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Integration of Augmented Reality into Biophilic Design for Simulating Natural Elements in Buildings and Urban Spaces

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Abstract Rapid urbanization has reduced everyday contact with natural systems, and the resulting deficit is associated with elevated stress and diminished cognitive restoration among city dwellers. Biophilic design addresses this deficit by reintroducing daylight, vegetation, water and organic form into the built environment, yet its application is constrained in dense urban fabric where space, structural capacity and maintenance budgets are limited. This paper examines Augmented Reality (AR) as a means of simulating natural elements where physical installation is impractical. The study combines a structured narrative review of literature published between 2006 and 2025, an analysis of four documented applications in public participation and interpretive settings, and a set of author-produced AR visualizations covering an open urban space, a covered circulation space, an office interior and a building atrium. Findings indicate that exposure to simulated natural environments is associated with improved positive affect, reduced perceived stress and reduced mood disturbance, but that pooled comparison places these effects below those obtained from physical natural settings. Simulated vegetation also delivers none of the thermal, hydrological or ecological functions of planting, and AR hardware carries its own life-cycle burden. The paper therefore positions AR as a complement to green infrastructure rather than a substitute for it, sets out a seven-stage implementation framework, and identifies controlled evaluation in occupied buildings as the principal empirical gap.

Keywords: *augmented reality, biophilic design, simulated nature, environmental psychology, urban design, sustainable built environment*

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1. Introduction

Urbanization has reshaped the global settlement pattern. Approximately 55% of the world population lived in urban areas in 2018, and this share is projected to reach 68% by 2050 [1]. Densification concentrates people within constructed environments and progressively displaces the vegetation, water and daylight conditions that characterized earlier settlement patterns [2]. The consequences are not only aesthetic. Reduced contact with natural systems has been associated with elevated physiological stress; attention related fatigue and diminished affective well-being among urban residents [3].

Biophilic design responds to this condition. The approach proceeds from the biophilic hypothesis advanced by Wilson [4], which holds that human beings possess an evolved affinity for living systems, and translates that premise into architectural strategy by reintroducing daylight, vegetation, water and organic form into occupied space [5]. Browning, Ryan and Clancy [6] codified the approach into fourteen design patterns spanning direct experience of nature, indirect analogues such as material and pattern, and the spatial conditions of prospect, refuge and mystery. At the settlement scale, Beatley [7] extended the argument from the individual building to the city as a whole. A recent systematic review of healthcare environments reports that biophilic interventions are associated with reduced length of stay, lower reported pain and lower staff stress, although the authors note substantial heterogeneity in study design [8].

Implementation, however, remains constrained. Vegetated facades, courtyards and water features require structural capacity, irrigation, maintenance budgets and, above all, floor area. In dense and already-built urban fabric these resources are frequently unavailable. Retrofit is expensive, and in interior settings such as below-grade offices, transit concourses and clinical corridors, physical greening may be precluded outright by servicing or

hygiene requirements. A gap therefore persists between the documented benefits of biophilic design and the range of settings in which those benefits can actually be delivered.

Augmented reality (AR) offers one route across that gap. AR superimposes computer-generated content onto a live view of the physical environment while preserving the user's awareness of, and orientation within, that environment [9]. In architectural practice it has been applied to design review, on-site verification, construction sequencing and pedagogy [10,11]. Its application to biophilic objectives is more recent. Emamjomeh, Zhu and Beck [12] demonstrated that immersive simulation can meaningfully alter occupant perception of biophilic building features, which establishes the premise that mediated natural content is perceptually consequential rather than decorative.

That premise requires scrutiny rather than advocacy. Meta-analytic evidence indicates that simulated natural settings do not reproduce the affective benefit of physical ones in full [13], and any design argument that treats digital greenery as equivalent to planted greenery risks displacing investment away from green infrastructure that also delivers cooling, stormwater retention and habitat. The contribution of this paper is therefore to specify the conditions under which AR is and is not an appropriate biophilic instrument, rather than to argue for its adoption in general.

1.1. Research Questions and Objectives

This paper addresses four questions. First, which technical capabilities of current AR platforms are relevant to the simulation of biophilic elements? Second, what evidence exists for the psychological and behavioral effects of simulated natural elements, and how does that evidence compare with the evidence for physical nature? Third, what workflow and stakeholder configuration is required to implement AR biophilic interventions at building and street scale? Fourth, under what conditions is AR an appropriate complement to green infrastructure, and under what conditions is it not?

The corresponding objectives are to synthesize the technical and psychological literature, to analyze documented applications, to demonstrate the design proposition through author-produced visualizations, and to derive an implementation framework together with a research agenda. Figure 1 sets out the conceptual structure that organizes the argument.

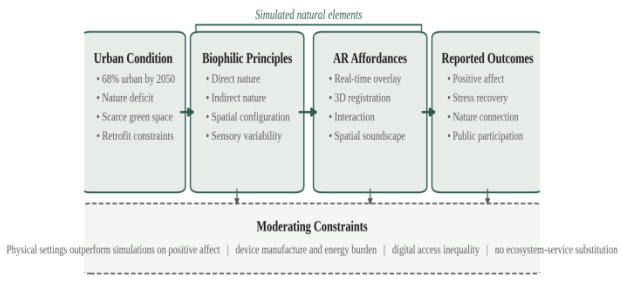


Figure 1. Conceptual framework relating the urban condition, biophilic principles and augmented reality affordances to reported outcomes, with the constraints that moderate them

2. Research Methodology

This study adopts a qualitative, interpretive research design appropriate to an emerging field in which controlled trials of the specific intervention are not yet available. Three strands of evidence are combined.

The first is a structured narrative review of literature published between 2006 and 2025. Sources were retrieved from Scopus, Web of Science and Google Scholar using combinations of the terms augmented reality, biophilic design, simulated nature, virtual nature, restorative environment and urban greening. Priority was given to peer-reviewed journal articles, systematic reviews and meta-analyses. Conference proceedings and monographs were included where they constitute foundational statements of theory or technology.

The second strand is the analysis of documented applications. Four cases were selected purposively against three criteria: that the application be sited in the built environment, that it involve registration of natural or environmental content onto a real setting, and that outcomes be reported in an accessible source.

The third strand is a set of author-produced AR visualizations, prepared to demonstrate the design proposition across four setting types. These are presented as design demonstrations rather than as an experiment. No participants were recruited, no perceptual or physiological measurements were taken, and no claim of measured effect is made on their basis.

No interviews, surveys or other human-subject procedures were undertaken in this study. All statements concerning well-being outcomes rest on effect estimates reported in the reviewed literature and are attributed accordingly.

3. Literature Review

3.1. Principles and Current Practice of Biophilic Design

Biophilic design is the deliberate incorporation of natural elements and natural analogues into the built environment in order to sustain the human affiliation with living systems [3,4]. Kellert, Heerwagen and Mador [5] organize its content into three categories that remain the working taxonomy of the field: direct experience of nature, encompassing daylight, planting, water, air movement and weather; indirect experience, encompassing natural materials, colors, textures, fractal geometries and biomorphic form; and the experience of space and place, encompassing prospect, refuge, organized complexity and attachment to locality.

The precedents are long-standing. Courtyard typologies in Islamic architecture, the borrowed scenery convention of Japanese garden design and the Renaissance villa garden all mediate deliberately between enclosure and landscape. Formalization, by contrast, is recent. The environmental movements of the late twentieth century, followed by the LEED rating system and subsequently the WELL Building Standard, translated an intuition into assessable criteria.

Contemporary application concentrates on green roofs,

vegetated facades, atrium planting and pocket parks. Singapore's sustained program of vertical greening remains the most cited demonstration at metropolitan scale, and workplace projects such as the Seattle Spheres the most cited at building scale. In both instances the intervention is physical, capital-intensive and dependent on a permissive structural and regulatory context, which is precisely the condition that does not obtain in most existing urban fabric.

3.2. Augmented Reality in Architecture and Urban Design

AR superimposes registered digital content onto a live view of the physical world, and its introduction into architectural workflows has been characterized as a change in design paradigm rather than an incremental change in tooling [14]. Wang, Kim, Love and Kang [15] classify built-environment applications by the project stage at which they operate, and Billinghurst, Clark and Lee [9] provide the standard technical survey of the underlying tracking, display and interaction problems. Davila Delgado, Oyedele, Demian and Beach [11] set out a research agenda for the architecture, engineering and construction sector, identifying design review, stakeholder engagement, on-site assembly support and training as the domains of greatest maturity.

Three capabilities bear directly on the present argument. The first is in-situ visualization: three-dimensional content can be anchored to a real site so that stakeholders assess a proposal in its actual spatial and luminous context rather than on a screen. The second is real-time modification: parameters such as species, planting density, canopy height or seasonal state can be varied while the observer remains in place. The third is participation. Because AR runs on consumer handsets, it lowers the threshold at which non-specialists can inspect and comment on a proposal [16,17].

3.3. The Intersection of Augmented Reality and Biophilic Design

The two fields converge on a single question: whether a mediated representation of nature can carry the restorative content of nature itself. The question predates AR. De Kort, Meijnders, Sponselee and IJsselsteijn [18] framed it directly, reporting that mediated natural scenes did support stress recovery but that the magnitude depended on the immersive quality of the presentation. Emamjomeh et al. [12] extended the inquiry to biophilic building design, showing that occupant assessment of biophilic features is sensitive to the technology through which those features are presented.

This sensitivity carries a methodological consequence for practice. Design decisions in contemporary workflows are already mediated by computer-aided design, building information modeling and immersive review. If the medium alters perception of biophilic quality, the medium is not neutral to the design outcome, and its influence must be characterized rather than assumed benign.

A second convergence concerns environmental communication. Reaver [16] and Boos, Reichenbacher, Kiefer and Sailer [17] report that registering proposed environmental change onto the existing streetscape improves lay comprehension of that change. Cranmer and colleagues observe a comparable effect in heritage and cultural tourism, where AR interpretation is associated with increased reported awareness of conservation issues. The mechanism in both cases is the same: abstraction is replaced by situated depiction [19].

The literature nonetheless remains thin at the point of intersection. Studies of virtual nature are overwhelmingly conducted under laboratory conditions using head-mounted displays and screens rather than in occupied buildings using AR. Studies of AR in the built environment concentrate on constructional and participatory objectives rather than restorative ones. The evidential bridge between the two has not been built.

4. Enabling Technologies and Platforms

Three technology domains constitute the operational core of Augmented Reality i.e. display, three-dimensional registration and interaction [20].

4.1. Display Technology

Vision is the dominant channel through which environmental information is acquired, so display capability governs the perceptual credibility of simulated natural elements. Three device classes are in use. Head-mounted displays, which originate with Sutherland's work in 1968, present content optically or through video pass-through and offer the widest field of view [21]. Handheld devices, principally smart phones and tablets, composite content onto a live camera feed and account for the overwhelming majority of deployed AR by user numbers. Spatial and projection displays register content onto surfaces without requiring the user to wear or hold equipment, which suits public installations.

For biophilic applications the governing display parameters are field of view, luminance range and color fidelity. Simulated foliage that cannot be rendered at the luminance of a real daylit surface, or whose green values fall outside the gamut of natural vegetation, will be read as a graphic overlay rather than as vegetation.

4.2. Three-Dimensional Registration

Registration establishes and maintains the geometric correspondence between virtual content and the physical scene. It proceeds in two stages: determination of the pose of the display relative to the environment, and projection of content into that environment consistently with the pose [22]. Marker-based methods use fiducials of known geometry. Markerless methods, principally simultaneous localization and mapping, derive structure from the camera feed itself and therefore support unprepared environments. Registration quality determines whether a simulated element reads as present. Vegetation that drifts relative to the surface it is attached to, or that fails to occlude correctly behind furniture, breaks the perceptual illusion on which any restorative effect would depend. Plane detection, depth estimation and light estimation are consequently not incidental features but preconditions.

4.3. Interaction Technology

Interaction determines whether the occupant is a spectator or a participant. Current systems support gesture, gaze, touch, voice and location-triggered input, drawing on ergonomics and cognitive psychology as well as computer vision [20]. In a biophilic context, interaction permits the occupant to place, scale, prune or seasonally advance simulated planting, and this agency may contribute to engagement independently of the visual content itself.

4.4. Development Platforms

Table 1 summarizes the platforms in common use for authoring AR content in the built environment, together with the capability that is most consequential for biophilic application.

Table 1. Principal Augmented Reality Development Platforms

Platform (Developer)	Key Capabilities	Relevance to Biophilic Application
ARKit (Apple)	Plane and mesh detection, motion tracking, people occlusion, shared sessions	Accurate seating of planting on floors and walls; multi-user review of a scheme in place
ARCore (Google)	Motion tracking, environmental understanding, light estimation, depth API	Light estimation allows simulated foliage to respond to ambient daylight conditions
Vuforia (PTC)	Image, object and area targets; cross-platform deployment	Area targets suit fixed interiors such as lobbies, corridors and concourses
Wikitude SDK (Wikitude)	Image recognition, geo-referenced content, SLAM tracking	Geo-referencing suits street-scale and park-scale interventions
Unity with AR Foundation (Unity)	Abstraction layer over ARKit and ARCore; rendering, physics, audio	Common authoring environment for vegetation shaders, wind animation and soundscape

5. Case Studies and Demonstrations

5.1. Public Participation in Environmental Change

Reaver [16] reports an application in Oslo in which AR was used to engage young people in the municipal planning process. A proposal to plant one hundred thousand trees was registered onto the existing streetscape so that participants could observe the transformation from their own vantage point (Figure 2). The reported outcome was improved comprehension of the proposal and increased willingness to participate, which is consistent with the situated-depiction mechanism described in Section 3.3.

Duff-Meadwell [23] examines a comparable Canadian application in which AR and virtual reality were compared as instruments of citizen participation in street redesign (Figure 3). The study reports improved lay understanding of proposed changes, and identifies two constraints: unequal access to devices and unequal digital literacy among participants. Boos et al. [17] reach a convergent conclusion from a controlled study, reporting that AR improved spatial comprehension of planning proposals but that the benefit was not uniformly distributed across participant groups. Taken together, the two studies indicate that the participatory value of AR is real but is conditioned by the digital capability of the population it is intended to include.

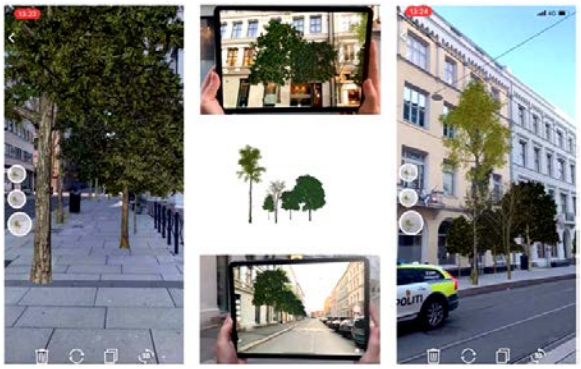


Figure 2. AR visualization of proposed urban tree-planting scheme prepared for Oslo Municipality (Adapted from Reaver) [16]



Figure 3. Proposed street section with shared cycle lane and pedestrian walkway visualized through augmented and virtual reality. Adapted from Duff-Meadwell [23]

5.2. Botanical and Interpretive Settings

Botanical gardens present a setting in which physical nature is already present and AR serves an interpretive rather than a substitutive function. Crilley [24] establishes that visitor satisfaction in such settings is driven by sensory quality rather than by facility provision alone, and Ballantyne, Packer and Hughes [25] show that satisfaction is generated where the environment engages multiple senses. Diaz-Meneses [26] examines the Viera y Clavijo Botanical Garden and identifies interpretation quality as an antecedent of visitor loyalty. AR interpretation, delivered by scanning markers placed adjacent to specimens, allows visitors to access species information, growth cycles and habitat context in situ, and Cranmer et al. [19] report that such interpretation is associated with increased reported environmental awareness. The comparison with Section 5.1 is instructive. Where nature is absent, AR substitutes. Where nature is present, AR explains. The second function is the better evidenced of the two, and it is also the function that carries no risk of displacing physical provision.

5.3. Author-Produced Design Demonstrations

Figures 4 to 7 present author-produced visualizations of AR biophilic intervention across four setting types. In each pair, (a) records the existing condition and (b) the same view with registered vegetation. Figure 4 addresses an open urban space in which hard paving predominates and planting is absent. Figure 5 addresses a covered

circulation space where enclosure is complete and no aperture for planting exists. Figure 6 and Figure 7 address building interiors, a workspace and an atrium respectively, in which maintenance regime, daylight availability or lease conditions preclude physical planting. In each case the simulated planting is placed at positions where physical planting would be specified were it feasible, so that the demonstration tests representation rather than novelty of placement.

These visualizations demonstrate feasibility of representation. They do not demonstrate effect. The distinction is material and is taken up in Section 6.2.



(a) (b)

Figure 4. Open urban space: (a) existing condition without planting, (b) the same view with augmented reality planting



(a)



(b)

Figure 5. Covered circulation space: (a) existing condition without planting, (b) the same view with augmented reality planting



(a)



(b)

Figure 6. Office interior: (a) existing condition without planting, (b) the same view with augmented reality planting



(a)



(b)

Figure 7. Building interior: (a) existing condition without planting, (b) the same view with augmented reality planting

6. Analysis and Discussion

6.1. Current Capabilities in Biophilic Application

Four capabilities are established by current technology.

Daylight and its temporal variation: Light estimation permits simulated apertures, shadow patterns and diurnal shifts to be registered onto interior surfaces. This addresses the dynamic and diffuse light pattern of the biophilic taxonomy in settings, such as below-grade offices, where no aperture is possible.

Vegetation and seasonal change: Planting can be registered at species-level fidelity and advanced through phenological states, delivering the temporal variability that static interior planting cannot provide.

Water: Water features carry substantial servicing, hygiene and acoustic implications when built. Simulated water delivers the visual and, with spatial audio, the auditory dimension without incurring them.

Multisensory augmentation through soundscape: Registered spatial audio, comprising birdsong, foliage movement and water flow, can mask traffic noise and constitutes the non-visual component of the intervention. This matter because the restorative effects reported in the

reviewed literature derives predominantly from audio-visual rather than visual-only presentation [27].

6.2. The Evidence Base and Its Limits

The claim that simulated nature produces measurable benefit is supported. The claim that it is equivalent to physical nature is not. Li, Ding, Zhao, Xu and Wei [27] synthesize twenty-six publications and report that audio-visual exposure to simulated natural environments is associated with increased positive affect and with reduced perceived stress and mood disturbance (Table 2). Frost et al. [28] reach a consistent conclusion in a systematic review of virtual immersion in nature, and Chan, Qiu, Esposito and Mai [29] report psycho-physiological evidence that simulated vertical greenery buffers the stress response.

Table 2. Reported Pooled Effects of Exposure to Simulated Natural Environments

Outcome	Pooled Effect (95% CI)	Summary
Positive affect	0.40 (0.22, 0.58)	Improved
Vigor	0.58 (0.30, 0.86)	Improved
Calmness	0.54 (0.17, 0.92)	Improved
Perceived stress	-0.38 (-0.71, -0.06)	Improved
Total mood disturbance	-0.87 (-1.17, -0.57)	Improved
Anxiety	-0.72 (-1.43, -0.02)	Improved
Negative affect	-0.09 (-0.23, 0.05)	No effect
Heart rate, blood pressure, heart rate variability	Not significant	No effect

Note: after Li et al. [27]. All included studies carried a moderate to high risk of bias.

Three qualifications must accompany these findings.

First, and most consequentially, Browning et al. [13] compared simulated and actual natural settings using a common instrument across a pooled sample and found that positive affect increased in the physical settings but not in their simulated counterparts, with a pooled effect of $g = 0.87$ favoring the physical setting. Reduction in negative affect was comparable across the two conditions. The asymmetry matters for design: simulation appears better at relieving negative states than at generating positive ones.

Second, immersion is not monotonically beneficial. Li et al. [27] report that medium immersion produced a larger effect on positive affect than either low or high immersion, a result they attribute in part to discomfort associated with highly immersive presentation. This is an argument in favor of AR specifically, since AR occupies an intermediate position on the immersion continuum.

Third, the evidence base is methodologically weak. All studies in the Li et al. synthesis carried moderate to high risk of bias. Samples are small, predominantly young, predominantly drawn from higher education and predominantly from high-income countries. Exposure durations are short and follow-up is rare. No study located during this review evaluated an AR biophilic intervention in an occupied building over a sustained period.

6.3. Augmented Reality Rather Than Virtual Reality

The choice of AR over virtual reality for biophilic application follows from the setting rather than from preference (Table 3). Virtual reality replaces the environment; AR modifies it. Biophilic design is concerned with the quality of the environment a person actually occupies, and an intervention that requires the occupant to stop occupying it is poorly matched to that objective. The practical corollaries are that AR runs on devices already in circulation, that it does not preclude movement or work, that it can be experienced collectively within a shared space, and that it sits at the intermediate immersion level which the meta-analytic evidence associates with the largest affective effect [27].

Table 3. Comparison of Augmented and Virtual Reality for Biophilic Application

Criterion	Augmented Reality	Virtual Reality
Relation to setting	Modifies the occupied space	Replaces it with a synthetic environment
Hardware	Consumer handset; headset optional	Dedicated head-mounted display
Concurrent activity	Compatible with work and movement	Precludes both
Social use	Multiple users within a shared space	Predominantly single-user
Immersion level	Intermediate	High
Content cost	Overlay onto an existing scene	Full environment authoring
Affective effect	Intermediate band, largest pooled effect [27]	Greater immersion, not a greater effect [27]

6.4. Complement Rather Than Substitute

The strongest objection to AR biophilic design is that it substitutes representation for provision. Three responses are required, and each narrows the claim.

The first concerns evidence. As established in Section 6.2, simulated settings do not reproduce the positive-affect benefit of physical ones [13]. A design strategy that treats the two as interchangeable is not supported by the literature it invokes.

The second concerns ecosystem services. Vegetation in the built environment performs functions that representation cannot: evapotranspirative cooling and mitigation of the urban heat island, particulate capture, stormwater attenuation, habitat provision and carbon sequestration. None of these is delivered by a rendered tree. Where an authority faces a choice between planting and simulation, the case for planting is not primarily perceptual and is therefore not answered by perceptual evidence.

The third concerns the footprint of the technology itself. AR is not immaterial. Screening life-cycle assessment of a contemporary head-mounted display attributes substantial environmental burden to device manufacture, with results sensitive to the sourcing of gold and to the carbon intensity of the electricity used in assembly and wafer processing [30]. Handset-based delivery reduces this

burden by drawing on devices already owned, but does not eliminate the associated compute, network and replacement demand. An intervention presented as a sustainability measure must account for its own resource cost.

The defensible position is accordingly narrower than the enthusiastic one. AR biophilic design is appropriate where physical greening is genuinely infeasible, as an interpretive layer that increases the legibility of existing green infrastructure, and as a participatory instrument that renders proposed planting comprehensible before it is funded. It is not appropriate as an alternative to planting where planting is possible [31,32].

6.5. Implementation Framework

Figure 8 and Table 4 set out a seven-stage workflow derived from the reviewed applications. The workflow is iterative rather than linear: evaluation findings return to objective setting rather than terminating the process.

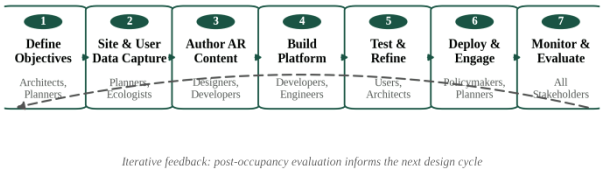


Figure 8. Seven-stage implementation workflow for augmented reality biophilic interventions, showing the lead stakeholders at each stage and the evaluation feedback loop

Table 4. Implementation Stages, Principal Tasks and Expected Outcomes

Stage	Principal Tasks	Expected Outcome
1. Define objectives	Specify restorative, interpretive or participatory purpose; identify the user group	Explicit criteria against which the intervention can later be evaluated
2. Capture data	Survey geometry, luminance and acoustic conditions; establish an ecological reference for species selection	Registration-ready site model and a defensible planting palette
3. Author content	Model species and water elements; specify seasonal states; design interaction and soundscape	Content library matched to measured site conditions
4. Build platform	Implement on the selected SDK; verify occlusion, light estimation and tracking stability	Functioning application on the target device class
5. Test and refine	Evaluate in situ under real lighting; collect user feedback; correct registration failures	Credible registration under operational conditions
6. Deploy and engage	Release to users; provide on boarding for low digital literacy	Accessible intervention with documented uptake
7. Monitor and evaluate	Measure affective and behavioral outcomes against Stage 1 criteria; audit device and energy cost	Evidence for iteration and for the wider literature

Stage 7 is the stage most frequently omitted in practice and the one on which the credibility of the field depends. Without it, an AR biophilic installation generates no evidence beyond the assertion that it was installed.

6.6. Limitations of the Study

Four limitations qualify the foregoing. First, the study is interpretive rather than systematic. The literature search was structured but did not follow a registered protocol, and selection bias in source inclusion cannot be excluded. Second, the cases were selected purposively from accessible sources and are not representative of practice as a whole. Two are situated in Northern Europe and one in North America, so transferability to hot-arid, tropical and lower-income urban contexts is untested. Third, the visualizations presented in Section 5.3 are design demonstrations without measured outcomes. Fourth, the effect estimates cited in Section 6.2 derive from studies of screen-based and headset-based virtual nature rather than from AR specifically. Their transfer to AR is inferential, and this constitutes the principal empirical gap identified by this paper.

7. Conclusions

Augmented reality provides a means of introducing biophilic content into settings where physical natural elements cannot be installed. Current platforms support registration of vegetation, daylight and water at sufficient fidelity, and the reviewed evidence indicates that exposure to simulated natural environments is associated with improved positive effect, reduced perceived stress and reduced mood disturbance.

That evidence does not support equivalence with physical nature. Pooled comparison of simulated and actual settings shows an advantage to the physical setting on positive effect, and simulated vegetation delivers none of the thermal, hydrological or ecological functions of planting. AR is therefore properly positioned as a complement to green infrastructure: appropriate where greening is infeasible, valuable as an interpretive layer on existing green assets, and effective as a participatory instrument that renders proposed environmental change legible to non-specialists [33]. Framing it otherwise risks converting a useful supplement into an argument for not planting.

Three priorities follow for research. The first is controlled evaluation of AR biophilic interventions in occupied buildings, using physiological as well as self-reported measures and with follow-up sufficient to distinguish sustained effect from novelty. The second is comparative assessment of AR against screen-based and headset-based delivery, since the existing immersion evidence suggests that the intermediate position occupied by AR may be advantageous rather than merely convenient. The third is life-cycle accounting for the intervention itself, so that claims of environmental benefit are stated net rather than gross. Until these are addressed, the case for AR in biophilic design rests on plausibility and demonstrated feasibility rather than on measured outcome.

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