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On Greenhouses and the Making of Atmospheres

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Abstract

Broadly associated with the effects of climate change, the “greenhouse” term designates a building type that gains ground in contemporary design practices and demands architectural, technical, theoretical and aesthetic attention. This article explores the evolution of the greenhouse from a place of plant propagation to nature preservation to a vehicle of experimentation into new ways of inhabiting the city. It focuses on how the incorporation of greenery into buildings, by means of large span glazed envelopes and regulated interiors, has brought forth new forms of togetherness between human and non-human organisms. In so doing, it investigates a new understanding of the nature-culture oppositional relationship, in which the condition of *a living together* intersects with novel definitions of beauty, calling for a reinterpretation of agency in architecture.

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The incorporation of nature in built objects has spawned visionary design projects across the twentieth century by means of large span, glazed, vegetated environments.

Introduction

The original proposal of Anne Lacaton and Jean-Philippe Vassal for the *Documenta 12* (2007) pavilions revolved around the model of the transparent, lightweight, naturally ventilated greenhouse; a structure defined by the architects “neither as a simple formal object nor as a systematic element,” but as “the minimum, most elegant system,” able “to transform the exterior climate to make it livable” (Lacaton, Vassal, 2006). Despite the fact that the realized pavilions were ultimately modified, they were conceived as elements that formed “part of a larger system that included [the rest of the exhibition premises] and the park” (Oswalt, Vassal 2019), unifying inside the outside, architecture and landscape realms alike. Valued for issues of material efficiency, comfort, artistic expression and technological progress, the greenhouse has served as a powerful reference for housing design in Lacaton & Vassal’s work, ranging from their early experimental low-cost dwelling prototype (1992) to the more recent Cité manifeste units in Mulhouse (2005). Standing, more broadly, as a building model apt to be reappropriated, it highlights the architects’ belief that “the architectural potential of technology lies not in its origins or original definition but in its potential to be reprogrammed and combined with other things” (Ruby, Ruby, 2006: 18).

Departing from the displacement of the greenhouse into dwelling in the work of Lacaton & Vassal, this article explores key functions and meanings attributed to the novelty of such building type in architectural thinking and practice as well as its evolving character and contemporary relevance for the design project. First, it retraces the evolution of the greenhouse from a place of nature propagation to a catalyst of interdisciplinary experimentation into new types of public urban spaces. Second, it examines the ways in which the incorporation of nature in built objects has spawned visionary design projects across the twentieth century by means of large span, glazed, vegetated environments. Finally, it discusses the intersection of the greenhouse concept with theoretical discourses of architectural atmospheres and how this may promote new conceptualizations of and for the architectural project. In light of the pressing demands for environmental sustainability, it focuses a consistent attention

on practices and theories which have promoted new forms of relationship between nature and artifice, inhabitants and building, human and non-human organisms, in connection to the design of the built environment.

Indoor landscapes: Between nature preservation and human habitat

Greenhouses promoted the creation of picturesque landscapes, rendering exotic, non-native, plants, flowers, and biomes available to broader audiences and geographic contexts. Proliferating in the nineteenth century as plant nurseries, through examples such as the Great Conservatory at Syon Park (1828) and the Palm House at Kew Gardens (1848), they fulfilled the fervent desire for new vegetal species cultivation, primarily for collection purposes, allowing for the development of innovative methods for their import, categorization and study (Hix, 1996; Stein, Virts, 2017). Further to the cultivation of non-native rare plant species in the moderate temperatures of Northern Europe, they symbolized a multifaceted exchange of customs and cultural ideas. Similarly to the “landscaped gardens, [domestic conservatories] were transformed from objects of scientific interest and inquiry into cultural artifacts with considerable aesthetic and symbolic value” (Sparke, 2021: 29), giving rise to the creation of picturesque indoor landscape compositions. As they gradually evolved into places for accommodating human activities, “the word ‘conservatory’, in contrast to ‘glasshouse’, ‘hothouse’ and ‘greenhouse’, came to denote a space that not only was associated with plants but also supported social interaction” (Sparke, 2021: 30). Greenhouses, by means of uninterrupted surfaces of glass and vegetated interior spaces, hence emerged as a new type of public urban space, assuming a collective, shared dimension.

Large span, glazed, regulated structures addressed concerns about the provision of healthy environments in the emerging industrial cities, triggering a different understanding of architecture’s relation to the natural environment. Greenery was included in an all-glass structure whose design, construction and maintenance oscillated between horticulture, architecture, and engineering, highlighting the emergence of a novel design field that considered issues of environmen-

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Fig. 1 - The Great Exhibition in the Crystal Palace, Hyde Park, London: the transept looking north. Steel engraving by W. Lacey after J.E. Mayall, 1851. 677034i © Wellcome Collection. Public Domain Mark.

tal management. The 1851 proposal of Joseph Paxton for an urban sanatorium, as part of a larger collection of winter park projects, is a suggestive example. In this body of work, which included the influential Crystal Palace in Hyde Park (Fig. 1), Paxton addressed plants as “an integral part of the environmental system,” conceiving the interior space as “a type of self-contained biosphere, in which plants and animals, including human beings, mutually participate in the sustenance of an internal carbon dioxide and oxygen cycle” (Schoenefeldt, 2008: 285) and underline the intersections between ecology and the built environment. The “study of temperature, humidity, solar radiation and air movement and their effect on the health of plants” defined new conceptualisations of architectural space as the habitat of different biological species (Schoenefeldt, 2008: 283).

This mutual exchange between humans and plants is highlighted, as cultural historian Eva Horn has pointed out, in the context of eighteenth and early-nineteenth century theories on “climates” defined as “that which flows around

organisms, engulfs and transports the bodies of living beings, be they plants, animals, or human beings, in an [...] ever-changing medium (Horn, 2018: 13). The raised ecological awareness thereby laid the basis for an architectural research stance that recognized equally the effect of a given environment on man as well as the environmental functions associated with this environment.

The technological progress in materials and building techniques in those days led to the creation of “vegetated assemblages such as living walls and greenhouses,” anticipating contemporary design phenomena that “are starting to occupy the greenhouse spaces with program,” in which “humans have become embedded within the assemblage” (Zaera-Polo, Anderson, 2022: 326). As architectural historian Dustin Valen has observed, in England, “despite some architects’ resistance to technical and material innovations, horticulture and medicine played a crucial role by mediating between architecture and environmental practices as engineers looked to these scientific fields to elaborate a theory of warming and ventilating – imbricating architecture with efforts to reconstruct foreign climates” across the country (Valen, 2016: 420). The design and realization process of glasshouses revealed the need for a transdisciplinary approach to design. The dialectic relationship between building and the natural world would continue to be a growing concern for architects, designers, and urban planners alike with the aim to influence new definitions of living space and forms of cohabitation between people and plants.

From Bauhaus to the Greenhouse

The greenhouse model grew pertinent to early twentieth-century experimentations which cast a special attention on the non-physical aspects of space connected to comfort, hygiene and concepts of health. In his 1929 book *Befreites Wohnen. Licht, Luft, Öffnung* [Liberated Dwelling. Light, Air, Opening], Sigfried Giedion asserts that “it took almost 100 years for architects to have the courage to demand light for humans [and] build liberated walls dematerialized in glass” (Giedion, Geiser, ed. 2019 [1929]: 62). He discusses the greenhouses at the Jardin de Plantes in Paris (Rouhault Fils, 1833) as antecedents of Modern Movement

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Fig. 2 -Luigi Figini and Gino Pollini, The greenhouse of "casa elettrica" [La serra della "casa elettrica"], Villa Reale di Monza, IV Triennale di Monza, 1930. Photo: Girolamo Bombelli. TRN_IV_12_0665. © Triennale Milano - Archivi.



architecture, keenly interested in technical progress, in recognition of the fact that indoor climate, air quality and thermal comfort needed to have a significant bearing on the design of living spaces.

Several modern architecture projects explicitly engaged hybrids between natural and artificial materials, plants and glazed surfaces, at the architectural interior. In Luigi Figini and Gino Pollini's Casa Elettrica installation for the IV Triennale di Monza (1930) (Fig. 2), in Mies van der Rohe's Tugendhat house in Brno (1929–30) and in his *Glasraum* installation in Stuttgart, designed in collaboration with Lilly Reich (1927) (Zeinstra, 2015), as well as in the *Stanza di soggiorno per una villa* by Franco Albini (1940), the indoor patio or winter garden forms an integral part of the interior, marking the evolution of the greenhouse from a place of constructing aesthetic experiences to incubator of new approaches to the design of the built environment.

This evolution was further exemplified in experimental projects such as the Case Study House #4, or Greenbelt House (1945), designed by Ralph Rapson, which envisioned the incorporation of a large glass-roofed vegetated area as an open, flexible, and programmatically non-defined domestic space. Highlighting its analogy with the agricultural greenhouse, the architect noted that the internal glazed garden was “fundamental to bring nature within the house – not in small pretty planting areas, but in a large scale that will do justice to nature” (McCoy, 1977: 23). These assemblages between natural and built materials drew fresh attention to the potential of incorporating greenery for the improvement of indoor thermal climate and air quality, pointing to architectural means of environmental control (Barber, 2021).

The phenomenon which saw the hybridization of residential and green spaces continued to manifest itself in the second half of the twentieth century through further explorations into bioclimatic design. On a smaller scale, residential projects such as Frei Otto's House and Atelier in Warmbronn (with Rob Krier, 1967-69) and Thomas Herzog's House in Regensburg (1977) comprised large scale glass prisms which encouraged the growth of tropical and subtropical plants: the dense vegetation which spread through the living rooms in both projects entertained the vivid sensation of the inhabitants being outdoors and had a

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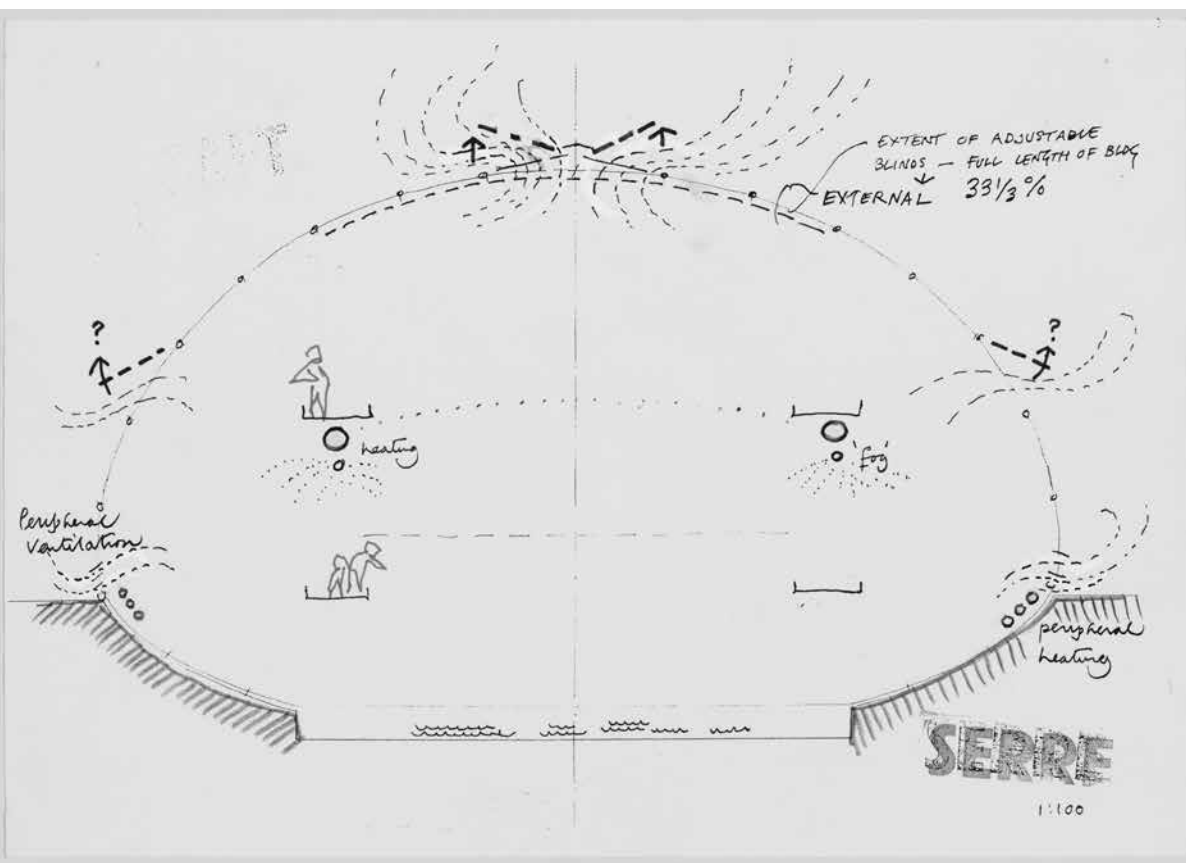


Fig. 3 - Cedric Price, Serre (2), Parc de La Villette, Paris, France, 1988-1990. Sketch showing adjustable blinds, heating and ventilation. Ink, graphite, white paint and coloured pencil over electrostatic print on heavy yellow paper, 21.1 x 29.7 cm. DR2004:0558:003. © Cedric Price fonds/ Canadian Centre for Architecture, Montréal.

marked impact on the conception of domestic space. Enhanced by the advances in construction, mechanical, and material technologies in those days, these projects rehearsed new approaches to the rapport between architecture, the body, and greenery, exploring principles that transgressed the boundaries between natural and anthropized environments. On a larger scale, office and university building projects, such as the Ford Foundation Headquarters in New York (Kevin Roche, John Dinkeloo and Associates, 1967), the School of Architecture of the University of Navarra in Pamplona (Rafael Echaide, Carlos Sobrini, Eugenio Aguinaga, 1974-1978) and Cedric Price's non-realized project for a greenhouse at Parc de la Villette in Paris (1986-1987) (Fig. 4), featuring a system of adjustable blinds which aimed to control indoor heating and ventilation (Fig. 3), similarly incorporated ample, glass-roofed vegetated atria, serving as sites for architectural design experimentation.

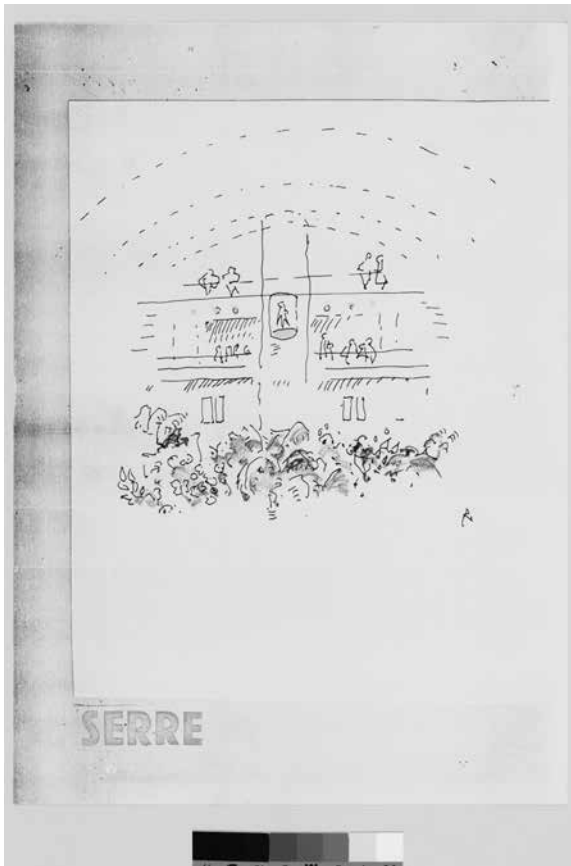


Fig. 4 - Cedric Price, Serre (2), Parc de La Villette, Paris, France, 1988-1990. Sketch of interior and crossed out sketch of interior [detail]. Coloured pencil, ink, and white paint over electrostatic print on heavy yellow paper 29.7 × 21.1 cm (sheet). DR2004:0558:002. © Cedric Price fonds/ Canadian Centre for Architecture, Montréal.

Another stream of late twentieth century architectural speculation suggested, however, an alternative reading of the greenhouse. It promoted a rigid distinction between indoor and outdoor climates, conceiving the former as the replica of *another*, ideal, constant climate. Architecture drew upon greenery and natural processes in the search for models that would provide insights into a *symbiotic* relation with the surrounding environment, human and non-human organisms. The evolution of a typological model could therefore be traced in the emergence of the glazed, sealed, and regulated dome. Drawing upon “previous concepts of nature’s preservation and conservation as separated from the urban milieu [it] gave rise to a novel naturalism of *artificial ecology*, where the functions of operations of nature were copied as precise analogues, in manmade systems” (Kallipoliti, 2010: 19). This understanding of designed ecologies pointed to an architecture of enclosed vegetated environments, in the

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spirit of Buckminster Fuller's geodesic dome Montréal Biosphere (1967), influencing visionary yet unsuccessful projects such as Mark Nelson's Biosphere 2 in Arizona (1987), which emerged as disconnected from an experiential perspective about human well-being. From the mid-1970s onwards, as concerns over the climate, air, and environmental quality began to grow stronger, "research increasingly focused on human influences on global warming" (Hill, 2012: 217), deploying terms such as the *greenhouse effect*: the phenomenon that describes the process by which greenhouse gas molecules and clouds, in a similar way to the glass greenhouse envelope, absorb and re-emit the radiation from the sun, hence causing the Earth's surface temperature to increase. In the context of architecture, the agricultural greenhouse model became particularly relevant with a growing climate crisis, nurturing the fantasy of the air-tight envelope and the regulated interior. In her seminal book *Thermal Delight in Architecture*, Lisa Heschong describes a future-oriented scenario in which regulated spaces perpetually succeed one another across different scales and contexts: "the building will need no windows or doors or individual heating plants," she anticipates, as "the entire landscape will be maintained at the same comfortable temperature" (Heschong, 1979: 20). As design practices would gradually distance themselves from passive means of climate control, in favor of mechanical air-conditioning systems, architecture's physical properties would come to the fore, following the conceptualization of the built space as a "space of air" (Stalder, 2010: 95) informed by the overlapping flows of tangible and intangible elements.

Design and/of the biosphere

The incorporation of greenery in building has assumed numerous different meanings over the last decades, testifying to the fact that "green additions have taken on various forms that continue to extend perceptions of the term" (Dean, 2011: 67). The binary opposition between the natural and the artificial is increasingly called into question, conceiving of plants, flowers, and biomes as central elements of new design scenaria for inhabiting the city. From winter gardens to indoor green atria, from new construction to transformation projects, and from



Fig. 5 - Olafur Eliasson and Günther Vogt, *The mediated motion*, 2001. Water, wood, compressed soil, fog machine, metal, plastic sheet, duckweed (*Lemna minor*), and shiitake mushrooms (*Lentinula edodes*). Installation view: Kunsthau Bregenz, Austria, 2001. Photo: Markus Tretter. The artist; neugerriem-schneider, Berlin; Tanya Bonakdar Gallery, New York / Los Angeles © 2001 Olafur Eliasson.



Fig. 6 - Lacaton & Vassal Architectes Karlsae pavilion for Documenta 12, Kassel, 2006. Exterior view. Photo: © Frank Schulenburg – Wikimedia Commons.

hybrid-use to urban farming buildings, recent design practices point to the fact that “green does not stop at a building’s surface: it also penetrates the interior, to give the impression of living everywhere with nature” (Zardini, Borasi, 2012: 19).

The contemporary adaptation of the greenhouse model to include spaces fit for human activities is growingly rooted in visions for social reform, in exploration of the ability of greenery to influence health-inducing, restorative spaces, promoting psychological, mental, and physical well-being. The broad-ranging fascination with greenery as a healer and as a remedy in contemporary societies becomes particularly relevant to the *biophilia* hypothesis (Wilson, 1984), as introduced by Edward O. Wilson, to the theme of “love of life and the living world,” as its derivation from Greek would propose. The building structure emerges as a hybrid of architectural and landscape features targeted at enhancing the thermal comfort and air quality of the interior, whilst improving the spatial experience. Placing emphasis on architecture’s interior, such a

hypothesis underlines the need to consider along with the tangible, the intangible, perceptual, and physiological aspects of space, which engage with issues of health and human well-being.

By distinguishing an inner space from its environmental surroundings and rendering it inhabitable, greenhouses make explicit the design of air, the control of temperature, condensation, and humidity. The human body is understood, in this context, as a living organism rather than as a measurement and scale reference, calling for a re-evaluation of the body-space relationship. As a result, the body emerges as an inherent design factor that “signifies and measures the air: space, or better the environment, is built around it,” giving rise to a field in which “space, technology, and society converge to design worlds altered by the climates they inhabit and by the innovations available” (Marini, 2017: 50). The vegetated, continuous and regulated interior spaces give rise to a condition of cohabitation in which the energies of the human body and the built artifact “converge to define a style based on unity that participates in an overall design” (ibid.). Rather than a mediated relationship between architecture and nature, such a condition entails a holistic approach to design, conceiving of human and non-human organisms as parts of an interdependent system.

This approach brings to the fore the competing logics inherent in the design for sustainability with regard to addressing the issue of health at both the individual and the planetary scale. It therefore invites us to reflect upon an architectural stance which does not merely aspire “to mitigate a building’s impact on natural systems” but seeks instead “at least rhetorically, to become a part of those systems” (Barber, Putalik, 2018: 236). It puts forward an important point for speculation as to whether natural elements and resources can serve not merely as performative-functional components of building but as catalysts to conceive of new relationships between architecture and the biosphere. It invites us to examine the potential of nature as a conceptual tool to shift contemporary design discourses towards the definition of more inclusive environments in respect of human and non-human organisms.

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Towards new forms of togetherness

The concept of the glasshouse resonates with contemporary theories of atmospheres which promote the understanding of the “environment as a shared climate” with reference to the entangled relationship between humans, plants, and the environment. It holds, for instance, a central role in philosopher Peter Sloterdijk’s discourse on spheres, according to the hypothesis that “it was the exercise of granting plants hospitality that first created the conditions under which it became possible to formulate a concept of environment” (Sloterdijk 2005: 945). Approaching “environmental design as atmospheric,” Sloterdijk “updates the concept of the environment into that of a sensorium, a sphere that is shared” (Blackman, Harbord, 2010: 313), suggesting a new form of togetherness that underlines the interconnected state of being *in* the biosphere. Such a state reveals, in particular, Sloterdijk’s “concern with examples of intimacy and interiority,” varying from “primitive interhuman and interspecies notions of intimacy” such as biophilic connections to “increasingly large-scale and complex modifications of interiority” such as the control of indoor climate (Lee, Wakefield-Rann, 2018: 159). Sloterdijk focuses a critical attention on the “climatization of the inhabited space” which entails “envisaging the anthropogenic climate in all its thematic intrusiveness” following different degrees of environmental appropriation (Sloterdijk, 2016: 461) that ring all the more familiar today as societies are confronted with the fragility of nature. For him, the greenhouse concept has nurtured a representation of nature as “non-external, as a housemate in the republic of beings,” in opposition to the theories that regarded the former “an outside force” (ibid.: 458-459). The increasing union of art and nature in the “continuous sensorium” of regulated climates may enable a different understanding of nature in the context of design, one which surpasses the dichotomy between “naturalization” and “symbolization” (Latour, 2006: 107) and points to new relations between human and non-human organisms.

To understand the interrelation between human bodies, natural objects, and environments, it means placing it in the growing explorations into the theme of atmosphere as an additional notion of the aesthetic

discourse. For Gernot Böhme, “the new resulting aesthetics [from the standpoint of ecology] is concerned with the relation between environmental qualities and human states” (Böhme, 1993: 114), with perception, affect, and mutual participation. Atmospheres, defined as the intermediate space which renders this relation possible, constitute the backdrop for this aesthetic experience, defined through “presence of persons, objects and environments” (Böhme, 1993: 126). They represent “the common reality of the perceiver and the perceived [to the extent that] in sensing the atmosphere s/he is bodily present in a certain way” (Böhme, 1993: 121). They align with a definition of “beauty not [as] a predicate, but [as] the characteristic of a co-presence; a shared reality of subject and object” (Böhme, 1995: 105). In this context, architectural atmospheres suggest an aesthetic experience which goes beyond visual perception in order to engage all aspects of the sensorial spectrum: they are interpreted not merely as projections but as a realm which touches us “as real, as part of our environment” (Moravánszky, 2010: 61).

The notion of inhabiting spheres of different environmental qualities, in a state of co-presence, coevolution, co-breathing between human and non-human organisms, suggests the construction of “an environment of relationality and interrelational movements” (Bruno, 2022: 286) and implies new ecology definitions. It testifies to the argument that to grapple with the issue of ecology in architectural design, what is of importance is our mediated relationship to natural objects rather than their understanding as performative apparatuses in support of our increasingly regulated environments (Kousidi, Daglio, 2023). Contemporary design practices continue to draw upon the glazed structure for the cultivation, preservation and display of tender flowers, plants or biomes, conceiving of built objects as interfaces between the natural and the man-made environments. The introductory affirmation by Lacaton & Vassal is therefore not foreign to recent design experimentations which draw upon the greenhouse model in search of an improved relationship between building and program, nature and artifice (Wilkinson, 2021).

To grapple with the issue of ecology in architectural design, what is of importance is our mediated relationship to natural objects rather than their understanding as performative apparatuses in support of our increasingly regulated environments.

Initially re-interpreted as a place for contemplation and retreat from the industrialized city, the greenhouse emerges today as a fertile symbolic and educational notion for architecture.

Conclusions

In Olafur Eliasson's site-specific installation *The mediated motion* (2001), developed in collaboration with landscape architect Günther Vogt, the interior spaces of Kunsthau Bregenz were transformed into environments of accentuated landscape features (Fig. 5). Natural materials, from duckweed to rough wood, filled the spaces of the porous glass-clad building envelope, designed by Peter Zumthor 1997 in allusion to a contemporary interpretation of the greenhouse (Fig. 6). The installation put forward and problematized different degrees of cross-contamination between natural and anthropized environments perceived through the experience of movement. It aimed at the mediation of "spaces as a garden-like structure" where each floor and the intermediate spaces between them presented differentiated environments, in which visitors could wander, "areas in which motion [was] essential" (Eliasson, 2001: 11). Situated in a building of which the weather forms part, the installation highlighted the need to reimagine the dialectical relation between culture and nature, in a contemporary context that sees many diverse degrees of entanglement of the natural with the built, the infrastructural and the technological.

The staged environment, defined in this case as neither internal nor external, as neither artificial nor pertaining to the biosphere, highlights a definition of the natural "as the site and locus of impetus and force, the ground of a malleable materiality, whose plasticity and openness account for the rich variability of cultural life, *and* the various subversions of cultural life that continue to enrich it" (Grosz, 2001: 97). As philosopher Elisabeth Grosz has suggested, the "interaction, arrangement, and regulation of [human and non-human] bodies" is central to establishing "the domains of both the architectural and the cultural" and points to the surpassing and reordering of the nature-culture dichotomy (Grosz, 2001: 99). Under the current demands for sustainability, design is called upon to envision new interrelations between nature and artifice, following "the proposition that the concepts of nature and architecture are not separable but interlaced inextricably" (Ursprung, 2007: 13). In this framework, the concept of the greenhouse underlines the urgency of safeguarding natural organisms and

environments, enabling us to reimagine architecture as part and expression of nature, as something that emerges from within the latter rather than opposing it. Initially re-interpreted as a place for contemplation and retreat from the industrialized city, the greenhouse emerges today as a fertile symbolic and educational notion for architecture. It re-affirms the need for new means of aesthetic expression mediated through the design project, where the natural is linked, on the one hand, with the animation of culture and its emblems and points, on the other, to a rethinking of the agency of architecture.

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