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An Analytical Reading of the Therapeutic Foundations of Natural Environments and Their Impact on Mental Health

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قراءة تحليلية في الأسس العلاجية للبيئات الطبيعية وأثرها على الصحة النفسية، مراجعة منهجية شاملة: التشجير الحضري والمساحات الخضراء في المدن | علم النفس البيئي

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Abstract

While the bond between the natural world and the human mind has long been recognized, it has recently come under rigorous scientific scrutiny with promising results. This paper explores the synergetic relationship between the biological characteristics of plants and the therapeutic dimensions of mental health, framed within a strategic vision for sustainable Quality of Life. Utilizing a thematic analysis of literature published between 2015 and 2025, the study reviews the concept of Ecotherapy — broadly defined as the therapeutic use of nature-based experiences — and the impact of green and blue spaces on psychological well-being.

The analysis reveals three core pillars. First, the eco-structural dimension, which illustrates how biodiversity and vegetation density — grounded in Attention Restoration Theory (ART) and Stress Recovery Theory (SRT) — mitigate cognitive fatigue. Second, the affective-psychological dimension, which examines the multi-sensory pathways through which plant environments regulate mood, ranging from neuroendocrine responses to volatile organic compounds (VOCs) to the calming visual effect of greenery. Third, the

therapeutic-sustainable dimension, which positions ecotherapy within urban planning and public health policies as a low-cost, scalable intervention.

The paper concludes that Plant Psychology represents a burgeoning field with significant implications for Sustainable Development Goals (SDG 3 and 11). However, it highlights critical research gaps, specifically the scarcity of data in low-income and Arabic-speaking countries, and the lack of standardised protocols for measuring therapeutic exposure doses.

Keywords: Plant Psychology, Ecotherapy, Mental Health, Biodiversity, Attention Restoration, Sustainable Development, Urban Green Space.

الملخص

على الرغم من أن الصلة بين العالم الطبيعي والعقل البشري موثقة منذ القدم، فإنها باتت في السنوات الأخيرة موضع تدقيق علمي صارم أسفر عن نتائج واعدة، تستكشف هذه الورقة العلاقة التآزرية بين الخصائص البيولوجية للنباتات وأبعادها العلاجية في مجال الصحة النفسية، وذلك ضمن رؤية استراتيجية لتحقيق "جودة حياة" مستدامة، واستناداً إلى تحليل موضوعاتي للأدبيات المنشورة بين عامَي 2015 و2025، تستعرض الدراسة مفهوم العلاج البيئي (Ecotherapy) — المعرَّف بوصفه التوظيف العلاجي للتجارب المرتبطة بالطبيعة — وأثر الفضاءات الخضراء والزرقاء على الصحة النفسية.

وقد كشف التحليل عن ثلاثة محاور جوهرية: أولاً، البُعد البيئي-البنيوي، الذي يوضح كيف يُسهم التنوع البيولوجي وكثافة الغطاء النباتي — المستندَين إلى نظرية استعادة الانتباه (ART) ونظرية التعافي من الضغط النفسي (SRT) — في التخفيف من التعب المعرفي، وثانياً، البُعد الوجداني-النفسي، الذي يدرس المسارات متعددة الحواس التي تنظم من خلالها البيئات النباتية المزاجَ البشري، بدءاً من الاستجابات العصبية الصمّاوية للمركبات العضوية المتطايرة (VOCs) وصولاً إلى الأثر التهدئوي للغطاء الأخضر بصرياً، وثالثاً، البُعد العلاجي-المستدام، الذي يُوظّف العلاج البيئي في سياق التخطيط العمراني وسياسات الصحة العامة بوصفه تدخلاً منخفض التكلفة وقابلاً للتوسيع.

وخلصت الورقة إلى أن "علم نفس النبات" حقل ناشئ تتسع آفاقه بوتيرة متصاعدة، وله انعكاسات جوهرية على أهداف التنمية المستدامة (SDG 3 وSDG 11)، غير أنها تُبرز فجوات بحثية حرجة، أبرزها: شُح البيانات في الدول منخفضة الدخل والبلدان الناطقة بالعربية، وغياب بروتوكولات موحّدة لقياس "الجرعات العلاجية" من التعرض للطبيعة.

الكلمات المفتاحية: علم نفس النبات، العلاج البيئي، الصحة النفسية، التنوع البيولوجي، استعادة الانتباه، التنمية المستدامة، الفضاء الأخضر الحضري.

1. **Introduction**

1.1 Research Problem

We are living through a quiet crisis. Mental health conditions now affect more than one billion people worldwide, and the consequences stretch well beyond individual suffering — the economic burden of untreated psychological distress is expected to surpass five trillion dollars before this decade closes (Bratman et al., 2019). These numbers are striking, but they can also obscure something more personal: behind every statistic is a person navigating daily life with insufficient support and, too often, insufficient options.

Pharmaceutical treatments have genuinely transformed psychiatric care, and their importance should not be minimised. However, they are not a complete answer. Cost, availability, and side effects leave many people without adequate relief — and this reality has pushed researchers, clinicians, and policymakers alike to ask a harder question: what else works?

One answer has been quietly accumulating evidence for decades. The idea that natural environments support psychological health is hardly new — healers in ancient Egypt prescribed sunlit courtyards, and the gardens of Babylon were, in some readings, as much therapeutic as they were aesthetic. What has changed is our capacity to test these intuitions rigorously. Controlled trials, neuroimaging, and population-scale epidemiological studies have begun to give empirical weight to what cultures across history seemed to understand intuitively.

This shift has brought new language with it. Terms like ecotherapy, biophilic design — an architectural approach that reintegrates nature into built environments — and green social prescribing have moved from the margins of academic discourse toward its centre. Yet the field still lacks a focused theoretical framework for one of its most important questions: what is it, specifically, about plants — their structure, their chemistry, their sensory presence — that makes green environments therapeutically potent?

This paper takes that question seriously. We introduce the concept of the Psychology of Vegetation as a framework precise enough to guide both clinical application and urban design, without losing sight of the broader human stakes involved. Notably, despite the global significance of this question, research from Arabic-speaking and low-income countries remains almost entirely absent from the literature — a gap this paper explicitly acknowledges and calls upon future researchers to address.

1.2 Research Objectives

The present review is guided by three overarching research objectives:

- To identify the primary psychological mechanisms through which the biological and structural characteristics of vegetation influence mental health outcomes in human populations.
- To determine which mental health conditions and population groups remain underexplored in the vegetation-mental health literature, and to map the methodological limitations that constrain current understanding.

- To evaluate which specific botanical features and environmental design qualities demonstrate the most robust and clinically meaningful therapeutic effects on psychological well-being.

Together, these objectives frame a review that is simultaneously diagnostic — mapping the current state of knowledge — and prospective, identifying the priorities that should shape the next decade of inquiry. The ultimate aim is to contribute to a theoretical framework robust enough to guide both clinical practice and urban planning policy.

1.3 Research Questions

To operationalise the objectives above, three corresponding research questions guide the analysis:

- RQ1: What are the primary psychological mechanisms through which the biological and structural characteristics of vegetation influence mental health outcomes in human populations?
- RQ2: Which mental health conditions and population groups remain underexplored in the vegetation-mental health literature, and what methodological limitations constrain current understanding?
- RQ3: Which specific botanical features and environmental design qualities demonstrate the most robust and clinically meaningful therapeutic effects on psychological well-being?

2. **Methods**

To map the multifaceted relationship between botanical environments and psychological health, this study employed a scoping review design. This approach was selected for its utility in synthesising broad, heterogeneous bodies of literature where the primary goal is to chart conceptual landscapes and identify research gaps rather than to perform a singular meta-analysis of effect sizes. The review was conducted in strict adherence to the Joanna Briggs Institute (JBI) methodological framework (Peters et al., 2020) and the PRISMA Extension for Scoping Reviews (PRISMA-ScR) guidelines (Tricco et al., 2018). A formal protocol was established a priori to ensure methodological transparency and minimise bias throughout the investigative process.

2.1 Search Strategy

A comprehensive electronic search was executed across six prominent interdisciplinary databases: PubMed/MEDLINE, Scopus, Web of Science, ScienceDirect, PsycINFO, and Google Scholar.

While the primary analytical lens was fixed on the most recent decade of scholarship (2015–2025), seminal foundational works were integrated where they provided essential theoretical scaffolding.

The search architecture was informed by the PECO framework (Population, Exposure, Comparator, Outcome), tailored to bridge the gap between ecological and psychological disciplines:

- Population: Adults across both general community and specialised clinical cohorts.
- Exposure: Engagement with vegetation or botanical settings, spanning direct physical immersion (e.g., forest bathing) to indirect or mediated contact (e.g., olfactory cues or virtual green spaces).
- Comparator: Urban landscapes devoid of greenery, built environments, or varying gradients of biodiversity.
- Outcome: A holistic spectrum of mental health markers, including stress and anxiety reduction, cognitive restoration (ART), and emotional regulation.

To ensure a robust retrieval process, search strings utilised complex Boolean operators across three primary conceptual domains:

- Botanical Exposure: e.g., "biodiversity", "urban forest", "phytogenic", "horticultural therapy".
- Psychological Outcomes: e.g., "emotional regulation", "attention restoration", "cortisol", "subjective well-being".
- Contextual Parameters: e.g., "urban planning", "clinical populations", "community residents".

2.2 Study Selection

The screening process was undertaken in two distinct phases. Initial screening involved a blind review of titles and abstracts against the eligibility criteria outlined in Table 1. Following this, the full texts of all potentially relevant papers were retrieved and scrutinised for inclusion. Any discrepancies in study selection were resolved through iterative deliberation, with a third-party reviewer consulted to achieve final consensus where necessary.

Table 1. Inclusion and Exclusion Criteria for Study Selection

Category	Inclusion Criteria	Exclusion Criteria
Population	Adults and general populations exposed to vegetation and natural environments	Studies focused exclusively on children under 5; non-human subjects
Exposure	Direct or indirect exposure to vegetation, green/blue spaces, forest environments, urban greenery, horticultural therapy	Purely indoor synthetic environments without any botanical element
Comparator	Comparison between natural and built environments, or between different vegetation types/densities	Studies with no comparison group or purely pharmacological control arms
Outcome	Mental health outcomes: stress, anxiety, depression, mood, attention restoration, emotional regulation, cognitive function, well-being	Exclusively physical health outcomes without psychological measures
Study Design	Peer-reviewed empirical studies (experimental, quasi-experimental, cross-sectional, longitudinal, qualitative, mixed methods), systematic reviews, meta-analyses	Conference abstracts, opinion pieces, editorials, grey literature, non-peer-reviewed sources
Language & Timeframe	English-language publications; 2015–2025 (seminal earlier works included where foundational)	Non-English publications; studies before 2007 unless foundational

2.3 Data Extraction and Thematic Synthesis

Data extraction followed the approach set out by Arksey and O'Malley (2005), adapted to suit thematic synthesis. For each included study, the following details were recorded: study design,

geographic location, participant characteristics, type and duration of vegetation exposure, mental health outcomes measured, assessment instruments, and primary findings.

The thematic analysis unfolded inductively across three phases, drawing on Braun and Clarke's framework. First, all included studies were reviewed to identify and code data items relevant to the research questions. Related codes were then grouped into candidate themes reflecting broader patterns of meaning across the literature. In the final phase, these themes were refined and named to be both conceptually clear and practically engaging. The three themes that emerged — Structural-Environmental, Emotional-Psychological, and Sustainable-Therapeutic — are introduced in the Results section and explored further in the Discussion.

3. Results

3.1 Search Outcomes

The database searches initially returned 3,847 records in total. Once duplicates were removed, 2,934 unique titles and abstracts proceeded to screening. The vast majority — 2,601 — were excluded at this early stage, most commonly because they dealt with physical rather than psychological health, involved non-botanical exposures, or were not peer-reviewed empirical studies.

That left 333 full-text articles to assess more closely, of which a further 247 were excluded: 89 lacked a mental health outcome measure, 61 focused on non-botanical exposures, 47 were not peer-reviewed, and 50 did not provide sufficient methodological detail. A manual search of reference lists added a further 34 articles. The final review corpus comprised 120 studies.

3.2 Characteristics of Included Studies

The 120 included studies reflect a genuinely broad range of methodological approaches — unsurprising given the multidisciplinary nature of this field. Table 2 below provides a quantitative summary of key study characteristics.

Table 2. Quantitative Summary of Included Study Characteristics (N = 120)

Characteristic	Proportion (%)	Notes
Experimental / Quasi-experimental	42% (n=50)	Dominant design; strongest internal validity
Cross-sectional observational	28% (n=34)	Common in large urban-epidemiology studies

Characteristic	Proportion (%)	Notes
Systematic reviews / Meta-analyses	18% (n=22)	Growing rapidly post-2018
Qualitative / Mixed-methods	12% (n=14)	Key for lived experience & cultural factors
High-income countries (Europe, E. Asia, N. America)	~86%	Major geographic bias; limits generalisability
Community-dwelling adults (non-clinical)	58%	Most studied group
Clinical populations	24%	Depression, anxiety, PTSD
Specific sub-groups (students, elderly, disadvantaged)	18%	Under-represented; priority for future research
Publications 2022–2025	~38%	Surge linked to post-COVID mental-health interest

Looking at publication dates, there is a clear uptick in output from 2018 onward, with 2022–2025 alone accounting for approximately 38% of all included studies. This acceleration likely reflects the surge of academic interest that followed the COVID-19 pandemic, which brought the mental health value of green and outdoor spaces into unusually sharp public focus (Pouso et al., 2021).

Geographically, the evidence base skews heavily toward high-income countries. Studies from Europe (especially the UK, Germany, and Scandinavia), East Asia (China, Japan, and South Korea), and North America together account for roughly 86% of the literature. This concentration is a real limitation: findings from these contexts may not translate straightforwardly to places with different climates, urban forms, cultural relationships to nature, or economic realities (Xian et al., 2024; Dong et al., 2024). Of particular note is the near-total absence of research from Arabic-speaking countries and the broader Arab world — a region characterised by distinct climatic conditions (arid and semi-arid environments) and culturally specific relationships with vegetation, gardens, and nature. This gap represents both a scholarly deficit and a practical barrier to evidence-based policy in the region.

Mental health was assessed using a wide range of validated tools, most commonly the Perceived Stress Scale (PSS), the Profile of Mood States (POMS), the Patient Health Questionnaire (PHQ-9), and the Generalised Anxiety Disorder 7-item scale (GAD-7), alongside physiological indicators such as cortisol levels, heart rate variability, and EEG measures.

3.3 Thematic Overview

The synthesis produced three overarching themes, each containing several sub-themes. It is worth noting that these themes are not mutually exclusive — the most effective therapeutic interventions tend to engage several mechanisms at once — but distinguishing between them serves a genuine analytical purpose and has practical implications for how nature-based interventions are designed and evaluated.

Table 3. Thematic Analysis Matrix: Themes, Sub-themes, Mechanisms, and Evidence

Theme	Sub-themes	Key Mechanisms	Representative Studies
Theme 1: Structural-Environmental	Biodiversity & species richness; green density; soundscapes; spatial configuration	Attention Restoration Theory (ART); Stress Recovery Theory (SRT); cognitive load reduction	Methorst et al. (2021); Wood et al. (2018); Ohly et al. (2016)
Theme 2: Emotional-Psychological	Sensory stimulation; phytoncides & VOCs; visual greenness; horticultural engagement	Biophilia Hypothesis; emotional regulation; autonomic nervous system modulation	Bratman et al. (2019); Park et al. (2010); Joubert et al. (2024)
Theme 3: Sustainable-Therapeutic	Ecotherapy frameworks; urban healing design; SDG alignment; social prescribing	Restorative environments theory; green social prescribing; biophilic urban planning	Summers & Vivian (2018); Menhas et al. (2024); White et al. (2019)

3.4 Theme 1: The Structural-Environmental Theme

The first theme brings together research on how the physical and ecological makeup of vegetated environments — their species diversity, structural complexity, sensory richness, and spatial

arrangement — generates measurable psychological benefits. This work sits at the crossroads of landscape ecology and environmental psychology, and carries clear implications for therapeutic green space design.

3.4.1 Biodiversity and Species Richness

One of the most consistently replicated findings in this field is the link between biodiversity and psychological restoration. Methorst et al. (2021), drawing on a large-scale study of German residents, found that species richness — both perceived and actual — was positively associated with life satisfaction and mental well-being, even after controlling for income, education, and urbanisation. The proposed mechanism centres on cognitive engagement: encountering diverse, unfamiliar plant forms stimulates what Kaplan and Kaplan called "soft fascination" — a gentle, undemanding form of attention that allows directed attentional resources to quietly replenish.

Wood et al. (2018) extended this in the context of urban green spaces, demonstrating that biodiversity — defined by plant species variety and structural heterogeneity — predicted restorative outcomes more strongly than simply having green space nearby. The distinction matters for planning: a monoculture lawn and a species-rich meadow may occupy the same physical space, but their psychological effects are not equivalent. Moreover, Fuller et al. (2007) similarly found that the benefits of urban greenspace scaled with biodiversity, pointing toward a dose-response relationship worth investigating at the clinical level.

Marselle et al. (2021) offered a useful conceptual framework for understanding how biodiversity converts into mental health benefits, tracing multiple pathways — emotional, cognitive, social, and physiological. Their synthesis makes a compelling case that biodiversity is not merely an ecological measure; it is a psychological resource whose erosion through urbanisation and agricultural intensification carries direct costs to population wellbeing.

3.4.2 Attention Restoration and Mental Fatigue

Attention Restoration Theory (ART), developed by Rachel and Stephen Kaplan in the 1980s, holds that natural environments restore depleted attentional resources by offering experiences with four key qualities: fascination, extent (a sense of being in a broader world), compatibility with one's inclinations, and a feeling of being away from everyday demands. Three decades of research have accumulated substantial support for this framework, and the evidence base continues to grow.

Ohly et al. (2016), in a systematic review of ART research, confirmed that natural environment exposure consistently improved attention and cognitive performance, though effects varied with duration, type of exposure, and individual differences. Bell et al. (2025), in a more recent meta-analysis, found that duration significantly moderated the relationship — exposures of fifteen minutes or more produced reliably larger effects than brief encounters, a finding with practical implications for how nature-based interventions are designed and prescribed.

Furthermore, Stenfors et al. (2019) provided experimental evidence that even fairly short exposures to natural settings improved performance on demanding cognitive tasks. Liu et al. (2025), focusing specifically on urban green spaces, found consistent cognitive benefits across varied populations and settings, though they cautioned that the quality of the green space — including its vegetation composition — played an important moderating role. Rhee et al. (2023) contributed an interesting finding: even indirect nature exposure through window views of vegetation or biophilic design features produced meaningful restorative effects, albeit smaller than those from direct contact.

3.4.3 Acoustic and Sensory Dimensions

The restorative value of natural environments is not limited to what we see. Natural soundscapes — birdsong, wind through leaves, running water — have been shown to reduce physiological stress and support psychological recovery. Hedblom et al. (2019), using a multisensory virtual reality setup, showed that auditory elements of natural environments contributed independently to stress reduction, suggesting that even when visual access to nature is limited, its sounds retain therapeutic value.

The phytochemical dimension of natural environments has attracted considerable attention, particularly in the Japanese and Korean forest therapy literature. Park et al. (2010), drawing on field experiments across twenty-four forests in Japan, found that exposure to forest atmospheres — rich in volatile organic compounds (VOCs) like phytoncides, elevated in negative ions, and low in ambient noise — produced significant reductions in cortisol, blood pressure, pulse rate, and sympathetic nervous system activity, alongside improvements in parasympathetic function.

3.5 Theme 2: The Emotional-Psychological Theme

The second theme focuses on the affective dimension of human-vegetation interaction: how contact with botanical environments shapes mood, reduces anxiety and depression, and supports emotional regulation. While Theme 1 centres on cognitive mechanisms, Theme 2 is more concerned with

emotional ones — though the two are deeply entangled, since attentional and emotional systems are interdependent in how they both deplete and recover.

3.5.1 Mood Enhancement and Emotional Regulation

Perhaps the most consistent thread running through the included literature is that vegetation exposure improves mood and reduces negative affect. Jimenez et al. (2021) found that green space contact was associated with reduced negative emotion, increased positive affect, and improvements in hedonic well-being across a wide range of study designs and populations. Franco et al. (2017) documented a similarly broad pattern of mood-enhancing effects, notably finding that these extended to people with pre-existing mental health vulnerabilities — not only those already in good psychological health.

Pasanen et al. (2023), in an ambitious eighteen-country study of adults living alone — a group at elevated risk of loneliness and depression — found that urban green space was associated with reduced anxiety and depression, with relational and collective restoration processes helping to explain the link. This highlights an often-overlooked social dimension: vegetation does not merely restore the individual mind; it also creates space for social connection and community.

Bratman et al. (2019) took an ecosystem-services perspective, synthesising evidence that access to natural environments reduces negative affect, rumination, stress, and anxiety while boosting positive affect, meaning-making, and cognitive function. By framing psychological benefits as ecosystem services, they made a compelling argument for aligning mental health with the logic of natural capital — potentially a powerful lever for conservation policy.

3.5.2 Anxiety and Depression Reduction

The evidence for vegetation-based interventions in clinical anxiety and depression has grown considerably in recent years. Rueff and Reese (2023) conducted a systematic review comparing ecotherapy with cognitive behavioural therapy (CBT) for depression and anxiety, finding that ecotherapy showed comparable efficacy to CBT for mild-to-moderate conditions, with some advantages on dimensions of well-being and ecological connectedness. Given CBT's status as a gold-standard treatment, this is a striking result — though larger, more rigorously controlled trials are needed before it can inform clinical recommendations.

Joubert et al. (2024), in a randomised controlled trial of horticultural therapy with psychiatric inpatients, found significant improvements in anxiety, depression, and quality of life among

participants engaged in structured plant-based activities compared with treatment-as-usual controls. The effects were meaningful given the short intervention period, suggesting horticultural therapy could serve as a valuable complement to pharmacological and psychological treatment. Bettmann et al. (2025), in a systematic review and meta-analysis focused on adults with mental illness, confirmed that nature exposure produced significant improvements across multiple clinical outcomes, including symptom severity, quality of life, and social functioning.

3.5.3 Phytoncides, VOCs, and Neurobiological Pathways

A particularly active area of inquiry concerns the neurobiological routes through which vegetation contact produces its psychological effects. Antonelli et al. (2020) catalogued the range of biologically active compounds released by trees and other vegetation — including alpha-pinene, limonene, and other terpenoids — and their documented capacity to modulate the autonomic nervous system, lower cortisol, enhance natural killer (NK) cell activity, and produce anxiolytic effects. The olfactory pathway, which connects directly to the limbic system and amygdala, provides a neuroanatomically plausible route through which forest air might produce rapid emotional effects.

Ma et al. (2024) offered an important counterpoint, showing that exposure to synthetic VOCs — typical of polluted indoor and urban environments — was associated with increased depression risk. Read alongside the evidence for natural botanical VOCs, this suggests that the chemical quality of the ambient environment, not just the presence of vegetation, is psychologically relevant. However, Jeong and Park (2021) found that complex, multi-layered vegetation elicited stronger parasympathetic activation and greater emotional positivity than simplified or uniform plant forms — reinforcing the broader evidence on biodiversity and structural complexity.

3.6 Theme 3: The Sustainable-Therapeutic Theme

The third theme looks beyond mechanisms to address the structural and policy dimensions of vegetation-based mental health promotion — specifically, how the growing evidence base can be translated into urban design practice, public health policy, and sustainable development strategy.

3.6.1 Ecotherapy as a Clinical and Community Intervention

Ecotherapy — the therapeutic use of nature-based experiences — spans a wide range of practices, from structured wilderness therapy and horticultural therapy in clinical settings to informal green social prescribing and community gardening. Summers and Vivian (2018) identified ecotherapy as

a significantly underused resource, with real preventive and therapeutic potential, noting that it has been largely sidelined in mainstream mental health provision despite mounting evidence for its efficacy.

Menhas et al. (2024), in a systematic review and meta-analysis of nature-based social prescribing, found significant positive effects on depression, anxiety, stress, and social connectedness, with particularly strong results among socially isolated individuals. White et al. (2019), in a landmark study drawing on nearly twenty thousand respondents across eighteen countries, found that spending at least 120 minutes per week in nature was robustly associated with good health and well-being — a finding that has begun to shape evidence-based nature prescriptions in several jurisdictions.

3.6.2 Urban Green Infrastructure and Therapeutic Landscape Design

Designing effective therapeutic green spaces involves considerably more than planting trees. Lyeo et al. (2025) identified a set of design principles consistently associated with restorative outcomes: spatial enclosure that provides a sense of safety; sufficient visual complexity to sustain soft fascination; acoustic management to reduce traffic noise and enhance natural soundscapes; multi-seasonal planting to maintain year-round engagement; and accessibility design that ensures equitable use across ages, mobility levels, and socioeconomic backgrounds.

Eager and McManus (2024) extended the analysis to blue space — bodies of water integrated into urban green infrastructure — finding that proximity to water enhanced the restorative value of green spaces beyond what vegetation alone delivers. Biophilic design offers a complementary strategy for delivering vegetation benefits where access to external green space is structurally limited (Chen et al., 2021). However, Dong et al. (2024) raised a critical equity issue: high-quality green space in cities is systematically concentrated in wealthier neighbourhoods, meaning those most likely to benefit from vegetation-based mental health interventions are also the least likely to have meaningful access to them.

3.6.3 Alignment with Sustainable Development Goals

The therapeutic dimensions of vegetation connect directly with several United Nations Sustainable Development Goals. SDG 3 (Good Health and Well-being) is the most direct link, tracing a causal pathway from green infrastructure investment to population mental health outcomes. SDG 11 (Sustainable Cities and Communities) is equally implicated, given that urban green space quality

and accessibility are core indicators of urban liveability. SDG 15 (Life on Land) gains an additional rationale through this lens: biodiversity conservation is not only an ecological imperative but a psychological one.

Barton and Rogerson (2017) and Twohig-Bennett and Jones (2018) both made the economic case for greenspace investment in mental health terms, estimating the potential cost savings from reduced psychiatric service use that would follow from improved population access to quality green space. In an era of constrained public health budgets, this kind of analysis is essential for moving evidence into policy.

4. Discussion

The central aim of this review was to synthesise contemporary evidence on the psychological effects of vegetation exposure, organise it thematically, and draw out implications for clinical practice, urban planning, and public health policy. The three themes identified — Structural-Environmental, Emotional-Psychological, and Sustainable-Therapeutic — together constitute what this paper calls the Psychology of Vegetation: a field that is more than the sum of its parts, and one with sufficient theoretical coherence and empirical depth to stand as a recognised sub-discipline.

4.1 RQ1: Psychological Mechanisms

The evidence supports a multi-pathway model of how vegetation affects mental health. Attentional mechanisms, as described by ART, work through the engagement of involuntary attention in low-demand, aesthetically rich environments — giving directed attentional resources the chance to recover. Psychophysiological mechanisms, elaborated through Stress Recovery Theory (SRT), involve shifts in autonomic nervous system activity driven by the visual, auditory, and olfactory properties of natural environments, with measurable reductions in cortisol, heart rate, blood pressure, and sympathetic arousal (Park et al., 2010; Hedblom et al., 2019).

Emotional mechanisms involve the more direct shaping of affective states through sensory contact with botanical environments — including phytoncide-mediated limbic activation and the mood-enhancing effects of visual complexity and colour (Antonelli et al., 2020; Jeong & Park, 2021). Critically, these mechanisms do not operate in isolation. Attentional restoration and emotional regulation are co-dependent: sustained attentional demands generate negative affect, while emotional disturbance disrupts attentional functioning. Natural environments appear to set off a virtuous cycle in which simultaneous gains in attention, emotional state, and physiological arousal reinforce one another. The practical implication is that therapeutic environments should be

designed to engage multiple pathways simultaneously — which is precisely the argument for multi-sensory, high-biodiversity landscapes.

4.2 RQ2: Gaps and Methodological Limitations

Several important gaps in the current evidence base emerged from this review. The first concerns dose. The relationship between vegetation exposure and mental health outcomes remains poorly characterised in terms of quantity needed. White et al.'s (2019) finding of a 120-minute weekly threshold provides a useful practical benchmark, but the optimal durations, frequencies, and intensities of exposure for different clinical populations and conditions are largely still unknown.

A second gap concerns diagnostic specificity. The literature is almost entirely silent on the differential effects of vegetation exposure across specific mental health diagnoses. The vast majority of studies assess general well-being, stress, or non-clinical mood — important outcomes, but ones that do not speak directly to the needs of people living with major depressive disorder, generalised anxiety disorder, PTSD, schizophrenia, or eating disorders.

Third, and of particular relevance to this paper's authors, the concentration of research in high-income and English-speaking countries represents a serious scholarly limitation. Research from sub-Saharan Africa, South Asia, Latin America, and — critically — the Arab world remains strikingly thin. The cultural, climatic, and botanical contexts of Arabic-speaking countries (including the role of oases, traditional gardens, and desert flora in local lifeforms and mental health) are entirely absent from the evidence base. Future research must prioritise these contexts if the Psychology of Vegetation is to develop as a genuinely global field.

Finally, methodological heterogeneity continues to hold the field back. The lack of standardised exposure measures, consistent outcome instruments, and agreed definitions of core constructs makes meta-analytic synthesis difficult and policy translation uncertain. Developing a standard measurement protocol for vegetation exposure, analogous to METs in physical activity research, would be a significant step forward.

4.3 RQ3: Botanically Optimal Therapeutic Environments

The evidence offers reasonably clear guidance on the botanical features associated with the greatest psychological benefit. High biodiversity — both in species richness and structural diversity across trees, shrubs, herbaceous layers, and ground cover — consistently outperforms monoculture plantings on restorative and emotional outcomes (Methorst et al., 2021; Wood et al., 2018; Fuller

et al., 2007). Multi-sensory richness — varied colours, textures, scents, and sounds — engages multiple neurobiological pathways at once and produces more comprehensive restorative effects.

Forest and woodland environments occupy a particularly privileged position in the evidence, likely reflecting the evolutionary significance of woodland habitats in human ancestral environments. Sacchelli et al. (2025), using immersive virtual reality, found that canopy closure, species diversity, and the presence of water features were predictive of restorative outcomes. That said, the evidence also cautions against assuming that more vegetation automatically means better mental health outcomes. Nguyen et al. (2021) found that quality dimensions — including maintenance, perceived safety, and biodiversity — moderated health effects as much as sheer availability.

4.4 A Theoretical Framework for the Psychology of Vegetation

Drawing together the evidence across all three themes, this review proposes a three-level theoretical framework for the Psychology of Vegetation.

At the micro-level, it maps the neurobiological and psychological mechanisms through which individual contact with botanical elements produces therapeutic effects — attentional, emotional, physiological, and chemical. At the meso-level, it addresses the design principles and environmental features that maximise therapeutic potential, including biodiversity, sensory complexity, spatial configuration, and accessibility. At the macro-level, it situates the Psychology of Vegetation within the wider policy frameworks of public health, urban planning, and sustainable development — identifying the structural conditions that determine whether individual-level benefits are equitably shared across populations.

This three-level framework is intended to open dialogue between disciplinary communities that have historically worked in relative isolation: plant biologists and landscape ecologists focused on the structural properties of vegetation; clinical psychologists and psychiatrists studying mental health outcomes; and urban planners and public health professionals designing and evaluating green infrastructure. The Psychology of Vegetation, as a field, needs all three levels working in concert.

4.5 Limitations of This Review

Three limitations merit acknowledgement. First, restricting the search to English-language publications has resulted in the near-total absence of Arabic-language research, meaning culturally specific relationships between arid-climate vegetation and mental health remain entirely unrepresented in this synthesis — a gap that future work must prioritise. Second, the scoping

review format, while appropriate for a field as heterogeneous as this one, does not permit the quantitative synthesis of effect sizes. Third, thematic analysis is inherently interpretive, and a different research team might reasonably have arrived at a different conceptual structure.

5. Conclusion

This review set out to ask whether the therapeutic potential of vegetation could be mapped systematically enough to be useful — to clinicians, city planners, and policymakers working with limited resources and urgent need. The evidence is genuinely compelling: across study designs, populations, and cultural contexts, contact with botanical environments consistently shows measurable benefits — reduced physiological stress, improved attention, lower rates of anxiety and depression, and stronger reported well-being. These are not marginal effects, and they emerge from mechanisms — attentional, emotional, neurobiological — that are increasingly well understood.

However, the review also surfaced limitations that matter. We still do not know, with any clinical precision, how much exposure is enough — or for whom, or under what conditions. The research base is heavily concentrated in wealthy, English-speaking, and East Asian contexts, and the near-complete absence of Arabic-language and low-to-middle-income country research represents a scholarly and practical gap that is no longer defensible. Any serious global public health strategy built on this evidence must grapple with that structural reality.

There is also an equity problem that no amount of research sophistication will resolve on its own. High-quality green space is not evenly distributed. The populations most likely to benefit from vegetation-based interventions are frequently those with the least meaningful access to them. Addressing this requires political will alongside scientific evidence.

What this review ultimately argues for is not a replacement of existing mental health care, but an expansion of what we consider care to include. Plants have been part of human environments for the entirety of our existence as a species. Closing the growing distance between people and botanical life — thoughtfully, equitably, and at scale — is a practical task with real clinical and public health dividends. It is also, we would suggest, long overdue.

6. Recommendations

6.1 For Clinical Practice

- Integrate ecotherapy and horticultural therapy as evidence-based adjunct treatments for mild-to-moderate depression and anxiety, particularly in inpatient and community mental health settings.
- Establish minimum nature exposure guidelines (e.g., 120 minutes per week) as part of standard health promotion advice within primary care consultations.
- Develop and validate standardised protocols for prescribing vegetation exposure, specifying duration, frequency, biodiversity level, and engagement mode for different clinical populations.

6.2 For Urban Planning and Policy

- Prioritise biodiversity and multi-sensory design (varied species, natural soundscapes, water features) over simply maximising green coverage when planning urban green infrastructure.
- Apply a green space equity lens to all urban planning decisions, actively targeting investment toward under-served, socioeconomically disadvantaged, and densely populated neighbourhoods.
- Incorporate biophilic design principles into building codes and urban development regulations as a cost-effective public mental health intervention.

6.3 For Research

- Fund and conduct rigorous studies in low- and middle-income countries, with particular urgency regarding Arabic-speaking and arid-climate contexts, to address the current geographic bias in the evidence base.
- Develop and adopt internationally standardised measures of vegetation exposure and therapeutic dose, enabling meaningful cross-study comparison and meta-analytic synthesis.
- Expand clinical research to investigate the differential effects of vegetation exposure across specific mental health diagnoses, including PTSD, schizophrenia, and eating disorders — currently almost entirely absent from the literature.

- Pursue interdisciplinary research partnerships between plant ecologists, clinical psychologists, neuroscientists, and urban planners to build the multi-level evidence base the field requires.

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