind chimes with natural Sound effects	Dynamic and diffused light;
	Natural plant essential oils	Irregular sensory stimuli
	Aromatic wood	Irregular sensory stimuli
	Soft translucent materials	Dynamic and diffused light

4. Case study on the practice of nature-friendly design in offices

4.1. Case studies of co-working spaces abroad

4.1.1. Case background: Second Home co-working space in London

Second Home, located in the Spitalfields area of East London, spans two floors and covers approximately 6,000 square meters. It stands as a typical example of biophilic office space design in recent years (**Figure 1**).

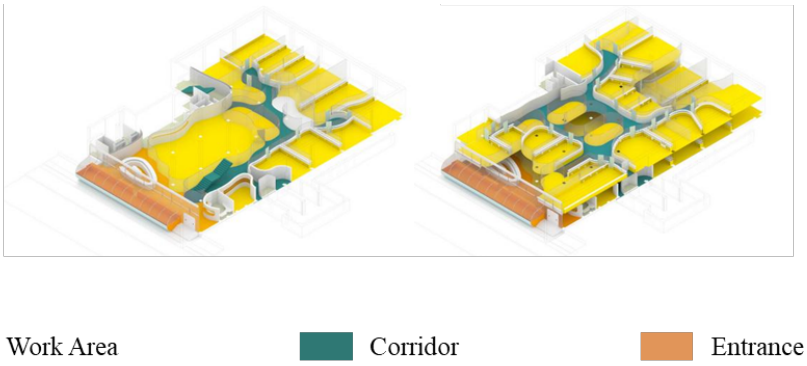

Figure 1. Ground and second floor plans (Image source: www.Archaily.com).

Its core objective lies in enhancing users' physical and mental health, as well as social interaction efficiency, through the deep integration of architecture and the natural environment. Distinct from traditional enclosed and mechanized office spaces, Second Home leverages natural light, abundant vegetation, and an organically flowing spatial layout to create an open and ecologically rich workplace. By introducing and integrating natural elements, this project not only fulfills individuals' physiological health needs but also enhances psychological pleasure and cognitive focus. Furthermore, Second Home has further expanded the connotation of biophilic design in terms of spatial organization and atmosphere shaping, transforming the office space into a "second home" that integrates ecology, creativity, and social interaction. Thus, this case exemplifies the trend of contemporary office environments shifting from functionality to humanism and sustainability.

4.1.2. Design highlights: deep integration of natural elements, dynamic optimization of environmental rhythms, and comprehensive enhancement of multi-sensory experiences

Firstly, in terms of the introduction of natural elements, the project extensively arranges green vegetation both indoors and outdoors (**Figure 2A**), giving the office environment the characteristics of an "urban oasis" or "indoor

forest". This large-scale vegetation not only provides natural scenery at the visual level, but also plays a positive role at the physiological and psychological levels, helping to reduce stress levels, enhance emotional states, and increase happiness [11].

Secondly, the project has undergone refined design in terms of light environment and spatial rhythm. Through large-area floor-to-ceiling glass, skylights, and translucent partitions (**Figure 2B**), the indoor space is able to maximize the introduction of natural light, allowing users to perceive changes in day and night and seasons during daily office work. This infiltration of dynamic light and shadow not only improves the comfort of the space but also helps regulate the human body's biological clock, enhancing attention and productivity [12].

Furthermore, Second Home fully embodies naturalness and organicness in its spatial form and material selection (**Figures 2A and 2B**). The design abandons the straight and rigid layout typical of traditional office settings, opting instead for a curved and flowing spatial arrangement, coupled with organic materials such as natural wood and glass, creating a soft and warm spatial texture. This design not only enhances sensory comfort but also echoes the principle of "natural form and texture" emphasized in biophilic design [13].

Figure 2. The interior real scene photos. A. Integration of indoor and outdoor vegetation creating an "urban oasis" office environment; B. Use of natural lighting through floor-to-ceiling glass and skylights to enhance spatial rhythm and comfort. (Data source: www.Archaily.com).

4.2. Case of domestic enterprise headquarters

4.2.1. Case background: The headquarters of a real estate company

The project is located in the Economic and Technological Development Zone in the north of Langfang City, Hebei Province, on the north side of Xiangyun Road and the west side of Yuquan Road. The aboveground building area is 17,420.71 square meters, divided into three main office buildings: B, C, and D (with a standard floor area of 2,100 square meters for buildings B + C). The building height is ≤ 48 meters, serving as the headquarters building for the real estate company. The internal functions include customer service/intelligent capability operation center, lifestyle experience center, and a core focus on the company's advanced intelligent and ecological office concept. The project innovatively combines nature-friendly design with employee behavior and scenario-based creation, hoping to provide new ideas for corporate headquarters office spaces (**Figure 3 and Figure 4**).

Figure 3. Architectural rendering (Image source: Drawn by the author).

Figure 4. Standard floor plan of buildings B and C (Image source: Drawn by the author).

4.2.2. Design highlights: Disassembly and reference of natural elements, creation of scenes imitating natural elements

Firstly, the project fully utilizes the direct introduction and indirect expression of natural elements, breaking them down into four dimensions (**Figure 5**): vertical greenery (using broad-leaved plants such as turtle-back bamboo that are easy to grow in the north) can effectively reduce the sound and visual interference from dynamic spaces to static spaces; the use of natural-looking office carpets helps reduce employees' work pressure and enhance comfort; mobile flower beds can be used to flexibly divide spaces and be called upon as needed; desktop greenery can choose plants such as Pothos that are easy to maintain, increasing the green content of the space and enhancing the comfort of the office environment.

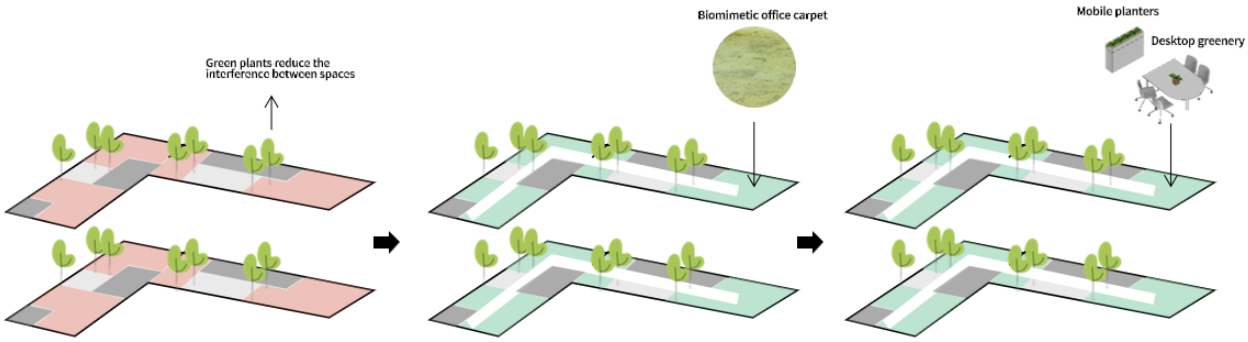

Figure 5. Incorporation of natural elements in the standard floor (Image source: Drawn by the author).

Secondly, the design utilizes natural wood-grain panels as the primary design element for the walls, combined with earth-toned paints for the ceiling and floor, as well as terrazzo, to simulate a natural indoor space. Furthermore, it incorporates linen carpets and locally green imitation grass carpets to distinguish different spatial attributes, complemented by organically shaped office furniture, creating various office scenarios that are conducive to employees' better value creation and work efficiency improvement (**Figure 6**).

Figure 6. Biophilic design in the standard floor office (Image source: Drawn by the author).

5. Challenges and optimization paths in the implementation of nature-friendly design

5.1. Technical challenge

5.1.1. Plant maintenance and indoor microecological balance

The sustainable operation of indoor plant systems faces multiple technical bottlenecks. Shade-loving plants have reduced photosynthetic efficiency in low-light environments, necessitating the use of artificial light compensation systems, which leads to increased energy consumption. The air circulation in enclosed spaces is limited, and plant transpiration often causes humidity to exceed the human comfort range. The imbalance of microbial communities is particularly prominent, and the concentration of mold spores in soil substrates may exceed standards. Existing solutions include developing new soilless cultivation media, using nano-coatings to inhibit the proliferation of pathogenic bacteria, and introducing intelligent environmental linkage systems. However, these technologies still

have drawbacks such as high cost or insufficient stability, which restrict their large-scale application [14].

5.1.2. Collaborative control of natural lighting and artificial lighting

The design of building lighting interface faces the contradiction between sunlight radiation and visual comfort, and glare is prone to occur when the visible light transmittance (VLT) of the curtain wall exceeds 40%. The existing lighting control systems mostly use single factor adjustment of illumination, which is difficult to adapt to the lighting environment requirements of different work scenarios [15]. The new light environment management system achieves dynamic matching of natural lighting and LED supplementary lighting through a distributed illuminance sensor network and a working face illuminance demand model. However, the system has technical defects such as response delay (about 2–3 seconds) and abrupt regional transitions, and the high-precision sensor array increases the initial cost by 25–30%, which restricts the popularization of technology [16].

5.2. Coordinated control of natural lighting and artificial lighting

5.2.1. Economic challenges

The initial investment in nature-friendly design is 20–35% higher than that of traditional solutions, primarily due to the procurement of ecological materials (such as a 40% premium for FSC certified wood) and the deployment of intelligent systems [17]. The comprehensive cost of a vertical greening system reaches 3,000–5,000 yuan per square meter, and the payback period is usually over 5 years [18]. However, a full life cycle assessment shows that through reduced energy consumption (saving 15–25% annually) and improved employee efficiency (equivalent to 3–5% of annual labor costs), the investment payback period can be shortened to 3–4 years [19]. The current market lacks standardized assessment tools, making it difficult for owners to quantify potential benefits when making decisions, which hinders project financing. Establishing a comprehensive cost-benefit analysis model has become crucial for promoting the implementation of this technology.

5.2.2. Supply chain constraints of low-carbon materials

The current low-carbon building materials market faces severe structural contradictions between supply and demand. The production capacity of recycled building materials that meet EPD certification can only meet 15% of the market demand, resulting in a 60–90 days extension of the delivery cycle [20]. The problem of regional supply imbalance is prominent, and the transportation of low-carbon concrete prefabricated parts from the western region to the eastern coastal region actually increases the carbon footprint. The material certification system is highly fragmented, and the varying requirements for recycled material content in standards such as LEED and BREEAM make it difficult for manufacturing enterprises to achieve large-scale production, severely restricting the standardized promotion of nature-friendly design.

5.3. Optimization of design methodology

5.3.1. Quantitative assessment tools: Such as the nature-friendly indicators in the WELL building standard

The current evaluation system still has significant limitations in the quantitative evaluation of pro natural design. Although the WELL v2 standard establishes the concept of “natural systems” (Feature X05), its seven scoring indicators only cover 30% of biologically friendly environmental elements. Especially for the evaluation of spatial sequences and natural rhythms, there is a lack of objective parameters, mainly relying on subjective scores from experts. The emerging digital assessment tools attempt to establish a mathematical model of the correlation between alpha wave activity and natural elements through EEG monitoring and eye tracking technology, but the sample size is insufficient, resulting in low reliability and validity. Developing an intelligent evaluation platform

that integrates physiological feedback and building parameters has become a key breakthrough direction for improving the scientificity of design.

5.3.2. Interdisciplinary collaboration: The Integration of architecture, environmental psychology, and IoT technology

The deepening of pro nature design urgently requires the construction of interdisciplinary collaboration frameworks. The architectural spatial form parameters (such as window to ground ratio and line of sight transparency) need to be quantitatively correlated with the stress threshold model (cortisol level < 15 **μg**/dL) used in environmental psychology research. The IoT sensor network can collect 12 environmental data in real-time, including CO_2 concentration (maintaining < 800 ppm) and light intensity (300–500 lux), but there are protocol incompatibility issues in multi-source information fusion. Digital twin technology provides a new path for interdisciplinary collaboration, integrating biometric data and building performance simulation through BIM platforms. However, the current efficiency of data exchange among various disciplines is insufficient. Establishing a unified data standard and collaborative design platform is the key to breaking through disciplinary barriers.

6. Conclusion

The application of nature friendly design in office spaces has evolved from a simple aesthetic pursuit to a systematic engineering that integrates environmental performance and humanistic care. Practice has shown that the intervention of natural elements in science can increase work efficiency by 12–18% and reduce building energy consumption by 20–30% [21]. The current technological bottleneck mainly focuses on the precision of microenvironment control and cross system collaboration, while the standardization of cost-benefit analysis will directly affect market acceptance. With the inclusion of biodiversity indicators in the scoring system of the "Green Building Evaluation Standards" (GB/T50378-2023), it is necessary to focus on breakthroughs in dynamic environmental optimization algorithms supported by digital twin technology in the future. The development of this field is not only related to the improvement of building performance, but also an important practice for reconstructing the symbiotic relationship between humans, buildings, and nature.

Disclosure statement

The author declares no conflict of interest.

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