



OPEN ACCESS

EDITED BY

Mohiuddin Md. Taimur Khan,
Washington State University Tri-Cities,
United States

REVIEWED BY

Keith Dana Thomsen,
Washington River Protection Solutions,
United States
Paul Rose,
University of Exeter, United Kingdom

*CORRESPONDENCE

Stefan Zerbe
✉ stefan.zerbe@unibz.it

RECEIVED 19 January 2025

ACCEPTED 18 February 2025

PUBLISHED 10 March 2025

CITATION

Zerbe S, Schmid H-L, Hornberg C,
Freytmüller J and Mc Call T (2025) Nature's
impact on human health and wellbeing: the
scale matters.
Front. Public Health 13:1563340.
doi: 10.3389/fpubh.2025.1563340

COPYRIGHT

© 2025 Zerbe, Schmid, Hornberg, Freymüller
and Mc Call. This is an open-access article
distributed under the terms of the [Creative
Commons Attribution License \(CC BY\)](#). The
use, distribution or reproduction in other
forums is permitted, provided the original
author(s) and the copyright owner(s) are
credited and that the original publication in
this journal is cited, in accordance with
accepted academic practice. No use,
distribution or reproduction is permitted
which does not comply with these terms.

Nature's impact on human health and wellbeing: the scale matters

Stefan Zerbe^{1,2*}, Hannah-Lea Schmid³, Claudia Hornberg³,
Julius Freymüller³ and Timothy Mc Call³

¹Faculty of Agricultural, Environmental and Food Sciences, Free University of Bozen-Bolzano, Bozen, Italy, ²Institute of Geography, University of Hildesheim, Hildesheim, Germany, ³Medical School OWL, Sustainable Environmental Health Sciences Bielefeld University, Bielefeld, Germany

Contact with nature can have a significant influence on human physical and mental health and wellbeing. As such, various concepts and theories as well as therapeutic approaches have been developed. The term “nature,” however, covers a broad range of size and scales, ranging from individuals or small groups of animals or plants, certain ecosystems toward landscapes. The purpose of this paper is to differentiate concepts, theories, and therapy forms according to the scales of nature. We base our conceptional approach on the biological/ecological scales of species/individuals, ecosystems/land-use types, and landscapes. Based on a review, we differentiate the current state of the utilization of greenspace exposure measurements and measures assessing mental health according to these scales. We argue that a clear differentiation of biological and ecological scales provides a better understanding of the impact of nature with its components, characteristics, and dynamics on human health and wellbeing. Our paper also supports further inter- and transdisciplinary research as well as methodological approaches with regard to environment and health, such as environmental public health.

KEYWORDS

biophilia, exposure measurements, greenspace, landscape, therapeutic landscapes

1 Introduction

With both increasing urbanization worldwide and land-use change, there is a growing disconnection of humans from nature (1, 2). However, a number of studies have found evidence for the positive effects of contact to nature on physical and mental health and wellbeing [e.g., (3–5)]. The term “nature” covers a broad range of size and scales, ranging from potted plants (6), individuals or small groups of animals or plants (7), a garden (8) or zoological gardens (9), to the wilderness of a national park (10) or highly transformed urban nature (11). In addition to the visible nature which addresses visual perception, there are multiple other characteristics of nature which are perceived by tactile, olfactory, auditory, and gustatory senses, as well as the dynamics of nature such as, for example, the seasons of the year (12–14). The exposure to nature can be direct or indirect, active or passive, incidental or intentional, as well as real or virtual (15, 16). Additionally, exposure is related to proximity, likelihood, and duration of nature contact (12).

The more it has become evident that contact of humans with nature has a positive effect on health and wellbeing, the more concepts (e.g., biophilia), theories (e.g., attention restoration theory), and therapeutic approaches with nature (e.g., animal-assisted therapy) have emerged or are being developed. They have been and are being developed in various scientific disciplines both, within the natural sciences (e.g., biophilia) and the social sciences (e.g., restorative environments). However, there is an increasing trend to use well-defined terminology and concepts out of contexts. This might be due to a lack of fitting terms in the respective discipline and/or in an effort to bridge certain disciplines. This partly leads to diluting the meaning of the terms or developing hybrid concepts which lack clear definitions. In environmental science

and restoration ecology, for example, “ecosystem health” [e.g., (17)] is such a hybrid concept (18) which tries to merge the ecological concept of “ecosystem” with the concept of “health” from medicine and the social sciences.

The distinction between the biological and ecological scales of species and individuals, ecosystems/land-use types, and landscapes has become less clear over time and has grown to include a large variety of settings. An example is the concept of “therapeutic landscapes” as discussed by Taheri et al. (19) which reveals the range of addressed “landscapes” from a garden to a desert [see also (20)]. This holds also true for “green” or “greenness,” often not clearly classified and differentiated (21). As such, scales of nature which are well defined in ecology and landscape ecology (Figure 1) have become mixed up, leading to an unclarity of certain concepts. Accordingly, the scales of biological organisms, ecosystems, and landscapes are no longer separated. Furthermore, many other concepts do not include information on the intended scale they pertain to, as well as empirical research that often fails to define the scales investigated (22, 23). When scale is addressed in research regarding nature and health, the focus is mostly the spatial scale from the human point of reference (24) without consideration of the biological/ecological scales [cp. (25)]. Although, this is important for investigating the exposure and experience, the first step is to define the type and scale of the “nature” in question. In fact, it has been shown that different types of nature at different scales can have different links to mental health (26).

Therefore, the aim of this paper is to address the relevance of scales when using the concepts of nature’s influence on human health and wellbeing. We base the scales of nature on the well-established biological and ecological foundations. Additionally, we analyze how the different scales are addressed in theory and research. Regarding current research, we used data gathered in the process of a scoping review (15) investigating the connection of greenspace and mental health methods to inform our findings. With this, we want to contribute to a clearer differentiation of such concepts based on the various scales of nature, the natural environment, and the elements of nature. Accordingly, (1)

we define the scales of nature based on biological and ecological principles, respectively. Then, (2) we relate these scales of nature to concepts and therapies with regard to human health and wellbeing. (3) Based on a previously published scoping review, we explore the utilization of greenspace exposure measurements and measures assessing mental health according to the ecological scales and their frequency of use in order to identify common patterns and research gaps. With this conceptual approach, we hope to provide guidance for defining and differentiating “nature” based on ecological concepts, also for empirical research, especially from other disciplines. In turn, we hope that this will support further inter- and transdisciplinary research with regard to environment and health, such as environmental public health.

2 Methodology

A multidisciplinary group was formed from two European universities (Bielefeld University and Free University of Bozen-Bolzano) with the aim of bringing together expertise in landscape ecology, urban ecology, environmental health, clinical medicine, and psychology. The group examined published reviews, as well as primary research reports, focusing on key theories, concepts, and therapeutic approaches of the nature and health nexus. Iterative discussions and consensus-building were then used to link these theories to the scales of nature. For the differentiation of the scales of nature, we refer to common approaches in biology and ecology, focusing on the scales of species/individuals, ecosystems and land-use types as well as landscapes (Figure 1; Table 1). We state examples how these three scales impact human health and give an overview on concepts and therapies related to nature and human health which we categorize according to the scales of nature (Figure 2; Table 2).

In a next step, we used data from a previously published scoping review (15) and analyzed which combinations of methods are employed at which scale in current research. The information regarding greenspace and mental health research, in particular, is based on data gathered in the context of this scoping review which focused on current methodologies of greenspace exposure and mental health research. Within this scoping review, we screened and extracted the information of 338 studies (references in Supplementary Table 1) regarding the scales and types of greenspaces, mental health outcomes, and measurements of greenspace exposure and mental health. The different categories of methods regarding greenspace and mental health in research were iteratively generated from the analyzed studies and described in the scoping review (15). Further information regarding the methodology, e.g., the screening process of the scoping review can be found in (15). We re-analyzed the data according to the three scales to identify patterns as well as potential research gaps. The biological/ecological scales used in the analysis are based on the aforementioned approaches which were identified in the existing literature. From this, we derive the up-to-date counts of utilization of greenspace exposure measurements and measures assessing mental health according to the biological/ecological scales. We visualize the distribution of the green space and mental health methods according to the scales in a bubble grid (Figure 3). The size of the bubbles is indicative of the frequency with which a specific combination of methods was utilized in comparison to other combinations. The pie charts and colors illustrate the scales and the ratio between the scales at which these combinations were employed.

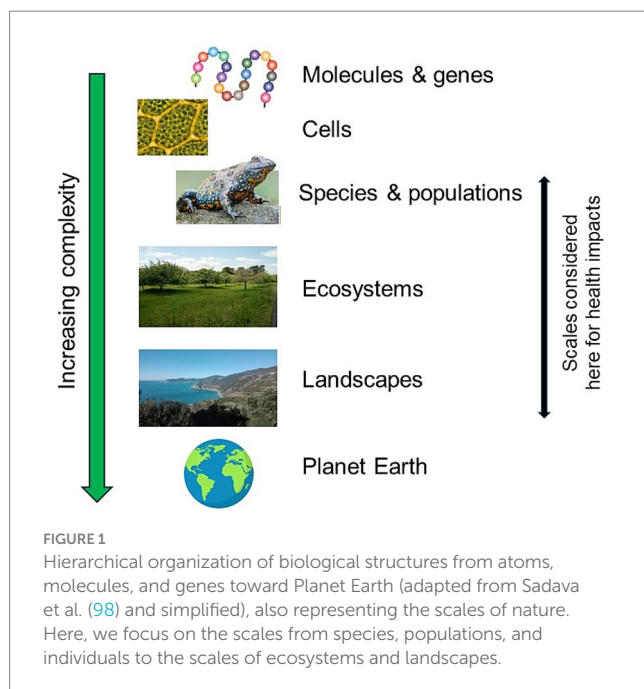
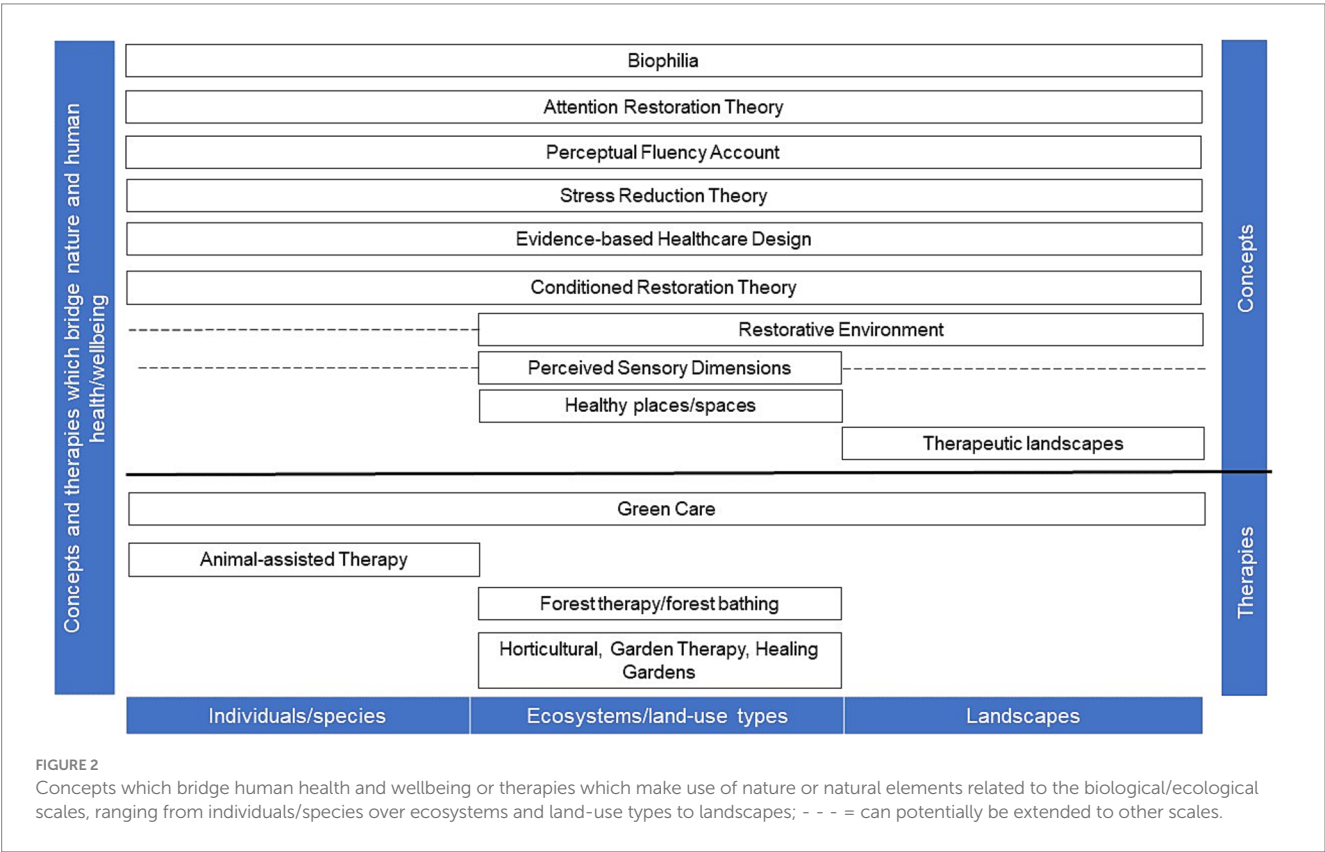


TABLE 1 Definition of the biological and ecological scales regarding species, ecosystems, and landscapes (cp. Figure 1) with selected key references.

Biological/ecological scale	Definition	Selected references	Examples which might refer to human health and wellbeing
Species	A group of organisms that can reproduce with one another in nature and produce fertile offspring. In fieldwork and for practical purposes such as, e.g., nature conservation and landscape architecture, so-called morphospecies are differentiated, taxonomically systematized, and termed, based on the morphological characters.	De Queiroz (99), Derraik et al. (100)	Trees, shrubs, herbs, grasses, horses, dogs, cats, birds, insects, reptiles
Ecosystem and land-use type	“The term ecosystem is used to denote the biological community together with the abiotic environment in which it is set. Thus, ecosystems normally include primary producers, decomposers and detritivores, a pool of dead organic matter, herbivores, carnivores and parasites plus the physicochemical environment that provides the living conditions [...]”	Begon and Townsend (101)	Forest, pastureland, managed grassland, reed stand, heathland, arable land
Landscape	“Spatially heterogeneous areas characterized by a mosaic of patches that differ in size, shape, contents, and history”; they range from relatively natural terrestrial and aquatic systems such as forests, grasslands, and lakes to human-dominated environments including agricultural and urban settings	Wu (102); see also, Council of Europe (103) and Zerbe (43)	(Traditional) Cultural landscapes such as, e.g., terraced landscape, riverscape, lakescape, seascape, monastic landscapes, landscape parks as well as urban landscapes



3 Results

3.1 Scales in biology, ecology, and landscape ecology

Biology, ecology, and landscape ecology provide definitions of three main scales, ranging from species (and individuals of species)

over ecosystems/land-use types to landscapes. These scales are defined in Table 1. In practices such as habitat (= biotope) mapping, nature conservation, ecosystem restoration or landscape planning, ecosystems often are referred to as land-use types, such as forests, grassland, heathland or arable land [e.g., (18, 27)]. The latter applies also to studies on the impact of nature and green on human health and wellbeing.

TABLE 2 Concepts of healing nature and therapy forms taking benefit of nature and natural elements (in alphabetic order) with selected references such as the introduction of the concept or review papers.

Concept of healing nature and forms of therapies with nature and natural elements	Selected references
Concepts and theories	
Attention Restoration Theory (ART)	Kaplan and Kaplan (54)
Biophilia	Wilson (53)
Conditioned Restoration Theory (CRT)	Egner et al. (104)
Evidence-based Healthcare Design	Ulrich et al. (105)
Healthy places/spaces	Bell et al. (20)
Perceived Sensory Dimensions	Grahn and Stigsdotter (106), Schmid et al. (57)
Perceptual Fluency Account	Joye and Van der Berg (108)
Restorative Environment	Hartig (107), Joye and van den Berg (108)
Stress Reduction Theory	Luo and Jiang (109), Ulrich (110), Ulrich et al. (111)
Therapeutic Landscapes	Gesler (61)
Therapies with nature and natural elements	
Animal-assisted Therapy	Kamioka et al. (112)
Forest Therapy (incl. “Forest bathing”/shinrin-yoku)	Wen et al. (40), Kim and Shin (113)
Green care	Cutcliffe and Travale (114)
Horticultural, Garden Therapy, Healing Gardens	Cooper-Marcus and Barnes (35), Stigsdotter and Grahn (115), Clatworthy et al. (39), Kamioka et al. (116), Cipriani et al. (117), Dushkova and Ignatieva (36)

For the nature scales, see Figure 2.

The biological and ecological differentiation of scales from molecules toward the planet (cp. Figure 1) do not necessarily correlate with spatial scales. Following the definition of a species’ habitat by Hall et al. (28) as “an area’s ability to provide resources for population persistence,” the ecosystem scale might be addressed. A monospecific reed stand [*Phragmites australis* (Cav.) Trin. Ex Steud.], for example, can cover many hectares or square kilometers, respectively, and thus, represent a wetland on the ecosystem or even landscape scale [e.g., (29)]. The Taiga of the northern hemisphere, dominated by Norway spruce (*Picea abies* L.) spans over thousands of square kilometers. Additionally, the same species has been afforested in many regions in Central Europe and thus, shaping whole mountain landscapes such as, e.g., the Thuringian forest or the Sauerland in Germany (18).

3.2 The various dimensions and scales of nature, and the influence on human health and wellbeing

In the following, selected examples of studies are presented in which the effect of nature and natural elements in its various dimensions and scales on human health and wellbeing are addressed. Cox et al. (30), for

example, explored how individual urban trees vary in their contribution to indirect nature experiences in a human population, thus supporting urban design and planning toward green health interventions. Similarly, Zhao et al. (31) investigated the visual preference of trees by focusing on the effects of tree attributes and seasons. Finally, individuals of certain animals are often part of particular therapies such as animal-assisted interventions. Accordingly, horses (32), dogs (33), and cats (34), for example, are employed to promote human health or assist recovery from mental or physical diseases.

Ecosystems and land-use types are addressed in human health concepts, particular therapies, and health interventions. As such, healing gardens (35–37) or therapeutic gardens (38) can contribute to mental health [see also (39) on gardening-based mental health interventions]. Forests can relieve from stress, what has been coined as forest bathing (40). Emerging from Japan as “Shinrin-Yoku,” empirical research elucidates the physiological and psychological effects of forest bathing (41, 42).

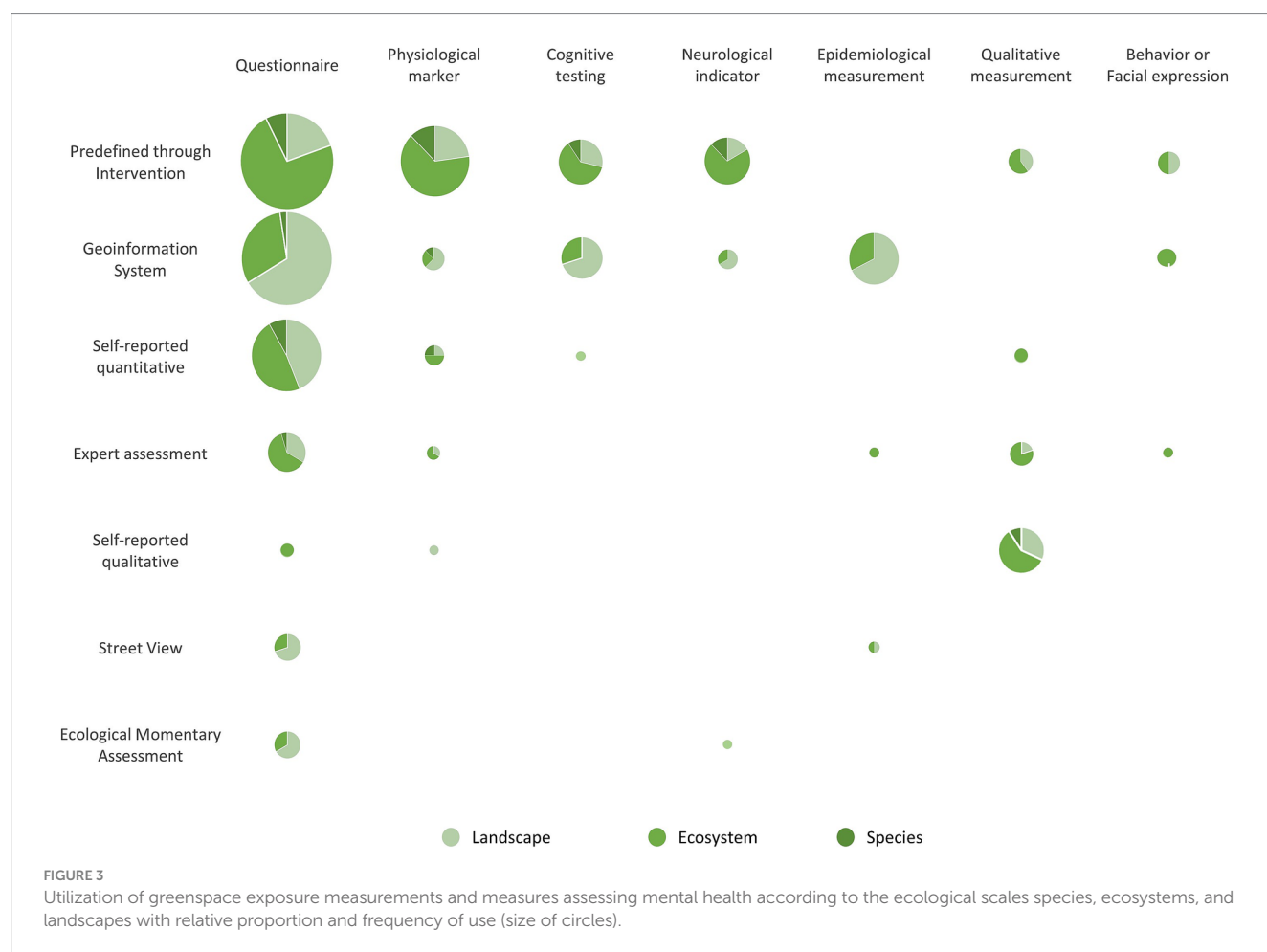
The various aspects of green care can also involve the ecosystem and land-use type scale [e.g., Cutcliffe et al.; for an overview, see (43)]. If farms and small-scale living facilities (44) or agricultural land (45) are related to human health or integrated into therapies, the scale of land-use types is addressed. Finally, and more general “healthy places” are a subject of health geography (20). By putting the anthropocentric ecosystem service concept [cp. (46)] to the practice of human health, Bratman et al. (12) show how ecosystem service assessments can be expanded to include mental health, and provide a heuristic, conceptual model for doing so. Often, the scale of ecosystems and land-use types is also addressed if species richness (diversity with its various indices) is related to human health [e.g., (47); see also (48)].

The benefits of landscapes to human health are explored by Opdam (49), and, in this context referred to as landscape services. Menatti and Casado da Rocha (50) discuss the concept of therapeutic landscapes and refer to, e.g., national parks and urban landscapes. The relationship between multifunctional landscapes and wellbeing is investigated by Fagerholm et al. (51) through measuring self-reported wellbeing across 13 rural and peri-urban sites in Europe.

While it is far from comprehensive, the brief overview above demonstrates the wide range of the scales of nature—species (with individuals), ecosystems, and landscapes—and their influence on both mental/physical health and human wellbeing. Human health concepts and therapies with nature partly refer to specific scales, partly not as the following chapter will elucidate.

3.3 Human health concepts and therapies with nature related to the various scales of nature

Figure 2 depicts how concepts and therapies which bridge nature and human health and wellbeing are related to the different biological and ecological scales of nature. Hereby, concepts are differentiated from various forms of therapies with nature and natural elements, respectively. In Table 2, these concepts and therapy forms are listed and selected references given. Concepts such as therapeutic landscapes literally address the landscape scale. Animal-assisted therapies, on the contrary, are based on the interaction of an animal individual or species with humans in order to facilitate recovery from diseases or health problems. Other concepts and therapy forms range over various scales.



Studies on therapies and theoretical concepts on the interaction of human health and nature frequently fail to address or define the scale of the environment in question. Furthermore, the different types of greenspace at the same scale are often inconsistently or inaccurately defined. Such limitations may impede the comparability of results and interdisciplinary understanding. Accordingly, we scanned through current methodologies of greenspace exposure and mental health research in order to extract the methods employed at the different scales and analyze how they differ (15).

3.4 Greenspace and mental health research—the question of scale

Based on data collected within the scoping review from Freymüller et al. (15), we could combine greenspace exposure methods and mental health measurements referring to the scales differentiated here (Figure 3). Generally, distinct greenspace measures are used at different scales, while the mental health measures do not show such a clear pattern. The “landscape” scale is most often assessed via GIS approaches. The scales “ecosystems” and “species” are mostly investigated via interventions. Overall, the ecosystem’s scale is the most frequent in both, research and theory. Qualitative (self-reported) mental health measures often focus on ecosystems. However, the qualitative theoretical concepts are often based on landscapes such as therapeutic landscapes. Species

and natural elements are rarely directly addressed by the studies investigated. Some methods are not combined in current research (e.g., street view and physiological markers) and some combinations only employed at some scales (e.g., self-reported qualitative and questionnaire). Applying different combinations of methods at the different scales can reveal new insights as all measurements feature their own benefits and biases. Nevertheless, it should be noted that some methods can be combined better than others.

4 Discussion

Nature with its various dimensions, characteristics, dynamics, and scales can have a positive influence on human health and human wellbeing. Each level and scale of nature, however, provides important components in understanding what contact with nature can and cannot do for human health (52). The ecological scales can be a useful way to describe nature in health research. We demonstrated that certain concepts and therapeutic interventions directly address the question of the scales of nature, while others do not adequately address or define it. Some concepts and therapies exhibit a high degree of specificity, relating to a single scale, while others demonstrate a greater degree of versatility, applicable to a range of scales. In this regard, concepts are often broader and therapeutic approaches more specific. The present analysis of contemporary research methodologies reveals

that distinct greenspace metrics are employed at varying spatial scales. In contrast, the utilization of mental health metrics does not exhibit such a consistent pattern. Furthermore, some discordance emerges between the theoretical underpinnings and the research methods employed in relation to the scale level.

4.1 Concepts of healing nature

Concepts, as shown in Figure 2, often address the whole range of biological-ecological scales which means, “nature *per se*.” This, for example, holds true for biophilia which describes the evolutionary adaptation of humans to nature (53). This is supported by the attention restoration theory which explains how natural environments provide positive human health and wellbeing benefits (54, 55), regardless of the scale of nature. Other concepts cannot be easily assigned to a scale such as the concept of perceived sensory dimensions. In many studies, the perceived sensory dimension concept refers to parks, gardens, and greenspaces and thus, the ecosystem and land-use scale [e.g., (56–58)]. Although, the concept refers to ecosystem services (59) and thus to the ecosystem and land-use scale, in principle, it can be applied to the whole range of nature scales. Nevertheless, Stoltz and Grahm (58) point out that a general distinction can be made between perceived sensory dimensions requiring a larger scale (natural, serene, cohesive, and open dimension) and dimensions possible on a smaller scale (shelter, diverse, social and cultural dimension). The concepts of healthy places/spaces and therapeutic landscapes however, can be clearly assigned to the ecosystem and land-use scale and the landscape scale, respectively.

First introduced by Gesler (60, 61), the concept of therapeutic landscapes has been used to draw attention to “the complex intermingling of physical, social and symbolic processes that determine a place’s potential to positively or negatively affect health” [(62), p. 10]. Various terms and terminologies have emerged in this context (20). Consequently, these “therapeutic landscapes” include a large variety of settings (19, 63), situations, and milieus (36) as well as scales of which some are indeed landscapes and some, however, address other nature scales. Accordingly, those settings studied as “therapeutic landscapes” span from the places of pilgrimage such as Lourdes in France (64), churches such as the Basilica of Sainte Anne de-Beaupré in Quebec, Canada (65), a public library (66), a café (67), “healing sites” such as the Asclepian sanctuary at Epidauros in Greece (68), and “symbolic landscapes” (69), over farms (70), communal and domestic gardens (71), health camps (72), and psychiatric hospitals (73, 74) to wilderness (75–78) and urban green and blue spaces (79–81).

4.2 Therapies with nature and nature-based therapies

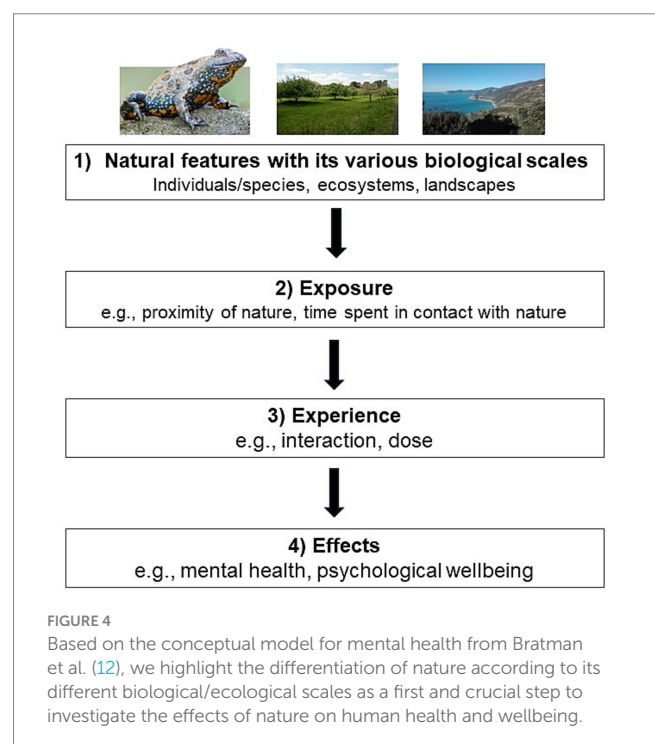
In contrast, the therapy forms with which nature or natural elements are directly or indirectly applied to promote human health and wellbeing are often clearly assigned to a certain scale. This makes sense, given that interventions have to be more concrete than theories. The species scale (with its individuals of plants and animals) offers direct interaction and responsiveness which, for example, is applied within animal-assisted therapies. The ecosystem scale, encompassing

land-use types in cultural landscapes, has been increasingly addressed in environment-human health research, and its implications for practice with the introduction of the ecosystem services’ concept [e.g., (82–84)]. However, the ecosystem and land-use type scale becomes more complex with its components and dimensions. This has been addressed by Lovell et al. (85) with regard to community gardening. Accordingly, the participation in the gardening activities may improve wellbeing through social contact and culturally valued activities, as well as through healthy food production.

Since the complexity increases with the landscape scale, there is no specific therapy approach yet focusing only on landscapes (Figure 2). This might be the reason for the comparably low number of studies on the impact of therapy forms employing landscapes compared to the impact of organisms and ecosystems. Accordingly, studies often are qualitative, applying interview approaches and field observations [e.g., (22, 86, 87)]; only few studies are quantitative [e.g., (88, 89)]. Given these complex conditions it is difficult to determine the effects of the landscape, e.g., the relation between the wilderness in wilderness-interventions and the therapeutic outcomes, which many studies do not directly engage with (90).

4.3 The complexity of nature-health interaction regarding scales

These scales discussed here do not inform *per se* about the effect of nature or natural elements on human health. However, it is a first and crucial step for studying the effects of nature on human health and wellbeing (Figure 4). Accordingly, by establishing a coherent definition of biological/ecological scales can help to reveal possible differences in their effects. This is particularly relevant due to the multitude of pathways that nature such as greenspaces has on human health (91, 52). After having differentiated these scales, exposures, experiences,



effects and mechanisms can be observed and measured with greater accuracy and comparability in future research.

Landscape and human health impact might not be investigated in its complexity. In their literature review, Velarde et al. (23), revealed that in studies comparing the health outcomes of visual exposure to different categories of landscapes, the categories compared were generally very coarse. They conclude that “these coarse categories clearly fail to reflect the vast variety of landscapes and landscape elements that are important in defining the character of [...] landscapes” [(23), p. 208].

Besides exposure (e.g., proximity to nature, time spent in contact with nature) and experience [e.g., interaction, dose; (12)], Bratman et al. (92) point out in their review that both the scale and the different types are essential to understand the underlying psychological mechanisms for human health. The authors conclude that “at a minimum, it would be most informative were the research to specify the types of environments used in experiments in some detail, using modern quantitative methods at multiple scales” [(92), p.120]. Accordingly, this would lead to a more coherent set of postulates about which particular aspects of nature may have impacts on human health and wellbeing and what the causal pathways are for these effects. Furthermore, clear and consistent definitions of shared concepts allow more fruitful inter- and transdisciplinary research to develop (15). This will help to reveal approaches in future research that enhance beneficial outcomes for human health and wellbeing alongside nature conservation or restoration.

Other concepts, not analyzed here, are also addressing the effect of nature on human health and wellbeing at different scales. However, these concepts are often derived from existing concepts such as, e.g., “nature connectedness” as the exposure to natural environments which should have a positive impact on health and wellbeing (93). Accordingly, this concept is very similar to the theoretical framework of biophilia. The “one health” concept is an overarching framework which is “an integrated, unifying approach to balance and optimize the health of people, animals and the environment” (94). This approach is aiming at the mobilization of multiple sectors, disciplines, and communities at varying levels of society to cooperate and thus has a transdisciplinary character [see also (95)]. Similarly, “planetary health” is a transdisciplinary field and social movement which addresses human health and all life on Earth. This concept is “based on the understanding that human health and human civilization depend on flourishing natural systems and the wise stewardship of those natural systems” [(96), p. 1974]. The EcoHealth concept focuses on the interactions between the ecological and socio-economic dimensions of a given situation, and their influence on human health. Furthermore, it addresses how people use or impact ecosystems, the implications for the quality of ecosystems, the provision of ecosystem services, and sustainability (97). As one approach to mitigate negative impacts of degraded environments on human health and wellbeing, “nature-based solutions” can be considered (36). Particularly in urban environments this means the restoration of nature at all scales, from single natural elements toward landscape settings.

5 Conclusion

The different ecological scales are addressed using different methods and covered in different concepts and theories, respectively.

Empirically, there is a clear focus on the ecosystem scale, particularly through interventions. Concepts on nature and health often comprise the whole range of ecological scales, however the scale is often not clearly stated. We would assign the concept of therapeutic landscapes to the landscape scale; however, it is often used to investigate ecosystems or species. Overall, landscapes are often assessed quantitatively through GIS methods, the therapeutic landscapes concept however has a qualitative focus. The therapeutic approaches are more clearly assigned to specific scales, with an emphasis on the species scale. In contrast, species are addressed the least in current research on greenspace and health. At the landscape level, no therapies were identified. Our study shows that increased attention to types and scales of nature is needed in both, practical research and theory. Established ecological scales can provide a common basis for interdisciplinary research and improve comparability. This will elucidate the potential differences in the impact of the diverse forms and dimensions of nature on human health. Particularly, for interdisciplinary studies which integrate (landscape) ecology and public health or medicine the differentiation of biological/ecological scales might support clearer understanding and designs of studies and their implications for practice.

Future research should focus on documenting effect sizes at the clearly defined relevant scale, for given outcomes of interest including underlying theories and concepts. In addition, a corresponding central data repository containing multiple studies or meta-analyses could be of interest to researchers and practitioners.

Data availability statement

The original contributions presented in the study are included in the article/[Supplementary material](#), further inquiries can be directed to the corresponding author.

Author contributions

SZ: Conceptualization, Funding acquisition, Methodology, Visualization, Writing – original draft, Writing – review & editing. H-LS: Conceptualization, Visualization, Writing – review & editing. CH: Funding acquisition, Writing – review & editing. JF: Writing – review & editing. TM: Writing – review & editing.

Funding

The author(s) declare that financial support was received for the research, authorship, and/or publication of this article. This research was funded within the program “Healthy Places - Therapeutic Landscapes” by the Peter Beate Heller-Stiftung of the German Stifterverband (Project number: T0160/33738/2019/kln).

Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Generative AI statement

The authors declare that no Gen AI was used in the creation of this manuscript.

Publisher's note

All claims expressed in this article are solely those of the authors and do not necessarily represent those of their affiliated organizations,

or those of the publisher, the editors and the reviewers. Any product that may be evaluated in this article, or claim that may be made by its manufacturer, is not guaranteed or endorsed by the publisher.

Supplementary material

The Supplementary material for this article can be found online at: <https://www.frontiersin.org/articles/10.3389/fpubh.2025.1563340/full#supplementary-material>

References

- Barrable A, Booth D. Disconnected: what can we learn from individuals with very low nature connection? *Int J Environ Res Public Health*. (2022) 19:8021. doi: 10.3390/ijerph19138021
- Lee JH, Lee SJ. Nature experience influences nature aversion: comparison of South Korea and Germany. *Soc Behav Pers*. (2018) 46:161–76. doi: 10.2224/sbp.6794
- Aerts R, Honnay O, Van Nieuwenhuysse A. Biodiversity and human health: mechanisms and evidence of the positive health effects of diversity in nature and green spaces. *Br Med Bull*. (2018) 127:5–22. doi: 10.1093/bmb/ldy021
- Bowler DE, Buyung-Ali LM, Knight TM, Pullin AS. A systematic review of evidence for the added benefits to health of exposure to natural environments. *BMC Public Health*. (2010) 10:456. doi: 10.1186/1471-2458-10-456
- Nejade RM, Grace D, Bowman LR. What is the impact of nature on human health? A scoping review of the literature. *J Glob Health*. (2022) 12:04099. doi: 10.7189/jogh.12.04099
- Frumkin H, Bratman GN, Breslow SJ, Cochran B, Kahn PH Jr, Lawler JJ, et al. Nature contact and human health: a research agenda. *Environ Health Perspect*. (2017) 125:075001–11. doi: 10.1289/EHP1663
- Matchock RL. Pet ownership and physical health. *Curr Opin Psychiatry*. (2015) 28:386–92. doi: 10.1097/YCO.0000000000000183
- Gerlach-Spriggs N, Kaufman RE, Warner SB. Restorative gardens: The healing landscape. New Haven, CT, USA: Yale University Press (1998).
- Rose P, Riley L. Five ways to wellbeing at the zoo: improving human health and connection to nature. *Front Psychol*. (2023) 14:1258667. doi: 10.3389/fpsyg.2023.1258667
- Harper NJ, Ferner CR, Gabrielsen LE. Nature's role in outdoor therapies: an umbrella review. *Int J Environ Res Public Health*. (2021) 18:5117. doi: 10.3390/ijerph18105117
- Shanahan DF, Fuller RA, Bush R, Lin BB, Gaston KJ. The health benefits of urban nature: how much do we need? *Bioscience*. (2015) 65:476–85. doi: 10.1093/biosci/biv032
- Bratman GN, Anderson CB, Berman MG, Cochran B, de Vries S, Flanders J, et al. Nature and mental health: an ecosystem service perspective. *Science. Advances*. (2019) 5:eax0903. doi: 10.1126/sciadv.aax0903
- Conniff A, Craig T. A methodological approach to understanding the wellbeing and restorative benefits associated with greenspace. *Urban For Urban Green*. (2016) 19:103–9. doi: 10.1016/j.ufug.2016.06.019
- Soga M, Gaston KJ. The ecology of human–nature interactions. *Proc R Soc B*. (2020) 287:20191882. doi: 10.1098/rspb.2019.1882
- Freytmüller J, Schmid H-L, Senkler B, Lopez Lumby S, Zerbe S, Hornberg C, et al. Current methodologies of greenspace exposure and mental health research - a scoping review. *Front Public Health*. (2024) 12:1360134. doi: 10.3389/fpubh.2024.1360134
- Vilcins D, Sly PD, Scarth P, Mavoa S. Green space in health research: an overview of common indicators of greenness. *Rev Environ Health*. (2022) 39:221–31. doi: 10.1515/revh-2022-0083
- Aronson JC, Blatt CM, Aronson TB. Restoring ecosystem health to improve human health and well-being: physicians and restoration ecologists unite in a common cause. *Ecol Soc*. (2016) 21:39. doi: 10.5751/ES-08974-210439
- Zerbe S. Restoration of ecosystems – Bridging nature and humans. A transdisciplinary approach. Spektrum Berlin, Heidelberg: Springer (2023).
- Taheri S, Ghasemi Sichani M, Shabani A. Evaluating the literature of therapeutic landscapes with an emphasis on the search for the dimensions of health: a systematic review. *Soc Sci Med*. (2021) 275:113820. doi: 10.1016/j.socscimed.2021.113820
- Bell SL, Foley R, Houghton F, Maddrell A, Williams AM. From therapeutic landscapes to healthy spaces, places and practices: a scoping review. *Soc Sci Med*. (2018) 196:123–30. doi: 10.1016/j.socscimed.2017.11.035
- Van den Bosch M, Sang AO. Urban natural environments as nature-based solutions for improved public health – a systematic review of reviews. *Environ Res*. (2017) 158:373–84. doi: 10.1016/j.envres.2017.05.040
- Evered E. The role of the urban landscape in restoring mental health in Sheffield, UK: service user perspectives. *Landsc Res*. (2016) 41:678–94. doi: 10.1080/01426397.2016.1197488
- Velarde MD, Fry G, Tveit M. Health effects of viewing landscapes – landscape types in environmental psychology. *Urban For Urban Green*. (2007) 6:199–212. doi: 10.1016/j.ufug.2007.07.001
- Labib SM, Lindley S, Huck JJ. Spatial dimensions of the influence of urban green-blue spaces on human health. A systematic review. *Environ Res*. (2020) 180:108869. doi: 10.1016/j.envres.2019.108869
- Marselle MR, Irvine KN, Warber SL. Walking for well-being: are group walks in certain types of natural environments better for well-being than group walks in urban environments? *Int J Environ Res Public Health*. (2013) 10:5603–28. doi: 10.3390/ijerph10115603
- Beute F, Marselle MR, Olszewska-Guizzo A, Andreucci MB, Lammel A, Davies ZG, et al. How do different types and characteristics of green space impact mental health? A scoping review. *People Nature*. (2023) 5:1839–76. doi: 10.1002/pan3.10529
- Zhang C, Li X. Land use and land cover mapping in the era of big data. *Landscape*. (2022) 11:1692. doi: 10.3390/land11101692
- Hall LS, Krausman PR, Morrison ML. The habitat concept and a plea for standard terminology. *Wildl Soc Bull*. (1997) 25:171–82.
- Brix H, Ye S, Laws EA, Sun D, Li G, Ding X, et al. Large-scale management of common reed, *Phragmites australis*, for paper production: a case study from the Liaohai Delta, China. *Ecol Eng*. (2014) 73:760–9. doi: 10.1016/j.ecoleng.2014.09.099
- Cox DTC, Bennie J, Casalegno S, Hudson HL, Anderson K, Gaston KJ. Skewed contributions of individual trees to indirect nature experiences. *Landsc Urban Plan*. (2019) 185:28–34. doi: 10.1016/j.landurbplan.2019.01.008
- Zhao J, Xu W, Li R. Visual preference of trees: the effects of tree attributes and seasons. *Urban For Urban Green*. (2017) 25:19–25. doi: 10.1016/j.ufug.2017.04.015
- Ward J, Hovey A, Brownlee K. Mental health benefits of mounted equine-assisted therapies: a scoping review. *Health Soc Care Community*. (2022) 30:e4920–35. doi: 10.1111/hsc.13904
- Glenk LM, Foltin S. Therapy dog welfare revisited: a review of the literature. *Vet Sci*. (2021) 8:226. doi: 10.3390/vetsci8100226
- Tomaszewska K, Bomert I, Wilkiewicz-Wawro E. Feline-assisted therapy: integrating contact with cats into treatment plans. *Polish Annals of Med*. (2017) 24:283–6. doi: 10.1016/j.poamed.2016.11.011
- Cooper-Marcus C, Barnes M. Healing gardens: Therapeutic benefits and design recommendations. New York: John Wiley (1999).
- Dushkova D, Ignatieva M. New trends in urban environmental health research: from geography of diseases to therapeutic landscapes and healing gardens. *Geography, Environ, Sustain*. (2020) 13:159–71. doi: 10.24057/2071-9388-2019-99
- Jiang S. Therapeutic landscapes and healing gardens: a review of Chinese literature in relation to the studies in western countries. *Front Architectural Res*. (2014) 3:141–53. doi: 10.1016/j.foar.2013.12.002
- Murroni V, Cavalli R, Basso A, Borella E, Meneghetti C, Melendugno A, et al. Effectiveness of therapeutic gardens for people with dementia: a systematic review. *Int J Environ Res Public Health*. (2021) 18:9595. doi: 10.3390/ijerph18189595
- Clatworthy J, Hinds J, Camic PM. Gardening as a mental health intervention: a review. *Ment Health Rev J*. (2013) 18:214–25. doi: 10.1108/MHRJ-02-2013-0007
- Wen Y, Yan Q, Pan Y, Gu X, Liu Y. Medical empirical research on forest bathing (Shinrin-yoku): a systematic review. *Environ Health Prev Med*. (2019) 24:70. doi: 10.1186/s12199-019-0822-8
- Hansen MM, Jones R, Tocchini K. Shinrin-Yoku (Forest bathing) and nature therapy: a state-of-the-art review. *Int J Environ Res Public Health*. (2017) 14:851. doi: 10.3390/ijerph14080851
- Siah CJR, Goh YS, Lee J, Poon SN, Ow Yong JQY, Tam WW. The effects of forest bathing on psychological well-being: a systematic review and meta-analysis. *Int J Ment Health Nurs*. (2023) 32:1038–54. doi: 10.1111/inm.13131

43. Zerbe S., (2022). Restoration of multifunctional cultural landscapes. Merging tradition and innovation for a sustainable future. Landscape series 30, 1–716. Springer, Cham, Switzerland.
44. De Boer B, Hamers JP, Zwakhalen SM, Tan FE, Beerens HC, Verbeek H. Green care farms as innovative nursing homes, promoting activities and social interaction for people with dementia. *J Am Med Dir Assoc.* (2017) 18:40–6. doi: 10.1016/j.jamda.2016.10.013
45. García-Llorente M, Rubio-Olivar R, Gutierrez-Briceño I. Farming for life quality and sustainability: a literature review of green care research trends in Europe. *Int J Environ Res Public Health.* (2018) 15:1282. doi: 10.3390/ijerph15061282
46. Haines-Young R., Potschin M., (2018). Common international classification of ecosystem services (CICES) V5.1. Guidance on the application of the revised structure. Available online at: <https://cices.eu/content/uploads/sites/8/2018/01/Guidance-V51-01012018.pdf> (Accessed on 08.04.2021)
47. Methorst J, Bonn A, Marselle M, Böhning-Gaese K, Rehdanz K. Species richness is positively related to mental health – a study for Germany. *Landsc Urban Plan.* (2021) 211:104084. doi: 10.1016/j.landurbplan.2021.104084
48. Marselle MR, Hartig T, Cox DTC, de Bell S, Knapp S, Lindley S, et al. Pathways linking biodiversity to human health: a conceptual framework. *Environ Int.* (2021) 150:106420. doi: 10.1016/j.envint.2021.106420
49. Opdam P. Implementing human health as a landscape service in collaborative landscape approaches. *Landsc Urban Plan.* (2020) 199:103819. doi: 10.1016/j.landurbplan.2020.103819
50. Menatti L, Casado da Rocha A. Landscape and health: connecting psychology, aesthetics, and philosophy through the concept of affordance. *Front Psychol.* (2016) 7:571. doi: 10.3389/fpsyg.2016.00571
51. Fagerholm N, Martín-López B, Torralba M, Oteros-Rozas E, Lechner AM, Bieling C, et al. Perceived contributions of multifunctional landscapes to human well-being: evidence from 13 European sites. *People Nature.* (2020) 2:217–34. doi: 10.1002/pan3.10067
52. Hartig T, Mitchell R, de Vries S, Frumkin H. Nature and health. *Annu Rev Public Health.* (2014) 35:207–28. doi: 10.1146/annurev-publhealth-032013-182443
53. Wilson EO. Biophilia: The human bond with other species. Cambridge, USA: Harvard University Press (1984).
54. Kaplan R, Kaplan S. The experience of nature: A psychological perspective. Cambridge, UK: Cambridge University Press (1989).
55. Ohly H, White MP, Wheeler BW, Bethel A, Ukoumunne OC, Nikolaou V, et al. Attention restoration theory: a systematic review of the attention restoration potential of exposure to natural environments. *J Toxicol Environ Health Part B.* (2016) 19:305–43. doi: 10.1080/10937404.2016.1196155
56. Chen H, Qiu L, Gao T. Application of the eight perceived sensory dimensions as a tool for urban green space assessment and planning in China. *Urban For Urban Green.* (2019) 40:224–35. doi: 10.1016/j.ufug.2018.10.001
57. Schmid H-L, Nowak AC, Oeljeklaus L, Mc Call T, Hornberg CM, Caspers BA, et al. Greenspaces of psychiatric clinics and patient perceptions: a mixed-methods exploration. *People Nature.* (2024) 6:1592–1604. doi: 10.1002/pan3.10671
58. Stoltz J, Grahn P. Perceived sensory dimensions: an evidence-based approach to greenspace aesthetics. *Urban For Urban Green.* (2021) 59:126989. doi: 10.1016/j.ufug.2021.126989
59. Memari S, Pazhouhanfar M, Grahn P. Perceived sensory dimensions of green areas: an experimental study on stress recovery. *Sustain For.* (2021) 13:5419. doi: 10.3390/su13105419
60. Gesler WM. The cultural geography of health care. Pittsburgh, PA: University of Pittsburgh Press (1991).
61. Gesler WM. Therapeutic landscapes: medical issues in light of the new cultural geography. *Soc Sci Med.* (1992) 34:735–46.
62. Kaley A, Hatton C, Milligan C. Therapeutic spaces of care farming: transformative or ameliorating? *Soc Sci Med.* (2019) 227:10–20. doi: 10.1016/j.socscimed.2018.05.011
63. English J, Wilson K, Keller-Olaman S. Health, healing and recovery: therapeutic landscapes and the everyday lives of breast cancer survivors. *Soc Sci Med.* (2008) 67:68–78. doi: 10.1016/j.socscimed.2008.03.043
64. Gesler W. Lourdes: healing in a place of pilgrimage. *Health Place.* (1996) 2:95–105. doi: 10.1016/1353-8292(96)00004-4
65. Williams A. Spiritual therapeutic landscapes and healing: a case study of St. Anne de Beaupre, Quebec, Canada. *Soc Sci Med.* (2010) 70:1633–40. doi: 10.1016/j.socscimed.2010.01.012
66. Brewster L. The public library as therapeutic landscape: a qualitative case study. *Health Place.* (2014) 26:94–9. doi: 10.1016/j.healthplace.2013.12.015
67. Valladares A, Bornstein L, Botero N, Gold I, Sayanvala F, Weinstock D. From scary places to therapeutic landscapes: voices from the community of people living with schizophrenia. *Health Place.* (2022) 78:102903. doi: 10.1016/j.healthplace.2022.102903
68. Gesler W. Therapeutic landscapes: theory and case study of Epidaurous, Greece. *Environ Plan D: Society Space.* (1993) 11:171–89. doi: 10.1068/d110171
69. Williams A. Therapeutic landscapes in holistic medicine. *Soc Sci Med.* (1998) 46:1193–203. doi: 10.1016/S0277-9536(97)10048-X
70. Gorman R. Smelling therapeutic landscapes: embodied encounters within spaces of care farming. *Health Place.* (2017) 47:22–8. doi: 10.1016/j.healthplace.2017.06.005
71. Milligan C, Gatrell A, Bingley A. “Cultivating health”: therapeutic landscapes and older people in northern England. *Soc Sci Med.* (2004) 58:1781–93. doi: 10.1016/S0277-9536(03)00397-6
72. Kearns RA, Collins DC. New Zealand children’s health camps: therapeutic landscapes meet the contract state. *Soc Sci Med.* (2000) 51:1047–59. doi: 10.1016/S0277-9536(00)00020-4
73. Curtis S, Gesler W, Fabian K, Francis S, Priebe S. Therapeutic landscapes in hospital design: a qualitative assessment by staff and service users of the design of a new mental health inpatient unit. *Environ Plan C: Government Policy.* (2007) 25:591–610. doi: 10.1068/c1312r
74. Oeljeklaus L, Schmid H-L, Kornfeld Z, Hornberg C, Norra C, Zerbe S, et al. Therapeutic landscapes and psychiatric care facilities: a qualitative meta-analysis. *Int J Environ Res Public Health.* (2022) 19:1490. doi: 10.3390/ijerph19031490
75. Ahmadi M, Herron RV, Allan JA, Waddell CM. Identifying places that foster mental health and well-being among rural men. *Health Place.* (2021) 71:102673. doi: 10.1016/j.healthplace.2021.102673
76. Brooke K, Williams A. Iceland as a therapeutic landscape: white wilderness spaces for well-being. *GeoJournal.* (2021) 86:1275–85. doi: 10.1007/s10708-019-10128-9
77. Milligan C, Chalfont G, Kaley A, Lobban F. Wilderness as therapeutic landscape in later life: towards an understanding of place-based mechanisms for wellbeing through nature-adventure activity. *Soc Sci Med.* (2021) 289:114411. doi: 10.1016/j.socscimed.2021.114411
78. Palka E. Accessible wilderness as therapeutic landscape: experiencing the nature of Denali National Park, Alaska In: A Williams, editor. Therapeutic landscapes. Lanham, USA: University Press of America (1999). 29–52.
79. Finlay J, Franke T, McKay H, Sims-Gould J. Therapeutic landscapes and wellbeing in later life: impacts of blue and green spaces for older adults. *Health Place.* (2015) 34:97–106. doi: 10.1016/j.healthplace.2015.05.001
80. Völker S, Kistemann T. The impact of blue space on human health and well-being - Salutogenetic health effects of inland surface waters: a review. *Int J Hyg Environ Health.* (2011) 214:449–60. doi: 10.1016/j.ijheh.2011.05.001
81. Völker S, Kistemann T. “I’m always entirely happy when I’m here!” urban blue enhancing human health and well-being in Cologne and Düsseldorf, Germany. *Soc Sci Med.* (2013) 78:113–24. doi: 10.1016/j.socscimed.2012.09.047
82. Ford AE, Graham H, White PC. Integrating human and ecosystem health through ecosystem services frameworks. *EcoHealth.* (2015) 12:660–71. doi: 10.1007/s10393-015-1041-4
83. Hahn I, Dyson B, Neale A, Gould R, Huber P, Biedenweg K, et al. Review of ESA 2019 SYMP 8: integrating human health with ecosystem services - research to provide practical tools for healthier and more resilient communities. *Bull Ecol Soc Am.* (2021) 102:e01786:1–11. doi: 10.1002/bes2.1786
84. Sandifer PA, Sutton-Grier AE, Ward BP. Exploring connections among nature, biodiversity, ecosystem services, and human health and well-being: opportunities to enhance health and biodiversity conservation. *Ecosyst Serv.* (2015) 12:1–15. doi: 10.1016/j.ecoser.2014.12.007
85. Lovell R, Husk K, Bethel A, Garside R. What are the health and well-being impacts of community gardening for adults and children: a mixed method systematic review protocol. *Environ Evid.* (2014) 3:20. doi: 10.1186/2047-2382-3-20
86. Pinder R, Kessel A, Green J, Grundy C. Exploring perceptions of health and the environment: a qualitative study of Thames chase community Forest. *Health Place.* (2009) 15:349–56. doi: 10.1016/j.healthplace.2008.06.006
87. Sahlin E, Matuszczyk JV, Ahlberg G Jr, Grahn P. How do participants in nature-based therapy experience and evaluate their rehabilitation? *J Therapeutic Horticulture.* (2012) 22:8–23. Available at: <https://www.jstor.org/stable/24865>
88. Barton J, Bragg R, Pretty J, Roberts J, Wood C. The wilderness expedition: an effective life course intervention to improve young people’s well-being and connectedness to nature. *J Exp Educ.* (2016) 39:59–72. doi: 10.1177/1053825915626933
89. Pretty J, Peacock J, Hine R, Sellens M, South N, Griffin M. Green exercise in the UK countryside: effects on health and psychological well-being, and implications for policy and planning. *J Environ Plan Manag.* (2007) 50:211–31. doi: 10.1080/09640560601156466
90. Rutko EA, Gillespie J. Where’s the wilderness in wilderness therapy? *J Exp Educ.* (2013) 36:218–32. doi: 10.1177/1053825913489107
91. Markevych I, Schoierer J, Hartig T, Chudnovsky A, Hystad P, Dzhambov AM, et al. Exploring pathways linking greenspace to health: Theoretical and methodological guidance. *Environ Res.* (2017) 158:301–17.
92. Bratman GN, Hamilton JP, Daily GC. The impacts of nature experience on human cognitive function and mental health. *Ann N Y Acad Sci.* (2012) 1249:118–36. doi: 10.1111/j.1749-6632.2011.06400.x
93. Capaldi CA, Dopko RL, Zelenski JM. The relationship between nature connectedness and happiness: a meta-analysis. *Front Psychol.* (2014) 5:976. doi: 10.3389/fpsyg.2014.00976
94. WHO. (2017). One health. World Health Organization. Available online at: <https://www.who.int/news-room/questions-and-answers/item/one-health> (Accessed on 12.12.2023)

95. Zinsstag J, Schelling E, Tanner M. From “one medicine” to “one health” and systemic approaches to health and wellbeing. *Prev Vet Med.* (2011) 101:148–56. doi: 10.1016/j.prevetmed.2010.07.003
96. Whitmee S, Haines A, Beyrer C, Boltz F, Capon AG, de Souza F, et al. Safeguarding human health in the Anthropocene epoch: report of the Rockefeller Foundation-lancet commission on planetary health. *Lancet.* (2015) 386:1973–2028. doi: 10.1016/S0140-6736(15)60901-1
97. Charron DF. Ecohealth research in practice. Innovative applications of an ecosystem approach to health. Insight and innovation in international development. New York: Springer (2012).
98. Sadava D, Hillis DM, Heller HC, Hacker SD In: J Markl, editor. *Purves Biologie*. Berlin, Heidelberg: Springer Spektrum (2019)
99. De Queiroz K. Species concepts and species delimitation. *Syst Biol.* (2007) 56:879–86. doi: 10.1080/10635150701701083
100. Derraik JG, Early JW, Closs GP, Dickinson KJ. Morphospecies and taxonomic species comparison for Hymenoptera. *J Insect Sci.* (2010) 10:108. doi: 10.1673/031.010.10801
101. Begon M, Townsend CR. *Ecology: From individuals to ecosystems*. 5th ed. Hoboken, US: Wiley (2021).
102. Wu J. Landscape ecology In: R Leemans, editor. *Ecological systems*. New York, NY: Springer (2013). 179–200.
103. Council of Europe. European landscape convention. *European Treaty Series*. (2000) 176:1–7.
104. Egner LE, Sütterlin S, Calogiuri G. Proposing a framework for the restorative effects of nature through conditioning: conditioned restoration theory. *Int J Environ Res Public Health.* (2020) 17:6792. doi: 10.3390/ijerph17186792
105. Ulrich RS, Zimring C, Zhu X, DuBose J, Seo HB, Choi YS, et al. A review of the research literature on evidence-based healthcare design. *HERD.* (2008) 1:61–125. doi: 10.1177/193758670800100306
106. Grahn P, Stigsdotter UK. The relation between perceived sensory dimensions of urban green space and stress restoration. *Landsc Urban Plan.* (2010) 94:264–75. doi: 10.1016/j.landurbplan.2009.10.012
107. Hartig T. Restorative environments In: C Spielberger, editor. *Encyclopedia of applied psychology*. Academic: San Diego (2004). 273–9.
108. Joye Y, van den Berg A. Is love for green in our genes? A critical analysis of evolutionary assumptions in restorative environments research. *Urban For Urban Green.* (2011) 10:261–8. doi: 10.1016/j.ufug.2011.07.004
109. Luo L, Jiang B. From oppressiveness to stress: a development of stress reduction theory in the context of contemporary high-density city. *J Environ Psychol.* (2022) 84:101883. doi: 10.1016/j.jenvp.2022.101883
110. Ulrich RS. View through a window may influence recovery from surgery. *Science.* (1984) 224:420–1. doi: 10.1126/science.6143402
111. Ulrich RS, Simons RF, Losito BD, Fiorito E, Miles MA, Zelson M. Stress recovery during exposure to natural and urban environments. *J Environ Psychol.* (1991) 11:201–30. doi: 10.1016/S0272-4944(05)80184-7
112. Kamioka H, Okada S, Tsutani K, Park H, Okuizumi H, Handa S, et al. Effectiveness of animal-assisted therapy: a systematic review of randomized controlled trials. *Complement Ther Med.* (2014) 22:371–90. doi: 10.1016/j.ctim.2013.12.016
113. Kim JG, Shin WS. Forest therapy alone or with a guide: is there a difference between self-guided forest therapy and guided Forest therapy programs? *Int J Environ Res Public Health.* (2021) 18:6957. doi: 10.3390/ijerph18136957
114. Cutcliffe JR, Travale R. Unearthing the theoretical underpinnings of “Green care” in mental health and substance misuse care: theoretical underpinnings and contemporary clinical examples. *Issues Ment Health Nurs.* (2016) 37:137–47. doi: 10.3109/01612840.2015.1119220
115. Stigsdotter UA, Grahn P. What makes a garden a healing garden? *J Therapeutic Horticulture.* (2002) 22:60–9.
116. Kamioka H, Tsutani K, Yamada M, Park H, Okuizumi H, Honda T, et al. Effectiveness of horticultural therapy: a systematic review of randomized controlled trials. *Complement Ther Med.* (2014) 22:930–43. doi: 10.1016/j.ctim.2014.08.009
117. Cipriani J, Benz A, Holmgren A, Kinter D, McGarry J, Rufino G. A systematic review of the effects of horticultural therapy on persons with mental health conditions. *Occup Ther Ment Health.* (2017) 33:47–69. doi: 10.1080/0164212X.2016.1231602