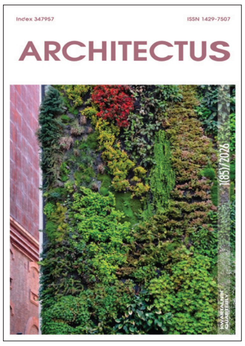

Architectus

2026
1(85)

DOI: 10.37190/arc260105

Dominika Kumorek*, Przemysław Kiełb**

Biophilic solutions in higher education – an analysis of their presence on the Central Campus of the Warsaw University of Technology

Abstract

For millennia, humans have been closely connected to nature. The progress of industrialization has significantly limited this connection. Biophilic design is a response to the effort to reintegrate nature into everyday life. The aim of this article is to assess the presence and extent of selected biophilic patterns within the Central Campus of the Warsaw University of Technology. The adopted research methods included a literature review, field observation, and an analysis of the occurrence of 14 biophilic patterns at selected campus locations. Data, in the form of ratings assigned to each point, were collected through an online survey form. The results of the study are presented as maps of the Central Campus, with color-coded markings corresponding to the collected evaluations. The article concludes with recommendations for the future development of the campus in line with the principles of biophilia.

Key words: biophilia, biophilic design, 14 patterns, academic campus, Warsaw University of Technology

Introduction

What is biophilia?

For millennia, humans were inextricably linked with nature. It dictated the rhythm of daily and annual life, agricultural practices, seasonal activities, and many other aspects of human existence. However, the last centuries of industrialization have effectively limited our connection with the natural world. Before the Industrial Revolution, the vast majority of people lived in rural areas and, by necessity, spent much of their time in natural surroundings. The American landscape architect Frederick Law Olmsted argued as early as 1865 that […] *the enjoyment of scenery employs the mind without fatigue and yet exercises it, tranquilizes it and yet enlivens it; and thus, through the influence of the mind over the body, gives the effect of refreshing rest and reinvigoration to the whole system* (Olmsted 1990, 504). This tendency stems from the human inclination to seek a connection with nature. Such an innate attachment to life or living systems eventually came to be known as biophilia. The term was first defined by the German psychoanalyst Erich Fromm, who in 1973 wrote that it is […] *the passionate love of life and of all that is alive; it is the wish to further growth, whether in a person, a plant, an idea, or a social group* (1973, 365). The concept was subsequently popularized by the biologist Edward O. Wilson. In his book *Biophilia*, he defined the phenomenon as: […] *innate tendency to focus on life and lifelike processes* (1984, 1) and put forward the hypothesis that this relationship is not merely physiological but has a genetic basis. This hypothesis assumes that humans possess an inherited need to connect with nature and other biotic forms due to their evolutionary dependence on them, rooted in the fundamental drive for survival as well as personal fulfillment.

Biophilic design

The theoretical foundations of biophilic design were developed in the 1990s by Stephen Kellert, a professor of

* ORCID: 0009-0000-3477-5558. Faculty of Architecture, Warsaw University of Technology Doctoral School, Poland, e-mail: dominika.kumorek.dokt@pw.edu.pl

** ORCID: 0009-0000-0965-8528. Faculty of Architecture, Warsaw University of Technology Doctoral School, Poland.

social ecology. In his subsequent publications, he tried to translate theory into the foundations for the practical application of biophilia (Kellert, Wilson 1993; Kellert 1997; 2008; 2018; Kellert et al. 2008). To this end, he defined the principles of biophilic design as having two fundamental dimensions. The first is the organic or naturalistic dimension, defined as shapes and forms within the built environment that reflect the innate human affinity for nature in the following ways:

– direct – unstructured contact with elements of the natural environment, such as daylight, plants, animals, natural habitats, and ecosystems;

– indirect – contact with nature that requires ongoing human intervention to survive, e.g., a potted plant, a fountain, or an aquarium;

– symbolical – not requiring actual contact with nature, e.g., a painting, photograph, etc.

The second dimension concerns buildings and landscapes that connect with the culture and ecology of a given place or geographic area. It encompasses what has been termed the "spirit of place" (*genius loci*), that is, the way in which […] *buildings and landscapes of meaning to people become integral to their individual and collective identities, metaphorically transforming inanimate matter into something that feels lifelike and often sustains life* (Kellert et al. 2008, 6). Based on these fundamental dimensions, Kellert further identified six elements of biophilic design: environmental features, natural shapes and forms, natural patterns and processes, light and space, place-based relationships, and evolved human–nature relationships. These were subsequently elaborated into more than 70 attributes of biophilic design. However, the foundations outlined by Kellert for designers were largely intuitive. He did not define specific measurments, characteristics, or other parameters that would clearly indicate guidelines for implementation in design. Nor did he present empirical evidence justifying the validity of his assumptions. Nevertheless, the health-promoting effects of contact with nature had already been confirmed at that time, among others through the groundbreaking study by Roger Ulrich, which compared recovery indicators among patients with access to a view of nature and those without such access (Ulrich 1983).

Over time, biophilic design – albeit still largely intuitively – began to be implemented dynamically in new projects. *We weren't trying to ride the green wave, we were driving that wave* […] (mcdonoughpartners.com), stated Ed Nagelkirk from the American company Herman Miller, whose manufacturing facility designed by William McDonough + Partners in the 1990s was one of the first projects confirming the validity of these assumptions. The experiment conducted there linked mechanisms of increased productivity with connecting building users to nature (Heerwagen, Hase 2001). Since then, scientists and designers have continued to work on defining those aspects that have the greatest impact on our satisfaction with the built environment. In the last decade, there has been a steady increase in studies at the intersection of neuroscience and architecture, both in research and in practice (Cama 2009; McCollough 2009; Bowler et al. 2010; Annerstedt, Währborg 2011; Marcus, Sachs 2014; Frumkin 2001; Ulrich et al. 2008; Gillis, Gatersleben 2015).

Design patterns – search criteria

One of the key contributions to the development of design patterns is the report prepared by William Browning, Catherine Ryan, and Joseph Clancy (Browning et al. 2014). In this work, the authors move from research on human responses to biophilic factors toward practical design applications. They present biophilic design in the context of the history of architecture, health sciences, and contemporary architectural practice, and also briefly address key issues related to its implementation. The report concludes with 14 patterns of biophilic design, supported by empirical evidence and theoretical studies derived from extensive interdisciplinary research. The authors focus on the psychological, physiological, and cognitive benefits resulting from the application of individual patterns. The use of the term "patterns" is justified by the explanation offered by the architect and theorist Christopher Alexander, who stated that patterns […] *describes a problem which occurs over and over again in our environment, and then describes the core of the solution to that problem, in such a way that you can use this solution a million times over, without ever doing it the same way twice* (Alexander et al. 1977, 10). Browning, Ryan, and Clancy focus on known, suggested, or theorized patterns of nature that can be applied across different sectors and scales in order to mitigate common stressors or enhance other selected characteristics. They divide biophilic design into three categories: *Nature in the Space*, *Natural Analogues*, *and Nature of the Space*. These are further specified through 14 patterns (7 for *Nature in the Space*, 3 for *Natural Analogues*, and 4 for *Nature of the Space*), illustrating their usefulness in supporting three functions: stress reduction, enhancement of cognitive performance, and improvement of emotions, mood, and the overall condition of the human body. The authors outline what may be described as degrees of proven effectiveness, through which they scale the extent to which a given pattern has been scientifically confirmed by rigorous empirical data. The better documented the health-promoting effects of a given attribute (in terms of the quantity and quality of available peer-reviewed evidence), the more points it received on a unit scale (0–3), and thus the greater its impact. Although some of the presented patterns received a score of zero, the researchers emphasize that […] *the anecdotal information is adequate for hypothesizing its potential impact and importance as a unique pattern* (Browning et al. 2014, 22).

Moreover, Browning, Ryan, and Clancy provided detailed descriptions of each pattern, emphasizing the relationships between them, the ways in which they are experienced, their origins, and approaches to working with them in design. More importantly, from the perspective of the research presented in this article, they also presented examples of built projects employing individual patterns, as well as spatial or experiential elements – either occurring naturally or simulated – that determine the identification of patterns within a given space. These elements are particularly useful in the context of analyzing the scale and locations of biophilic components on the Central Campus of the Warsaw University of Technology.

Nature in the Space refers to the presence of natural elements within a given environment, both in physical form

– plants, water, and animals – and in ephemeral forms – wind, sounds, scents, and other less tangible natural phenomena. Their material representation may include potted plants, flower beds, bird feeders, butterfly houses, water bodies, fountains, aquaria, courtyard gardens, as well as green walls or roofs, among others. Creating meaningful and direct interactions with these elements – through their diversity, movement, and multisensory engagement – makes it possible to achieve the greatest benefits associated with *Nature in the Space* (Browning et al. 2014). This category includes seven biophilic design patterns:

1. Visual Connection with Nature – a view to elements of nature, living systems, and natural processes.

2. Non-Visual Connection with Nature – auditory, haptic, olfactory, or gustatory stimuli that engender a deliberate and positive reference to nature, living systems or natural processes.

3. Non-Rhythmic Sensory Stimuli – stochastic and ephemeral connections with nature that may be analyzed statistically but may not be predicted precisely.

4. Thermal & Airflow Variability – subtle changes in air temperature, relative humidity, airflow across the skin, and surface temperatures that mimic natural environments.

5. Presence of Water – a condition that enhances the experience of a place through the seeing, hearing or touching of water.

6. Dynamic & Diffuse Light – leveraging varying intensities of light and shadow that change over time to create conditions that occur in nature.

7. Connection with Natural Systems – awareness of natural processes, especially seasonal and temporal changes characteristic of a healthy ecosystem (Browning et al. 2014, 9).

Natural Analogues refer to organic, non-living, and indirect associations with and representations of nature, expressed through objects, materials, colors, shapes, sequences, and patterns found in nature, and manifested in the built environment as artworks, ornaments, furniture, decorations, and textiles. Imitating organic forms and natural materials provides a substitute for direct connections with nature. The strongest experience of *Natural Analogues* can be achieved by providing a richness of information in an organized – and sometimes evolving – manner. This category includes three biophilic design patterns:

8. Biomorphic Forms & Patterns – symbolic references to contoured, patterned, textured, or numerical arrangements that persist in nature.

9. Material Connection with Nature – materials and elements from nature that, through minimal processing, reflect the local ecology or geology and create a distinct sense of place.

10. Complexity and Order – rich sensory information that adheres to a spatial hierarchy similar to those encountered in nature (Browning et al. 2014, 10).

Nature of the Space refers to spatial configurations found in the natural environment. This includes both the innate and learned human desire to perceive surroundings beyond one's immediate range, as well as a fascination with what is potentially dangerous or unknown – such as obscured views and the moments of discovery associated with them – while still incorporating a trusted element that ensures safety. A meaningful experience of the *Nature of Space* is achieved by creating intentional and engaging spatial solutions combined with patterns of *Nature in the Space* and *Natural Analogues*. This category includes four biophilic design patterns:

11. Perspective – an unimpeded view over a distance, for surveillance and planning.

12. Refuge – a place for withdrawal from environmental conditions or the main flow of activity, in which the individual is protected from behind and overhead.

13. Mysery – the promise of more information, achieved through partially obscured views or other sensory devices that entice the individual to travel deeper into the environment.

14. Risk/Peril – an identifiable threat coupled with a reliable safeguard (Browning et al. 2014, 10).

State of research

For the purposes of this article, an analysis of scientific literature was conducted on studies concerning biophilic solutions in higher education institutions, as well as in classrooms of upper secondary schools representing a group comparable in age and stress exposure to university students. Due to the lack of prior comprehensive studies, the analysis focuses on publications from 2019 to 2024. Many of the available studies report experimental research comparing students' perceptions of two learning environments: biophilic and non-biophilic. These comparative studies can be divided into those in which environments were physically arranged for the duration of the experiment (Burton 2022) and those in which a simulated biophilic space was created using Virtual Reality (VR) tools (Mahrous et al. 2022; 2023). The primary focus of such studies is students' perceptions, levels of satisfaction, and cognitive performance. Parameters were assessed using surveys and interviews with numerical and descriptive scales (Burton 2022), focus groups (Peters, D'Penna 2020), as well as psychological and functional tests conducted before and after classes (Mahrous et al. 2022; 2023). Using these methods, a study conducted in a secondary school in Baltimore, USA, demonstrated that students using a biophilic classroom achieved better results than those in a control classroom (Determan et al. 2019). Moreover, the average increase in monthly test scores over three months for students in the biophilic classroom was more than three times higher than for those in the control classroom (Determan et al. 2019). The studies also indicated relationships between specific biophilic attributes and student preferences (Mahrous et al. 2022), showing that the greatest impact on performance improvement in academic design studios comes from [...] *lighting and shading, plantation, naturally inspired color* [...] *and daylighting* (Mahrous et al. 2022, 11). In terms of satisfaction, the most influential factors were natural lighting, the presence of greenery, large windows, indirect contact with nature, and natural finishing materials, increasing it by 78%, 76%, 63%, 66%, and 51%, respectively (Mahrous et al. 2023). The most frequently highlighted advantage of biophilic design in academic settings is stress reduction. This is particularly significant given that, globally, the prevalence of depression among students often exceeds that of the general population (Peters, D'Penna 2020). Students face stress stemming from academic demands, financial difficulties, family situations, and general uncertainty (Mahrous et al. 2022). Enhancing the health-promoting qualities of the environment through the introduction of biophilic attributes helps students reduce stress and focus better on their studies (Peters, D'Penna 2020).

Analysis of publications on biophilic preferences in outdoor spaces has revealed a clear preference for environments that are interesting and non-monotonous. Diversity in forms translates into a strong sense of comfort and attractiveness. Previous research consistently shows a preference for natural environments over urbanized spaces (Dosen, Ostwald 2016). Studies confirmed the preference for elements such as vegetation, seating areas, and water features. Student research also highlighted a strong liking for open spaces with lawns, while paved surfaces were considered the least attractive element (Hami, Abdi 2019). Preferred natural materials included wood and stone, with an emphasis on the importance of using local materials and styles as elements that foster a sense of place (Peters, D'Penna 2020). Diverse preferences were also observed for the arrangement of outdoor learning and recreational spaces. In educational areas, vertical natural elements were desirable, whereas in recreational spaces, the key features were shade-providing trees and benches. Additionally, winding sensory paths and colorful vegetation were shown to support student community engagement, promoting interaction and social integration (Hami, Abdi 2019). At the same time, prior studies indicate that students have limited – but growing – awareness of the concept of biophilia. They understand it primarily as the human need for contact with nature and the harmonious integration of natural elements into urban spaces. They are aware of the necessity for public participation in environmental protection and recognize the importance of education in fostering pro-ecological attitudes (Shin, Seol 2020). However, a thorough review of the literature revealed a lack of studies specifically addressing the knowledge, preferences, and impact of biophilic solutions on teachers and academic staff.

Fig. 1. Location of high greenery within the Central Campus of the Warsaw University of Technology: A – Main Building; B – Physics Building; C – Chemistry Building; D – Mechanics Building and The Old Boiler House; E – Environmental Engineering Building; F – residential buildings; G – New Drawing Office Building; H – Aerodynamics Building; I – Aeronautics Building; J – New Aeronautics Building; K – Electrical Engineering Building; L – Chemical Technology Building; M – Mathematics Building; ▲ – open entrance gates; ▲ – closed entrance gates; ● – fountain (elaborated by D. Kumorek, P. Kiełb based on data provided by the Environmental Protection Department, Office of the City of Warsaw)

Il. 1. Lokalizacja zieleni wysokiej na terenie Kampusu Centralnego Politechniki Warszawskiej: A – gmach główny; B – gmach fizyki; C – gmach chemii; D – gmach mechaniki i starej kotłowni; E – gmach inżynierii środowiska; F – budynki mieszkalne; G – gmach nowej kreślarni; H – gmach aerodynamiki; I – gmach lotniczy; J – gmach lotniczy nowy; K – gmach elektrotechniki; L – gmach technologii chemicznej; M – gmach matematyki; ▲ – bramy wjazdowe czynne; ▲ – bramy wjazdowe nieczynne; ● – fontanna (oprac. D. Kumorek, P. Kiełb na podstawie danych udostępnionych przez Biuro Ochrony Środowiska Urzędu Miasta Stołecznego Warszawy)

Methods

The study was conducted to analyze the presence, scale, and spatial distribution of biophilic elements on the Central Campus of the Warsaw University of Technology. The territorial scope of the research encompassed publicly accessible outdoor spaces. The existing campus layout, including the distribution of low and high vegetation as well as the functional zoning of the area, is presented in Figure 1.

The study was conducted in January and February 2025 (winter semester). To ensure reliable results, each day of data collection was selected to have similar weather conditions. Meteorological data for January and February were analyzed, and the following criteria were established:
– general conditions: moderate cloud cover;
– air temperature: 0–5°C,
– precipitation: none,
– wind speed: 1–5 m/s,
– wind direction: stable, without sudden changes,
– visibility: very good, no fog.

Data collection was conducted between 10:00 a.m. and 3:00 p.m., corresponding to peak campus activity. For the field study, observation and analysis of the presence and scale of the 14 biophilic design patterns were performed. The assessment was carried out at pre-selected field points using a prepared data recording form. Field points were determined by overlaying a 20 × 20 m grid on a map of the campus, positioned so that the grid nodes covered as many publicly accessible outdoor spaces as possible (Fig. 2). From preliminary spacing proposals, this grid width was chosen to generate a sufficient number of points for accurate analysis while avoiding unnecessary data multiplication. This resulted in 152 survey points. During the study, 14 of the 152 points were excluded from the assessment due to lack of access, caused by ongoing construction work, entry restrictions, or encountering closed areas. Consequently, 138 field points were analyzed.

Due to the large volume of potential data and the resulting need to optimize data collection time, the survey form was created using a Google Workspace tool – Google Forms. It consisted of a set of questions aimed at both identifying the presence of and assessing the intensity of the 14 biophilic patterns at each field point. The evaluation used a semantic scale with the following values and descriptions:

0 – absence of the pattern and no impact,
1 – presence with very weak impact,
2 – presence with weak impact,
3 – presence with moderate impact,
4 – presence with strong impact,
5 – presence with very strong impact.

Each survey response was assigned the number of the corresponding field point, according to the previously described grid. The criteria for assessment were based on the work of Browning et al. (2014), which provided guidance on what should be considered a manifestation of a given pattern. A detailed analysis of the implementation of patterns – which were often incidental or based solely on the researchers' impressions – was not the focus of this article. The respondents for the survey were exclusively the authors of this publication. Selected biophilic elements were photographed to validate the authors' assessments and are presented in Figure 3.

Fig. 2. Map of the Central Campus of the Warsaw University of Technology showing the locations of field points (elaborated by D. Kumorek, P. Kiełb)

Il. 2. Mapa Kampusu Centralnego Politechniki Warszawskiej z lokalizacją punktów terenowych (oprac. D. Kumorek, P. Kiełb)

Results

The results of the study are presented as a set of campus maps with color-coded markings (Fig. 4). The colors correspond to the ratings of individual biophilic patterns (1 to 14) at the nodes of the initially established grid. The presentation of results also includes a map showing the cumulative assessment of the degree of biophilia at the surveyed locations, using a different color scheme for clarity (Fig. 5).

The analysis of the presence and impact of the 14 biophilic design patterns on the Central Campus of the Warsaw University of Technology revealed significant variation both in their spatial distribution and in the intensity of their effects.

The patterns with the greatest representation belonged to the *Nature in the Space* category, particularly *Visual*

Fig. 3. Compilation of photographs of selected biophilic elements: 1 – biophilic forms and patterns, 2 – perspective, 3 – refuge, 4 – risk/danger, 5 – mystery (photo by D. Kumorek)

Il. 3. Zestawienie fotografii wybranych elementów biofilnych: 1 – formy i wzory biomorficzne, 2 – perspektywa, 3 – schronienie, 4 – ryzyko/niebezpieczeństwo, 5 – tajemnica (fot. D. Kumorek)

Fig. 4. Compilation of maps of the Central Campus of the Warsaw University of Technology with color-coded markings corresponding to the ratings of individual biophilic patterns (1–14) at the surveyed field points (elaborated by D. Kumorek, P. Kiełb based on data provided by the Environmental Protection Department, Office of the City of Warsaw)

Il. 4. Zestawienie map Kampusu Centralnego Politechniki Warszawskiej z oznaczeniami kolorystycznymi odpowiadającymi ocenom poszczególnych wzorców biofilnych (1–14) w badanych punktach węzłowych (oprac. D. Kumorek, P. Kiełb na podstawie danych udostępnionych przez Biuro Ochrony Środowiska Urzędu Miasta Stołecznego Warszawy)

Connection with Nature (pattern 1), *Connection with Natural Systems* (pattern 7), and *Dynamic and Diffuse Light* (pattern 6). These patterns are mainly present in the central part of the campus, among the greenery surrounding the Physics building and along pedestrian routes traversing the more open areas of the campus. In the center, due to the fountain located there, an increased presence of *Water* (pattern 5) was also observed. Moving toward the periphery of the study area, an increase in the impact of *Non-Rhythmic Sensory Stimuli* (pattern 3) can be noted.

Patterns from the *Natural Analogues* group were much less represented. In particular, *Biomorphic Forms and Patterns* (pattern 8) and *Material Connection with Nature* (pattern 9) appeared only sporadically with high values, while in most cases they exhibited a low degree of impact. They were mainly present as incidental decorations or architectural details lacking coherence and systematization. A consistent material narrative referencing the local ecology or geology was also absent. The lack of rhythmic façades and the diversity of architectural styles was reflected in the very low values for *Complexity and Order* (pattern 10).

Elements assigned to the *Nature of the Space* category, such as *Prospect* (pattern 11), *Refuge* (pattern 12), *Mystery* (pattern 13), and *Risk/Peril* (pattern 14), appeared only incidentally, mainly in relation to the existing spatial layout (e.g., alcoves and courtyards). There was no evidence that these elements had been intentionally designed to utilize these patterns. Functional limitations – such as an excess of parking spaces, low-quality pedestrian areas, and insufficient accessibility for people with disabilities – further diminish the opportunities for experiencing and using the space in accordance with biophilic design principles.

The conducted study, while enabling the identification of significant biophilic gaps on the Central Campus of the Warsaw University of Technology, has certain limitations that should be considered when interpreting the results.

First, field observations were carried out during the winter season, which affected the perception of some biophilic patterns, particularly those related to the seasonality of vegetation or variability in weather conditions. Repeating the analysis in other seasons could reveal a different picture of the intensity and distribution of the examined patterns. While the study could be classified as a "winter study", the authors considered that conducting it at this time would not fundamentally determine its overall outcomes.

Second, the evaluation forms were completed exclusively by the authors. Although this ensured consistency in the applied criteria, it limited the objectivity of the results. Due to the availability of literature sources, findings from previous studies (Dosen, Ostwald 2016; Hami, Abdi 2019; Peters, D'Penna 2020) were used as a reference for understanding the perceptions and preferences of users of the Central Campus. Additional data from current campus users could be obtained through structured, two-stage workshops. In the first stage, participants would assess the space intuitively, without prior knowledge, and in the second stage, following a lecture component, they would evaluate the area again equipped with the appropriate "tools". This approach would allow a comparison between innate sensitivity to nature and the theoretical aspects of biophilia. Such a study could be

Fig. 5. Map of the Central Campus of the Warsaw University of Technology with markings corresponding to the overall biophilic quality assessment at the surveyed field points (elaborated by D. Kumorek, P. Kiełb)

Il. 5. Mapa Kampusu Centralnego Politechniki Warszawskiej z oznaczeniami odpowiadającymi sumarycznej ocenie jakości biofilnej w badanych punktach węzłowych (oprac. D. Kumorek, P. Kiełb)

the subject of future research, as the knowledge of other campus users regarding biophilia was not addressed in the present article.

In future studies, it would be valuable to involve a broader group of respondents – including students, academic staff, and administrative personnel – to better reflect the diverse experiences of campus users. Another limitation was the inaccessibility of certain survey points due to ongoing renovation works, which prevented a complete recording of the existing conditions.

Future research should focus on several directions of development. It would be important to extend the analysis to the interiors of educational and administrative buildings, where biophilic attributes play an equally significant role, particularly in the context of stress reduction and cognitive performance enhancement. The use of surveys, qualitative interviews, or psychological experiments could be considered to evaluate users' subjective experiences in comparison with the results of field observations.

This article presented the results of a spatial analysis, which provides a foundation for further empirical studies. An additional promising direction for future research could be a comparative study of the Warsaw University of Technology campus with other academic campuses in Poland and abroad. Such a comparison would situate the findings within a broader context and allow verification of the universality of the proposed recommendations.

Conclusions

Based on the presented results and the reviewed literature, conclusions were formulated in the form of design recommendations to support the development of the Central Campus of the Warsaw University of Technology in accordance with the principles of biophilia.

The recommendations were classified into two categories: general recommendations, which include spatially non-specific, universal guidelines, and detailed recommendations, which outline stages for implementing potential corrective measures in the areas of the campus with the most unfavorable biophilic conditions.

General recommendations

1. Reorganization and rationalization of space.

It is recommended to relocate a significant portion of parking functions outside the campus to free up space for the predominantly pedestrian traffic within the study area. Parking spaces that must remain on campus should not significantly interfere with the green fabric. Solutions such as permeable surfaces or integrating parking areas with compact high- and medium-height greenery as visual and acoustic buffers are suggested. New structures, however, should not obstruct existing axial lines and sightlines (*Prospect*, pattern 11). Reducing the share of car-related functions in the campus layout will allow for a more efficient organization of space that meets the needs of the academic community. Recommendations in this area include creating green, quiet spaces for relaxation and recreation, and areas for direct contact with nature, such as campus community gardens that integrate permanent campus residents with other users, or outdoor recreational zones. Zoning functionally diverse spaces will provide users with a sense of *Refuge* and impart a sense of *Mystery* to the environment (*Refuge* and *Mystery*, patterns 12 and 13). This goal can also be supported through the design of urban niches and interiors, year-round pavilions, and thoughtfully arranged greenery.

2. Increasing year-round accessibility of spaces.

Recommended actions, considering the seasonal variability of weather conditions, include increasing the accessibility of public spaces during colder periods, such as the central square, forecourts, and urban interiors of selected buildings. It is advisable to introduce solutions within the campus layout such as permanent or seasonal canopies and shelters, green windbreak structures, or local temporary heating installations like radiant heaters. These structures can also serve in warmer periods by providing localized shading, thereby reducing air temperature (*Thermal & Airflow Variability*, pattern 4). Openwork elements will additionally enhance the visual appeal of the space, creating dynamic patterns of light and shadow (*Dynamic & Diffuse Light*, pattern 6).

3. Increasing the presence and continuity of greenery.

Actions in this area should focus on increasing the presence of low-, medium-, and high-height vegetation. Particularly important for enhancing *Visual Connection with Nature* (pattern 1) is the addition of new medium- and high-height structures along publicly accessible pedestrian routes. To maintain the continuity of greenery, existing tree rows should be supplemented, forming a network of green landscape corridors that provide the site with biophilic cohesion. The proposed additional plantings would consist of targeted, small-scale interventions that improve the overall perception of the space without compromising usability or recreational opportunities, functioning as a form of spatial "acupuncture". Improving the condition of low vegetation will activate users, increasing both the functional and visual attractiveness of the space. Recommendations also include enhancing the biodiversity of plantings. Seasonal vegetation in pedestrian zones will help ensure a continuous visual presence of greenery throughout the year (*Connection with Natural Systems*, pattern 7).

4. Introducing a diversity of sensory stimuli.

It is recommended to introduce elements on campus that engage the senses–hearing, smell, and touch. *Non-visual connection with nature* (pattern 2) can be achieved through solutions that promote direct contact with natural elements. Examples include sensory gardens, aromatic flower meadows, or other low, multi-colored vegetation with olfactory qualities, such as herbs, as well as freestanding vertical gardens, green façades, and accessible green roofs. The presence of water can be provided through fountains, water curtains, or misting installations (*Water*, pattern 5). A *Material Connection with Nature* (pattern 9) and sources of *Non-Rhythmic Sensory Stimuli* (pattern 3) can be created through structures supporting small fauna – such as bird feeders and insect hotels – as well as sensory pathways composed of diverse natural materials, such as gravel, bark, or stones. When adding additional educational trails, care should be taken to maintain smooth circulation while enriching the space with features that improve areas exhibiting a low presence of biophilic elements. Local variations in terrain, such as small bridges, embankments, or localized depressions, can significantly enhance the perception of space and, combined with safe cues of *Risk/Peril* (pattern 14), create an environment that stimulates cognitive and physical engagement.

5. Implementation of biomorphic patterns and use of natural materials.

It is recommended to use renewable and locally sourced natural materials that complement the architectural expression of the existing campus buildings. Such materials include wood, stone, and brick (*Material Connection with Nature*, pattern 9). Existing *Biomorphic Forms & Patterns* in the study area, particularly sculptural elements on building façades, should be regularly maintained and supplemented as needed (pattern 8). New design and material structures should be visually coherent and consistent with the spatial hierarchy of the existing campus. It is especially important to respect the original fabric by maintaining the hierarchy of newly designed elements (*Complexity & Order*, pattern 10).

6. Educating and engaging the academic community.

Educational activities aimed at deepening knowledge of biophilia and the beneficial effects of biophilic design on human health and functional well-being constitute a particularly important element of strategies supporting the welfare of the academic community. Increasing awareness in this area can contribute to greater engagement in shaping campus spaces and, in the long term, support the mental, physical, and cognitive health of users. Recommended solutions to achieve these goals include: organizing independent workshops, seminars, and thematic meetings; integrating biophilia into the curricula of individual faculties; promoting the topic through semester projects and theses; and developing and disseminating innovative educational materials, such as multimedia games and applications with experience-mapping systems, or participatory platforms.

7. Systematic monitoring of biophilic quality.

A key element of a long-term strategy to enhance the biophilic quality of the Central Campus of the Warsaw University of Technology is the systematic monitoring and assessment of current conditions. Regular evaluation of the environment will enable the development and implementation of realistic management programs and support effective design decisions. It is therefore recommended to establish an interdisciplinary team responsible for managing environmental quality in the context of biophilic impact on campus, with tasks including the development of reliable research tools, preparation of regular reports with an updated list of recommendations, and implementation of pilot interventions along with studies of their social impact. Currently, digital IoT sensors are being used on campus for environmental monitoring (Koszewski et al. 2025). It is recommended to utilize such devices for collecting and analyzing data, including parameters such as air temperature and quality, wind direction and strength, humidity, noise levels, and sunlight exposure.

Fig. 6. Map of the Central Campus of the Warsaw University of Technology divided into areas: A – eastern area, B – central area, C – north-eastern area, D – north-western area, E – southern area, F – area not included in the study (elaborated by D. Kumorek, P. Kiełb)

Il. 6. Mapa Kampusu Centralnego Politechniki Warszawskiej z podziałem na obszary: A – obszar wschodni, B – obszar centralny, C – obszar północno-wschodni, D – obszar północno-zachodni, E – obszar południowy, F – obszar nieobjęty badaniem (oprac. D. Kumorek, P. Kiełb)

Detailed recommendations

The detailed recommendations include a timeline for the potential implementation of corrective actions. They refer to spatially defined clusters of biophilic nodes, hereafter referred to as areas (Fig. 6). This division was developed based on an analysis of the campus's spatial and circulation conditions, combined with results collected during the field study. Using literature sources and on-site observations, an analysis of user spatial activity was conducted, allowing the identification of zones with varying levels of foot traffic, including areas functioning as nodes and circulation corridors (Koszewski et al. 2025). As a result, Zone B was recognized as the area characterized by the highest pedestrian traffic intensity. This zone includes both a square serving as a gathering space and two key transit routes leading deeper into the campus. Zone A was recognized as a high, though not the highest, pedestrian traffic area. This zone includes two entrances facing the external circulation network and the main communication node of the system. Additionally, a factor reinforcing the concentration of movement within this area is the presence of the most intensively used building, i.e., the Main Building. Due to functional and spatial conditions, zones C, D, and E were recognized as areas with a similar, moderate level of pedestrian traffic. The results of the analysis were used to relate the conclusions drawn from the study to the intensity of biophilic pattern impact.

The stages of implementing the recommended actions are presented in Table 1.

The detailed recommendations for individual areas are presented in Table 2. It should be emphasized, however, that any interventions aimed at improving the biophilic quality of the campus should be planned and implemented holistically, taking into account the complexity and interrelationships of the site's spatial and biological features. This article does not constitute an execution-level design; its purpose was solely to gather information on the existing presence of biophilic design elements on the campus and to indicate where deficiencies require investment and which elements can improve the situation.

Table 1. Classification of remedial actions based on their implementation timeframe (elaborated by D. Kumorek, P. Kiełb)
Tabela 1. Klasyfikacja działań naprawczych ze względu na czas ich wdrażania (oprac. D. Kumorek, P. Kiełb)

Timeline name	Implementation time (years)	Actions description
Quick	0–1	actions not requiring significant time or financial investment
Medium-term	1–5	actions requiring a carefully planned implementation but not involving significant intervention
Strategic	+5	actions requiring a precise management plan and significant financial investment
Permanent	–	actions requiring continuous, systematic implementation as part of ongoing operations

Table 2. Compilation of detailed recommendations for individual areas, including a timeline for their implementation (elaborated by D. Kumorek, P. Kiełb)

Tabela 2. Rekomendacje szczegółowe dla poszczególnych obszarów z uwzględnieniem schematu czasowego ich wdrażania (oprac. D. Kumorek, P. Kiełb)

	Area name				
Timeline name	Zone A Eastern Area	Zone B Central	Zone C North-eastern Area	Zone D North-western Area	Zone E Southern Area
Quick	Supplementing tree rows with dense; insulating green structures; planting medium – to tall-height greenery; interventions of a “spatial acupuncture” character.	Planting medium- to tall-height greenery; installation of devices and elements such as water misters, heaters, bird feeders; small sensory installations, e.g., aromatic flowerbeds; reactivation of the existing fountain; reorganization and supplementation of small architectural elements, including benches, trash bins, and lighting.	Installation of devices and elements such as water misters, heaters, bird feeders; small-scale installations, e.g., aromatic flowerbeds; sensory installations.	Planting of tall and medium-high vegetation; installation of elements such as: water misters, heat emitters, bird feeders; small sensory installations, e.g., aromatic flowerbeds.	Supplementing tree alleys with dense; insulating green structures; interventions of a “spatial acupuncture” character.
Medium-term	Replacement of parts of the Main Building courtyard surfaces with green pavements.	Designation of small zones for recreation, rest, and study; introduction of minor freestanding structures, e.g., thematic pavilions, acoustic sculptures, canopies and shelters; localized replacement of surfaces with sensory pavements; arrangement of community gardens.	Introduction of small freestanding structures, e.g., thematic pavilions, acoustic sculptures, canopies and shelters; introduction of flower meadows or other plants with aromatic and colorful qualities; arrangement of community gardens.	Introduction of small freestanding structures, e.g., thematic pavilions, acoustic sculptures, canopies and shelters; establishment of flower meadows; arrangement of community gardens.	–
Strategic	Reorganization of parking areas; replacement of hard surfaces with permeable pavements; construction of freestanding vertical gardens in the courtyards of the Main Building.	–	Reorganization of parking areas; replacement of hardened surfaces with permeable pavements; construction of green roofs and façades.	Reorganization of parking areas; replacement of hard surfaces with permeable pavements; construction of green roofs and green façades.	Reorganization of parking areas; replacement of hard surfaces with permeable pavements; construction of green roofs and façades; replacement of artificial façade materials with natural and/or biomorphic ones.
Permanent	Maintenance of existing biophilic elements; educational and promotional activities; monitoring and assessment of biophilic quality.				

Summary

The analysis of the presence and intensity of the 14 biophilic design patterns across the Central Campus of the Warsaw University of Technology highlighted the varied character of the space, revealing both its strengths and deficiencies. The assessment showed that the campus's potential is not fully utilized – particularly in patterns related to sensory diversity, multi-sensory interaction with nature, and complexity and order. Several spatial and functional barriers were also identified, such as excessive parking areas, lack of material consistency, and limited accessibility for people with disabilities.

The results indicate the need for a comprehensive approach to campus planning in line with biophilic principles. Future interventions should include reorganizing the transportation layout, enhancing the role of greenery and water in public spaces, and implementing sensory, material, and spatial elements that support feelings of shelter, mystery, and discovery. Equally important is engaging the academic community in the transformation process through educational and participatory initiatives.

Overall, the Central Campus of the Warsaw University of Technology possesses significant biophilic potential, but currently it is only partially realized. Further design and research efforts could transform it into a model of a modern academic environment that promotes well-being, where architectural space harmoniously integrates with nature.

Translated by
Dominika Kumorek

Acknowledgement
The article was developed as part of the course program "Experimental Research Project" conducted at the Faculty of Architecture, Warsaw University of Technology during the winter semester 2024/2025.

References

Alexander, Christopher, Sara Ishikawa, Murray Silverstein, Max Jacobson, Ingrid Fiksdahl-King, and Shlomo Angel. *A Pattern Language: Towns, Buildings, Construction*. Oxford University Press, 1977.

Annerstedt, Matilda, and Peter Währborg. "Nature-Assisted Therapy: Systematic Review of Controlled and Observational Studies." *Scandinavian Journal of Public Health* 39, no. 4 (2011): 371–88. https://doi.org/10.1177/1403494810396400.

Bowler, Diana E., Lisette Buyung-Ali, Teri Knight, and Andrew Pullin. "A Systematic Review of Evidence for the Added Benefits to Health of Exposure to Natural Environments." *BMC Public Health* 10, no. 456 (2010): 1–10. https://doi.org/10.1186/1471-2458-10-456.

Browning, William, Catherine Ryan, and Joseph Clancy. *14 Patterns of Biophilic Design: Improving Health and Well-Being in the Built Environment*. Terrapin Bright Green, 2014.

Burton, Danielle. "Biophilic Design in Higher Education: Exploring Nature-Based Design Inclusion in Classrooms." Georgia Southern University, 2022. Honors College Theses. 734. Accessed August 14, 2025, at https://digitalcommons.georgiasouthern.edu/honors-theses/734/.

Cama, Rosalyn. *Evidence-Based Healthcare Design*. John Wiley and Sons, 2009.

Determan, Jim, Mary Anne Akers, Tom Albright, et al. "The Impact of Biophilic Learning Spaces on Student Success." American Institute of Architecture, Building Research Knowledgebase, 2019. Accessed August 14, 2025, at https://cgdarch.com/wp-content/uploads/2019/12/The-Impact-of-Biophilic-Learning-Spaces-on-Student-Success.pdf.

Dosen, Annemarie S., and Michael J. Ostwald. "Evidence for Prospect-Refuge Theory: A Meta-Analysis of the Findings of Environmental Preference Research." *City, Territory and Architecture* 3, no. 4 (2016): 1–14. https://doi.org/10.1186/s40410-016-0033-1.

Frumkin, Howard. "Beyond Toxicity: Human Health and the Natural Environment." *American Journal of Preventive Medicine* 20, no. 3 (2001): 234–40. https://doi.org/10.1016/S0749-3797(00)00317-1.

Fromm, Erich. *The Anatomy of Human Destructiveness*. Holt, Rinehart and Winston, 1973.

Gillis, Kaitlyn, and Birgitta Gatersleben. "A Review of Psychological Literature on the Health and Wellbeing Benefits of Biophilic Design." *Buildings* 5, no. 3 (2015): 948–63. https://doi.org/10.3390/buildings5030948.

Hami, Ahmad, and Babak Abdi. "Students' Landscaping Preferences for Open Spaces for Their Campus Environment." *Indoor and Built Environment* 30, no. 1 (2019): 1–12. https://doi.org/10.1177/1420326X19887207.

Heerwagen, Judith H., and Betty Hase. "Building Biophilia: Connecting People to Nature in Building Design." 2001. Accessed August 14, 2025, at https://www.slideshare.net/slideshow/building-biophilia-connecting-people-to-nature-in-building-design-pdf/273332207.

Kellert, Stephen R. *The Value of Life*. Island Press, 1997.

Kellert, Stephen R. "Dimensions, Elements, and Attributes of Biophilic Design." In *Biophilic Design: The Theory, Science, and Practice of Bringing Buildings to Life*, edited by Stephen R. Kellert, Judith H. Heerwagen, and Martin L. Mador. John Wiley and Sons, 2008.

Kellert, Stephen R. *Nature by Design: The Practice of Biophilic Design*. Yale University Press, 2018.

Kellert, Stephen R., Judith H. Heerwagen, and Martin L. Mador, eds. *Biophilic Design: The Theory, Science and Practice of Bringing Buildings to Life*. John Wiley and Sons, 2008.

Kellert, Stephen R., and Edward O. Wilson. *The Biophilia Hypothesis*. Island Press, 1993.

Koszewski, Krzysztof, Robert Olszewski, Piotr Pałka, et al. "Utilizing IoT Sensors and Spatial Data Mining for Analysis of Urban Space Actors' Behavior in University Campus Space Design." *Sensors* 25, no. 5 (2025): 1–27. https://doi.org/10.3390/s25051393.

Mahrous, Amira, Khaled Dewidar, Mostafa Refaat, and Ashraf Nessim. "Biophilia as a Sustainable Design Approach for University Buildings Design: A Case Study in University Campus Drawing Studios, Cairo, Egypt." *IOP Conference Series: Earth and Environmental Science* 1113, no. 1 (2022): 1–14. https://doi.org/10.1088/1755-1315/1113/1/012001.

Mahrous, Amira, Khaled Dewidar, Mostafa Refaat, and Ashraf Nessim. "The Impact of Biophilic Attributes on University Students' Level of Satisfaction: Using Virtual Reality Stimulation." *Ain Shams Engineering Journal* 15, no. 17 (2023): 1–11. https://doi.org/10.1016/j.asej.2023.102304.

Marcus, Clare C., and Naomi Sachs. *Therapeutic Landscapes: An Evidence-Based Approach to Designing Healing Gardens and Restorative Outdoor Spaces*. John Wiley and Sons, 2014.

McCullough, Cynthia. *Evidence-Based Design for Healthcare Facilities*. Sigma Theta Tau International, 2009.

Olmsted, Frederick L. *The Papers of Frederick Law Olmsted: The California Frontier, 1863–1865* (*Volume 5).* Johns Hopkins University Press, 1990.
Peters, Terri, and Kristen D'Penna. "Biophilic Design for Restorative University Learning Environments: A Critical Review of Literature and Design Recommendations." *Sustainability* 12, no. 17 (2020): 1–17. https://doi.org/10.3390/su12177064.
Shin, Jihye, and Mihyun Seol. "A Study on the Awareness of the University Students about the Biophilic City." *Journal of the Korean Institute of Landscape Architecture* 28, no. 4 (2020): 73–90. https://doi.org/10.17279/jkagee.2020.28.4.73.
Ulrich, Roger S. "Aesthetic and Affective Response to Natural Environment." In *Behavior and the Natural Environment*, edited by Irwin Altman and Joachim F. Wohlwill. Plenum Press, 1983.
Ulrich, Roger S., Craig Zimring, Xuemei Zhu, et al. "A Review of the Research Literature on Evidence-Based Healthcare Design." *HERD* 1, no. 3 (2008): 61–125. https://doi.org/10.1177/193758670800100306.
Wilson, Edward O. *Biophilia*. Harvard University Press, 1984.

Streszczenie

Rozwiązania biofilne w szkolnictwie wyższym
– analiza występowania na Kampusie Centralnym Politechniki Warszawskiej

Przez tysiąclecia człowiek związany był z przyrodą. Postęp industrializacji znacznie wpłynął na ograniczenie tej łączności. Odpowiedzią na próbę ponownego włączenia natury w codzienność społeczeństwa jest projektowanie biofilne.

Celem autorów artykułu była ocena obecności i skali występowania wybranych wzorców biofilnych na terenie Kampusu Centralnego Politechniki Warszawskiej. Za metody badawcze przyjęto studia literaturowe, obserwację obszaru badań oraz analizę skali występowania 14 wzorców biofilnych w wybranych punktach terenowych. Dane w postaci ocen, przyporządkowanych każdemu punktowi, zebrano za pomocą formularza internetowego. Wyniki badania przedstawiono w postaci map kampusu z oznaczeniami kolorystycznymi, odpowiadającymi zebranym ocenom. Artykuł wieńczą wnioski w postaci rekomendacji dla kierunku rozwoju tego terenu, zgodnego z duchem biofilii.

Słowa kluczowe: biofilia, projektowanie, 14 wzorców, kampus, Politechnika Warszawska