



Nature and human well-being: a systematic review of empirical evidence from nature-based interventions

Ana Silva, Marlene Matos & Mariana Gonçalves

To cite this article: Ana Silva, Marlene Matos & Mariana Gonçalves (11 Jul 2023): Nature and human well-being: a systematic review of empirical evidence from nature-based interventions, Journal of Environmental Planning and Management, DOI: [10.1080/09640568.2023.2227761](https://doi.org/10.1080/09640568.2023.2227761)

To link to this article: <https://doi.org/10.1080/09640568.2023.2227761>



Published online: 11 Jul 2023.



Submit your article to this journal [↗](#)



Article views: 681



View related articles [↗](#)



View Crossmark data [↗](#)



Citing articles: 1 View citing articles [↗](#)



REVIEW ARTICLE

Nature and human well-being: a systematic review of empirical evidence from nature-based interventions

Ana Silva, Marlene Matos and Mariana Gonçalves*

Psychology Research Center, School of Psychology, University of Minho, Braga, Portugal

(Received 19 August 2022; revised 25 May 2023; final version received 14 June 2023)

There is a growing body of knowledge that underlines the role of nature on human well-being, with an increase in the number of studies that report data on this topic in recent years. This systematic review provides a comprehensive overview of the state of the art regarding the impacts of nature-based interventions (NBIs) in both human well-being and nature-related outcomes (e.g. connection with nature). It also provides detailed information about methodological approaches, including the activities performed, measures used and parameters assessed. Thirty-eight studies met the inclusion criteria, presenting quantitative and qualitative data reporting positive outcomes regarding psychological (e.g. mental health, mood states, perceived levels of stress), physiological (e.g. physiological stress, neurocognitive function) and nature-related outcomes (e.g. connection with nature, attitudes towards the natural environment). Despite the need to overcome some fragilities and knowledge gaps, overall, the studies strongly suggest that natural environments have significant positive impacts on human well-being.

Keywords: well-being; nature; connection with nature; evaluation; intervention

With a current world population of over 8 billion (Worldometer website, on June 10, 2023), our planet's natural environment is under intensified pressure, resulting in depletion of natural resources and increasing environmental degradation (Berck, Levy and Chowdhury 2012), which pose a serious threat not only to natural ecosystems, but also to human health (WHO 2013). Although much has been achieved, sustainability is still far from being a reality, with public health and environmental sustainability being considered two of the major global issues of the twenty first century (Renner 2015; WHO 2015).

With more than half of the world population, as indicated on The World Bank website, on January 9, 2023, living in urban areas, interactions with nature are becoming alarmingly scarcer (Soga *et al.* 2018). As Robert Michael Pyle (1993) alerted, this alienation from nature, which he termed “experience extinction,” leads to the loss of personal benefits and fosters a disaffection with severe and broad consequences. These consequences occur at several levels, affecting individuals, societies and the world as a whole, and range from diminished public health and well-being to a decrease in nature connectedness and pro-environmental behaviors (Soga *et al.* 2018).

*Corresponding author. Email: marianagoncalves@psi.uminho.pt

1. Ecosystem services and human well-being

The Sustainable Development Goals, proposed in the declaration “Transforming Our World – the 2030 Agenda for Sustainable Development,” reinforce the connection between health and environmental sustainability through an integrative framework, anchored in three pillars – economic, environmental, and social (Smythe 2014; UN General Assembly 2015). According to Smythe (2014), it is important to address the SGDs through a holistic human welfare perspective that reinforces the relationship between the natural and social dimensions. The relevance of natural ecosystems to human well-being was also highlighted by the Millennium Ecosystem Assessment (2005). This report stressed the interconnection between natural ecosystem services and the components of human well-being, including: i) security (e.g. secure resource access, security from disasters); ii) basic material for a good life (e.g. adequate livelihoods, sufficient nutritious food); iii) health (e.g. strength, feeling good); iv) good social relations (e.g. social cohesion, mutual respect); and v) freedom of choice (Millennium Ecosystem Assessment 2005). Despite the fact that human health and well-being are highly dependent on the environment one lives in (Barton and Grant 2006), life is rapidly becoming an urban affair, with more than 54% of the population living in urban areas (WHO and UN Habitat 2016). As a result of growing urban areas and habits, contact with natural environments has suffered a strong decline (Pedretti-Burls 2007; Maller *et al.* 2006), with severe outcomes for individuals, their communities and cultures (Pretty *et al.* 2003). Reflecting this growing concern, many researchers from fields such as environmental psychology, ecology, biology, and psychiatry, have developed studies about the link between natural environments and human well-being (Biedenweg, Scott and Scott 2017; Maller *et al.* 2009). The expansion of research on this topic was also possible due to: i) the comprehension of health as “a state of complete physical, mental and social well-being and not merely the absence of disease or infirmity” (WHO 2006, 1), which enabled the integration of a wider variety of actors and fields of knowledge, reflecting the multidimensional and subjective character of health; and to ii) methodological and conceptual advances that allowed for in-depth study of topics as the effect of nature-based experiences in stress reduction (Hartig *et al.* 2014).

As a result, there is a significant body of knowledge that highlights the positive role of nature in improving and promoting broad positive outcomes regarding human well-being (Bowler *et al.* 2010; Cleary *et al.* 2017; Hartig *et al.* 2014; Keniger *et al.* 2013; Ray and Jakubec 2014). Well-being is a complex and controversial construct that still fosters debate among researchers (Ng and Fisher 2013; Ryan and Deci 2001). In this debate, two main streams, reflecting distinct but related components of well-being, have emerged: subjective well-being (SWB) and psychological well-being (PWB; Keyes, Shmotkin and Ryff 2002). SWB reflects the hedonic perspective, evaluating life through affective (e.g. overall happiness) and cognitive indicators (e.g. life satisfaction; Keyes, Shmotkin and Ryff 2002; Ng and Fisher 2013). The eudaimonic perspective (human potential, growth and purpose) is related to PWB, which assesses one’s psychological and social functioning (Keyes, Shmotkin and Ryff 2002; Ng and Fisher 2013).

1.1. Nature-derived benefits

Nature-derived benefits can result from different types of exposure (Beery *et al.* 2017; Keniger *et al.* 2013):

- Direct: direct exposure implies a physical presence in nature and/or an encounter with a physically present nature feature (e.g., potted plant in an office). Interactions can be incidental or intentional. Incidental interactions imply a physical presence in nature but occur as a by-product of other activities (e.g., exposure to urban greenspaces while walking to work). Intentional nature experiences imply a direct intention of interaction (e.g., hiking in a forest);
- Indirect: the interaction occurs without a physical presence in nature (e.g., viewing images of natural places or nature viewed from a window).

Researchers have identified a broad range of benefits, encompassing aspects of both SWB and PWB, including: i) physiological (e.g. reduced blood pressure and cortisol levels, reduced mortality rates from circulatory and respiratory diseases, reduced stress symptoms; e.g. Hartig *et al.* 2003; Triguero-Mas *et al.* 2017; Tsunetsugu *et al.* 2007; Tsunetsugu *et al.* 2013; Villeneuve *et al.* 2012); ii) psychological (e.g. improved mood states, reduced anxiety, increased self-esteem, lower levels of aggression; e.g. Berto 2005; Hartig *et al.* 2003; Hine *et al.* 2011; Kuo and Sullivan 2001a; Triguero-Mas *et al.* 2017; Tsunetsugu *et al.* 2013; van den Berg, Jorgensen and Wilson 2014); iii) cognitive (e.g. attentional restoration, reduced mental fatigue, improved cognitive function; e.g. Hartig *et al.* 2003; Kaplan and Kaplan 1989; Kaplan 2001; Shin *et al.* 2011); and iv) social/behavioral (e.g. improved social interaction, lower crime rates, perceived social safety, enhanced social cohesion and support; e.g. Kingsley and Townsed 2006; Kuo and Sullivan 2001a, 2001b; Maas *et al.* 2009). Nature can also constitute an important resource for child development, leading to opportunities for self-discovery and promoting self-efficacy, as well as having positive impacts on cognitive, affective, and moral maturation (Kellert 2002; Taylor *et al.* 1998; Wells 2000).

Within the scope of studies about the impact of nature on human well-being, special attention has been given to children and adolescents. As well as in the studies with adult populations, several nature-derived benefits were identified, ranging from improved physical and mental health, improved cognitive performance, higher levels of confidence, improved social connections, higher levels of connection with nature (CWN) and lower levels of behavioral and psychological problems (e.g. Larson, Bowers and Stephens 2017; Mygind *et al.* 2021; Piccininni *et al.* 2018; Sheldrake, Amos and Reiss 2019; Sobko, Jia and Brown 2018). A positive association between CWN and the development of pro-environmental behaviors was also identified (Chawla 2020). Raney, Hendry and Yee (2019) and Fjørtoft (2004) highlighted the importance of natural environments, especially those in school grounds and surroundings, as promoters of physical activity, social well-being, creativity and of an improved learning process. As underlined by Chawla (2020), there is an important generational effect in this dyadic nature-children interaction, translated by the influence of i) family behaviors and beliefs in the children's levels of CWN (e.g. children whose parents value the importance of experiencing nature have higher levels of CWN); ii) influence of childhood levels of CWN on nature connection in adulthood (e.g. children with higher levels of CWN tend to grow into adults with higher levels of CWN and more prone to develop pro-environmental behaviors).

2. Pathways and mechanisms

Despite the high number of studies reporting the effects of nature on components of, or overall, well-being, the underpinning mechanisms responsible for individual and

collective responses to natural environments and stimuli are not yet fully understood (Cleary *et al.* 2017; Bowler *et al.* 2010). Psychological restoration is widely accepted as a key mechanism to explain the positive outcomes of contact with nature (Scopelliti *et al.* 2016). Kaplan and Kaplan's attention restoration theory (ART) emphasizes the role of nature in attention fatigue recovery processes (Kaplan and Kaplan 1989). The authors propose that nature's restorative qualities, which allow for feelings of "being away" and "soft fascination," promote involuntary attention, enabling recovery and restoration of voluntary attention capacities (Bowler *et al.* 2010; Kaplan and Kaplan 1989; Ohly *et al.* 2016). In the stress reduction theory (SRT), Ulrich proposes that the restorative advantage of natural environments derives from our species evolutionary past and innate connection with nature (Ulrich 1981, 1983, 1984). Psychological well-being and stress recovery can be fostered by innate and adaptive responses to attributes of natural environments (e.g. spatial openness, water features) that elicit positive emotional reactions (Bowler *et al.* 2010; Ulrich *et al.* 1991). More recently, Hartig *et al.* (2014) proposed four intertwined pathways through which natural environments can affect human health and well-being: air quality, physical activity, social cohesion, and stress-reduction. These pathways interact simultaneously as nature constitutes a physical environment, a setting for the expression of individual or social behavior, and experience (Hartig *et al.* 2014).

The association between physical activity in natural environments and possible increased benefits is still unclear due to mixed results. Calogiuri and Chroni (2014) concluded that physical activity in natural environments provides greater benefits (e.g. positive emotions, improved psychological states) when compared with urban and indoor settings. The authors also stressed that increases in levels of connection with nature appear to mediate the relationship between experiences in nature and positive psychological states. Conversely, Keniger *et al.* (2013) highlighted the fact that the existing data does not allow definite conclusions about whether a natural setting increases the psychological well-being benefits of exercise.

The effect of specific components of the natural environment is also not yet clear, with studies providing divergent conclusions. For example, while Fuller *et al.* (2007) concluded that there was a positive association between plant biodiversity and psychological benefits, Dallimer *et al.* (2012), using the same method, did not identify a consistent relationship. More recently, Schebella *et al.* (2019) concluded that, although the relationship between well-being is not linear, biodiversity has an effect especially in stress improvement. The authors also highlighted that compared to objectively measured biodiversity, well-being benefits were more strongly associated with the participants' perceptions (e.g. perceived biodiversity, perceived naturalness).

Relevant to the development of eco-friendly behaviors and biospheric-orientated values, CWN is also associated with several components of well-being, including positive affect, vitality, autonomy and life satisfaction (Howell *et al.* 2011; Mayer and Frantz 2004; Nisbet, Zelenski, and Murphy 2011). Besides benefits to human well-being, Wolsko, Lindberg, and Reese (2019) also pointed out that higher levels of engagement with natural environments, for example through physical recreation, seem to be associated with a greater connection with nature. A mutually beneficial relationship seems to occur with higher levels of CWN leading to more frequent visits that, in turn, lead to an increase in well-being (Calogiuri and Chroni 2014).

In a world of rapidly rising urbanization and consumption rates, and as interaction with nature is perceived as more than a survival need (Keniger *et al.* 2013), it is

essential to systematize reliable data that sustain decision-making at different levels (e.g. policy, planning, management), relevant to ensure human well-being. Due to the wide variety of study features (e.g. aims, type of population, settings, employed intervention and evaluation methodologies) it is difficult to compare results and assess effect sizes. Even when possible, to perform a meta-analysis, results must be interpreted cautiously as the number of studies included tends to be low (Bowler *et al.* 2010).

In the last decade, several systematic reviews have been published regarding the relationship between nature and human health and well-being. They have mainly focused on: i) physical health and behaviour (e.g. Calogiuri and Chroni 2014; Lachowycz and Jones 2011; Thompson Coon *et al.* 2011; Twohig-Bennett and Jones 2018); ii) mental health (e.g. Clatworthy, Hinds, and Camic 2013; Gascon *et al.* 2015; Lackey *et al.* 2021; Ohly *et al.* 2016; Thompson Coon *et al.* 2011); iii) child development (e.g. Gill 2014); and iv) overall benefits (e.g. Bowler *et al.* 2010; Di Nardo, Saulle, and La Torre 2010; Keniger *et al.* 2013). While some reviews included a broad range of natural settings and features (e.g. Di Nardo, Saulle, and La Torre 2010; Keniger *et al.* 2013; Thompson Coon *et al.* 2011), others were concerned with specific settings, such as blue spaces (e.g. Britton *et al.* 2020; Gascon *et al.* 2017; Völker and Kistemann 2011). Other reviews also investigated evidence about nature-assisted therapy (e.g. Annerstedt and Währborg 2011), gardening (e.g. Clatworthy, Hinds, and Camic 2013), nature conservation (e.g. McKinnon *et al.* 2016), and biodiversity (e.g. Lovell *et al.* 2014) relationships with human health and well-being.

The amount of information and the fact that it is deeply fragmented (Martin *et al.* 2020) emphasizes the need for updated systematic reviews in order to ensure a well-defined view of the available information, provide an assessment of the quality of evidence, and identify possible bias, gaps and needs. Thus, we conducted a systematic review in order to i) collate and synthesize available evidence regarding the effects of direct outdoor interaction with nature on human overall well-being (physical, psychological, social); ii) analyze procedures, identifying methodological strengths and weaknesses; iii) identify relevant recommendations for future research and nature-based interventions. In this study, and drawing on the broader definitions presented by Shanahan *et al.* (2019) and Taylor *et al.* (2022), nature-based interventions (NBIs) comprehend a diverse array of programs and activities that allow participants to experience contact with nature with the specific goal of achieving improved health and well-being.

3. Methods

This systematic review was conducted following the PRISMA statement guidelines for reporting systematic reviews and meta-analyses (Liberati *et al.* 2009; Moher *et al.* 2009).

3.1. Literature search strategy

In order to prevent a biased literature sample, a comprehensive search was performed in multiple search engines and databases—Web of Science, Scopus, Pubmed, Science Direct, and PsycInfo/PsychArticles—using the following search expression: (Health OR Well-being OR Wellbeing) AND (Mental OR Psychological OR Emotional OR

Physical OR Social OR Adjustment) AND (“Nature experience” OR “Nature intervention”) AND (Impact OR Effect* OR Efficacy). The final keywords and expressions were selected after a brief overview of relevant literature to select commonly used terms. Taking into account the high heterogeneity of the studies’ characteristics, general commonly used keywords and expressions were used in order to reduce the probability of exclusion, due to the lack of a specific keyword or expression and to ensure that a wide variety of diverse studies (e.g. field of knowledge, intervention and evaluation methods, measured outcomes) would be included. The bibliographies of included articles and of other relevant reviews were also screened for additional references. Searches included articles published until July 2020. The accepted languages were Portuguese, English, French and Spanish. To establish inter-rater reliability, the literature search was conducted by two researchers who independently screened titles, abstracts and full texts of potentially eligible studies identified by the search strategy detailed above, and applied the established eligibility criteria. Any discrepancies were resolved by discussion with a third researcher.

3.2. Inclusion and exclusion criteria

In order to be included, studies had to: i) report primary empirical evidence regarding the impact of a nature-based outdoor intervention in overall human well-being and/or well-being specific components; ii) integrate activities that allowed participants to have direct contact with nature, i.e., participants are required to be physically present in nature (e.g. hiking in a forest, gardening, viewing wildlife while seated in a natural park); iii) present data from continuous or pre/post evaluation; iv) be published in a peer-reviewed scientific journal. There was no limitation regarding year of publication or study design, which could be qualitative, quantitative, or present a mixed-methods approach. Regarding participants’ characteristics, there were no limitations on age and gender. If an article presented more than one study and only one corresponded to the inclusion criteria, both were included if the author(s) compared results to draw general conclusions. Otherwise, only the study that fully fulfilled the inclusion criteria was included.

Studies were excluded if they only focused on indoor or virtual nature, if the participants presented serious mental health conditions or severe physical disorders, or if they reported data regarding only non-structured interventions (activities with no on-site intervention by the researcher/monitor; e.g. participants were questioned about their nature-interaction daily habits, or the NBI was guided through a mobile application without the presence of a researcher or monitor). Grey literature, including masters and PhD theses, reviews, conference proceedings, books and book chapters were also not included.

3.3. Data collection and synthesis

Two reviewers worked independently on data extraction and quality evaluation of the studies. Posteriorly, information was compared and agreement was reached via consensus. A standardized data extraction sheet was used to ensure controlled analysis and data extraction from each article. Information was retrieved about the article (authors, journal and year of publication, DOI, title) and the studies (country; participants – number, age, type; intervention – goal(s), setting(s), type of activities, evaluation

methods and outcome measures; results and main findings; limitations; future recommendations). After an overview of the intervention data presented by the studies, categories of classification were established regarding three overall themes: study characterization (Table 1), intervention characteristics (Table 2), and evaluation procedures and statistically significant quantitative results (Table 3). Outdoor environments were categorized according to Mausner's five-level classification, due to its usability in the selected articles' context (Mausner 1996): (1) totally natural environment – environment with no visible evidence of human presence. Includes, for example, forested wilderness, deserts, and oceans. Access is very difficult making recreational activities less likely to occur; (2) civilized natural environment – characterized by the predominance of natural elements unaffected by human interventions (e.g. forests with hiking trails, secluded ocean beaches). More accessible to human presence and closer to human-made structures and amenities. Recreational activities may occur but without having an impact on the environment; (3) quasi-natural environment – presents a readily apparent human impact, being predominantly composed of natural elements intended to make the environment appear natural. Designed to enhance aesthetic qualities; aesthetic appreciation tends to be the main human activity performed in such environments. For example, small landscaped parks, arboreta, and cultivated flower gardens; (4) semi-natural environment – natural and non-natural elements co-exist, enabling a balanced interaction between people and the environment. Closer to densely populated areas, allowing for the performance of several activities, including living (e.g. living on a farm) and recreational activities (e.g. skiing). May afford a limited experience of being-in-nature (e.g. small urban parks with cycling and walking paths, playgrounds, and strong urban influence, as traffic sounds and views of buildings; community gardens); and (5) non-natural environment – urban settings without open, undeveloped land (e.g. buildings, roadways, bridges). If natural elements appear, they seem out of place and exposed to high degradation rates. On another conceptualization, this can also correspond to settings with abundant natural elements but where human action has a severe and destructive impact (e.g. degraded areas due to mining or logging practices). Although some level of experimenting “being-in-nature” can occur, feelings of sadness are more likely to prevail (Mausner 1996). In this study indoor environments, with the exception of indoor gardens, greenhouses or similar, will be considered non-natural environments. Regarding duration, interventions were classified as occasional (occurred for a time period inferior to six months), or continuous if their duration was equal to or greater than six months. Three categories were established for activities' level of structure: structured, semi-structured, and non-structured activities. In structured activities participants, in groups or individually, were accompanied and guided throughout the activity. Semi-structured activities could be performed in groups or individually, and comprised two types: i) participants were accompanied by the researchers or monitors during the beginning and end of the NBI, being instructed on-site how to perform the activity, which they would do on their own; or ii) participants were accompanied throughout the activity but with only an occasional intervention and guidance from researchers and/or monitors. Data were collected considering three major dimensions: methods (quantitative, qualitative, mixed methods), evaluation moments (pre/post, continuous, follow-up) and measures (psychological, physiological, nature interaction). A narrative synthesis was undertaken to summarize and discuss the overall results of the studies.

Table 1. Studies’ characterization.

Authors	Year	Country	Main goals	Sample size	Age range or mean age	Sex	Type of participants	Evaluation methods
Anderson, Monroy, and Keltner	2018	USA	Examine how the impact of nature on well-being and stress-related symptoms is explained by experiences of awe.	243	NEI	56% (136) female 44% (107) male	Military veterans and youth from underserved communities (124); university students (119)	Mixed-methods
Arbuthnott and Sutter	2019	Canada	Examine whether songwriting retreats held in a natural setting would increase nature connectedness, as well as improve emotional well-being and performance on a creative reasoning task.	58	NEI	NEI	Study 1: high school students (9 th – 10 th grades) Study 2: adults (musicians)	Quantitative
Berman, Jonides, and Kaplan	2008	USA	Explore impact on cognitive performance of interaction with nature and urban areas.	50	23.4	62% (31) female 38% (19) male	University students	Quantitative
Bratman <i>et al.</i>	2015a	USA	Investigate the impact of nature experience on affect and cognition, clarifying the specific impacts that directed attention replenishment may have on cognitive function.	60	22.9	55% (33) female 45% (27) male	Urban/suburban residents (community participants: 16; university students: 44)	Quantitative
Bratman <i>et al.</i>	2015b	USA	Verify the impacts of a brief nature experience on rumination and neural activity	30	26.4	53.3% (16) female 46.7% (14) male	Urban/suburban residents	Quantitative
Cervinka, Schwab, and Haluza	2020	Austria	Assess the qualities of typical places in the forest and their potential to increase recreation and vitality and to widen one’s mind, and investigate changes in mood-states, perceived stress,	99	43.2	64% (64) female 36% (36) male	>16 years old forest visitors	Quantitative

(Continued)

Table 1. (Continued).

Authors	Year	Country	Main goals	Sample size	Age range or mean age	Sex	Type of participants	Evaluation methods
Chen, He, and Yu	2020	China	restoration, connectedness, and mindfulness before and after visiting the forest.	32	20.6	50% (16) female 50% (16) male	University students	Quantitative
			Examine alpha-theta brain activities and their potential connections with restoration during in situ exposures. This study was designed to explore the neural mechanism of environmental restorative experiences.					
de Brito <i>et al.</i>	2019	USA	Investigate the effects of repeated walking sessions completed in a green environment compared to walking in a suburban environment on measures of anxiety, mood and directed-attention.	23	49.7	82.6% (19) female 17.4% (4) male	General population	Quantitative
Deng <i>et al.</i>	2019	China	Explore the differences in the restorative effects of exposure to three different landscape type environments in an urban forest park, investigating whether any apparent differences in exposure to the area with different landscape composition had an impact on restorative experiences.	60	20.8	50% (30) female 50% (30) male	University students	Quantitative
Diessner <i>et al.</i> ^a	2015	USA	Determine if the directed-attention beauty walks would cause (a) an increase in noticing and paying attention to natural beauty,	61	21	52% (38) female 48% (35) men	University students	Quantitative

(Continued)

Table 1. (Continued).

Authors	Year	Country	Main goals	Sample size	Age range or mean age	Sex	Type of participants	Evaluation methods
Gatersleben and Andrews (only study 2 was included)	2013	UK	(b) an increase in levels of the trait of engagement with natural beauty, and (c) a lessening of depressive and anxiety symptoms.	34	23.18/20.88	58.8% (20) female 41.2% (14) male	University students	Quantitative
			Examine restoration in natural settings with different levels of accessibility, prospect and refuge.					
Hartig <i>et al.</i>	2003	USA	Test the relative restorative values of natural and urban settings	112	20.8	50% (56) female 50% (56) male	University students	Quantitative
			Assess the effects of a residential woodland education program on pro-environmental attitudes and aspects of well-being.					
Hinds	2011	UK		25	12-15	52% (13) female 48% (12) male	Young people of varying disadvantage degrees and socioeconomic backgrounds	Mixed-methods
Hitter <i>et al.</i> ^a	2019	Romania	Investigate the possible effect of a therapeutic horticulture intervention on people in depression amelioration.	8	21.1	87.5% (7) female 12.5% (1) male	University students	Quantitative
Hoag <i>et al.</i>	2013	USA	Assess the effectiveness of wildlife therapy	297	20.2	27% (80) female 73% (217) male	Young adult clients at a wilderness therapy program	Quantitative
Ibes and Forestell ^a	2020	USA	Determine whether students who engage in a sedentary task in an urban park-like setting experience improved mood and whether this effect is moderated by mindfulness meditation.	234	19.22	56.8% (133) female 43.2% (101) male	University students	Quantitative

(Continued)

Table 1. (Continued).

Authors	Year	Country	Main goals	Sample size	Age range or mean age	Sex	Type of participants	Evaluation methods
Irvine <i>et al.</i>	2020	UK	To investigate a 12-week group outdoor health walk (GOHW) incorporating activity trackers and use of a holistic health and wellbeing measure, the Self-assessment of Change (SAC) scale.	13	71	77% (10) female 23% (3) male	Outdoor walking group participants	Mixed-methods
Jeon, Yeon, and Shin	2018	South Korea	Compare the effects of direct and indirect nature experience on psychological and physiological affect.	30	21.2	NI	University students	Quantitative
Johnson <i>et al.</i>	2019	Canada	Test attentional changes, pre- and post-exposure to nature compared to an urban environment in a sample of typically developing children and adolescents.	60	11.4	51.7% (31) female 48.3% (29) male	Children (general population)	Quantitative
Koselka <i>et al.</i>	2019	USA	Guide the development of a protocol for future longitudinal studies that would assess multiple physiological and psychological outcomes.	38	24.6/21.2	52.6% (20) female 47.4% (18) male	University students (majority, 26), university employees, general population (residents of communities near the university)	Quantitative
Lee <i>et al.</i>	2009	Japan	Examine human physiological and psychological responses to exposure to real forest landscapes.	12	20-23	100% (12) male	University students	Quantitative

(Continued)

Table 1. (Continued).

Authors	Year	Country	Main goals	Sample size	Age range or mean age	Sex	Type of participants	Evaluation methods
Lee, Park, and Choi	2020	South Korea	Improve treatment effects for participants through a new venture called art psychotherapy in the outdoor natural environment.	16	28-53	68.8% (11) female 31.2% (5) male	Applicants to an art psychotherapy in nature program	Mixed-methods
Marselle <i>et al.</i>	2015	UK	Explore the health benefits of nature and investigate the effect of environment type and indicators of perceived environmental quality on emotional well-being; investigate whether perceived restorative quality of an environment moderates the effect of perceived environment type or perceived environmental quality on emotional well-being.	127	55-74	55.5% (70) female 44.5% (57) male	Participants of a group walk program	Quantitative
Maud <i>et al.</i>	2019	UK	Investigate the effectiveness of a structured nature-based intervention aiming to improve the mental health of individuals experiencing anxiety and/or depression through engagement with nature.	16	18-84	50% (8) female 50% (8) male	Individuals registered with a community mental wellbeing service, diagnosed with depression and/or anxiety	Mixed-methods
Mutz, Müller, and Göring ^a	2018	France	Investigate whether outdoor programs can serve as an antidote to negative health impacts of exaggerated screen time.	76	17.8	36.8% (28) female 63.2% (48) male	Adolescents participating in a 10-day outdoor and adventure program	Quantitative

(Continued)

Table 1. (Continued).

Authors	Year	Country	Main goals	Sample size	Age range or mean age	Sex	Type of participants	Evaluation methods
Olszewska-Guizzo <i>et al.</i> ^a	2020	Singapore	Examine the effects of exposure to urban green spaces with varying visual quality, on the pattern of brain activity recorded using EEG neuro-imaging.	21	32.9	59.1% (13) female 49.9% (9) male	General population	Quantitative
Pasanen <i>et al.</i> ^a	2018	Finland	Explore whether affective and attention restoration could be enhanced by psychological instructions that aim to deepen the different phases of a restorative experience.	246	55	83.1% (226) female 16.9% (46) male	General population (more nature-oriented)	Quantitative
Pretty <i>et al.</i>	2007	UK	Quantify the effects of countryside activities on participants' mental and physical health.	263	47.8	49% (129) female 51% (134) male	Green exercise activities participants	Quantitative
Razani <i>et al.</i> ^a	2018	USA	To test whether park prescriptions will improve stress and other behavioural and health outcomes for parents.	78	38	87% (68) female 13% (10) male	Parent child pairs were eligible if the child was a clinic patient between 4 ± 18 years old	Mixed-methods
Ryan <i>et al.</i>	2010	Canada/USA	Assess the vitalizing effects of being outdoors and nature exposure in actual and imagined contexts.	251	20	75.3% (189) female 24.7% (62) male	University students	Quantitative
Silva <i>et al.</i>	2018	Portugal	Assess the effectiveness of a nature-based intervention in promoting domestic violence victims' wellbeing.	32	43.47	100% (32) female	Women victims of domestic violence	Mixed-methods
Simkin, Ojaka, and Tyrväinen	2020	Finland	Investigate the restorative effects of short visits to four different types of forest that differ in terms of their management and/or age.	66	43.38	59% (39) female 41% (27) male	General population (full-time employees; urban residents)	Quantitative

(Continued)

Table 1. (*Continued*).

Authors	Year	Country	Main goals	Sample size	Age range or mean age	Sex	Type of participants	Evaluation methods
South <i>et al.</i> ^a	2018	USA	To evaluate whether interventions to green vacant urban land can improve self-reported mental health.	342	44.6	59.7% (204) female 40.3% (138) male	Urban/suburban residents	Quantitative
Stigsdotter <i>et al.</i>	2017	Denmark	To gain further knowledge of the restorativeness of the two environments - urban and natural - and their possible impact on physiological and psychological processes.	51	20-36	100% (51) female	University students	Quantitative
van den Berg and Custers	2011	Netherlands	Determine whether gardening has a causal impact on recovery from stress.	30	57.6	73.3% (22) female 26.7% (8) male	Urban/suburban residents	Quantitative
Wolf and Housley	2017	USA	Assess how an outdoor work environment may serve as a path to personal effectiveness and provide healing opportunities.	243	18-34 (majority; 22-24)	42% (102) female 58% (141) male	Conservation workers ^c	Mixed-methods
Yi <i>et al.</i> ^a	2019	South Korea	Develop forest therapy programs that can be run in urban forest areas for the elderly population to prevent cognitive decline.	88	>70	79.5% (70) female 20.5% (18) male	Elderly population	Quantitative
Yu and Hsieh	2020	Taiwan	Assess physiological and psychological responses of a 3-day forest therapy workshop; evaluate the effects of the forest therapy workshop on creativity; and examine the relationship between change in emotions and improvements in creativity.	128	60	66.4% (85) female 33.6% (43) male	Attendees of a forest therapy workshop	Quantitative

Note: NEI – not enough information; NI – no information; ^a – studies that present characterization data that refer to the initial group of participants and not to the participants that completed the evaluation, whose number is presented in the column “sample size”.

Table 2. Interventions' characteristics.

Authors	Type of intervention	Activities' typology	Outdoor nature activities	Settings	Season
Anderson, Monroy, and Keltner 2018	Occasional	StructuredSemi-structured	Rafting	NEI (whitewater river)	NEI
Arbuthnott and Sutter 2019	Occasional	Structured	Walking/hiking, musical activities	Civilized natural environment (national wildlife area – wetland, prairie habitat; regional park)	Spring, Fall
Berman, Jonides, and Kaplan 2008	Occasional	Semi-structured	Walking	Quasi-natural and non-natural environments (urban park – arboretum; downtown)	Summer, Fall, Winter
Bratman <i>et al.</i> 2015a	Occasional	Semi-structured	Walking	Semi-natural and non-natural-environments (urban park – grassland with scattered shrubs and trees; busy multi-lane street)	All seasons (low climate variation)
Bratman <i>et al.</i> 2015b	Occasional	Semi-structured	Walking	Semi-natural and non-natural-environments (urban park – grassland with scattered shrubs and trees; busy multi-lane street)	NI
Cervinka, Schwab, and Haluza 2020	Occasional	Structured	Walking, nature immersion and exploration	Civilized natural environment(mixed forest with areas of monocultures)	Spring, Summer, Fall
Chen, He, and Yu 2020	Occasional	Semi-structured	Viewing	Semi-natural and non-natural environments (small wooded garden by a pond; heavily trafficked road)	Spring
de Brito <i>et al.</i> 2019	Occasional	Semi-structured	Walking	Quasi-natural and non-natural environments (arboretum – unpaved trails, secluded areas, large trees, grassland, pond; medium traffic roads)	NI
Deng <i>et al.</i> 2020	Occasional	Structured	Walking, viewing	Quasi-natural environment (large urban forest park – lake, lawn and mountain)	Fall
Diessner <i>et al.</i> 2015	Occasional	StructuredSemi-structured	Walking, observation	Quasi-natural environment (college campus)	Fall
Gatersleben and Andrews (only study 2 was included) 2013	Occasional	StructuredSemi-structured	Walking	Civilized natural, quasi-natural, and non-natural environments (country park; indoor room)	NI

(Continued)

Table 2. (Continued).

Authors	Type of intervention	Activities' typology	Outdoor nature activities	Settings	Season
Hartig <i>et al.</i> 2003	Occasional	Semi-structured	Walking	Civilized natural and non-natural environments (wildlife preserve area; medium-density urban area)	Spring
Hinds 2011	Occasional	Structured	Outdoor educational and adventure program (e.g., nature awareness games, group work, storytelling, wood craft)	Civilized natural environment (mixed broad-leaved woodland)	Summer
Hitter <i>et al.</i> 2019	Occasional	StructuredSemi-structured Non-structured	Therapeutic horticulture program (e.g., gardening, walking, viewing, bird and insect watching)	NI	NI
Hoag <i>et al.</i> 2013	Occasional	Structured	Wilderness therapy program	NI	NI
Ibes and Forestell 2022	Occasional	Structured	Viewing	Semi-natural and non-natural environments (green landscaped area near a moderately traffic road and buildings; windowless room)	Spring,Fall
Irvine <i>et al.</i> 2020	Occasional	Structured	Walking	NEI (natural area near a village located in a national park)	Spring, Summer
Jeon, Yeon, and Shin 2018	Occasional	Semi-structured	Viewing	Civilized natural environment (flat, managed area with predominance of pine trees; indoor room)	NI
Johnson <i>et al.</i> 2019	Occasional	Structured	Walking	Civilized natural, quasi-natural, and non-natural environments (urban park; busy downtown)	NI
Koselka <i>et al.</i> 2019	Occasional	Semi-structured	Walking	Civilized natural and non-natural environments (forest - gravel trail near a river; multi-lane busy road)	NI
Lee <i>et al.</i> 2009	Occasional	Semi-structured	Viewing	Civilized natural and non-natural environments (urban forest; commercial urban area with normal traffic density)	Summer

(Continued)

Table 2. (Continued).

Authors	Type of intervention	Activities' typology	Outdoor nature activities	Settings	Season
Lee, Park, and Choi 2020	Occasional	Structured	Forest-art therapy program (e.g., reflection, meditation, artistic activities, observation, walking)	Civilized natural and quasi-natural environments (forest, including areas near facilities)	Spring, Summer
Marselle <i>et al.</i> 2014	Occasional	Semi-structured	Walking	Civilized natural, quasi-natural, semi-natural and non-natural environments (e.g., nature reserve, river path, public gardens, urban farms, seaside, streets, shopping centers)	Summer, Fall
Maund <i>et al.</i> 2019	Occasional	Structured	Nature-based health intervention (e.g., walking, bird feeding, bird and other watching, canoeing)	Civilized natural environment (wetland with high biodiversity)	Spring, Summer
Mutz, Müller, and Göringa 2019	Occasional	Structured	Outdoor educational and adventure program (e.g., canoeing, rappelling, cave expeditions, walking)	NI	Spring
Olszewska-Guizzo <i>et al.</i> 2020	Occasional	Structured	Viewing	Quasi-natural, semi-natural and non-natural environments (urban park, neighbourhood green space; busy urban street)	Spring
Pasanen <i>et al.</i> 2018	Occasional	Semi-structured	Walking, observation, relaxation	Civilized, quasi-natural and semi-natural environments (coniferous/mixed forest – lake and houses along the trail; urban park)	Spring, Summer
Pretty <i>et al.</i> 2007	Occasional	Semi-structured	Green exercise (e.g., walking, horse-riding, conservation activities, biking, boating)	Quasi-natural and semi-natural environments (e.g., woodland, shoreline, country parks, community gardens, lake)	Fall
Razani <i>et al.</i> 2018	Occasional	Semi-structured	Walking, games, unstructured play, picnicks	Quasi-natural and semi-natural environment (e.g., local parks - bayfront park with a beach, lake with woodlands, and redwood forest)	Summer
Ryan <i>et al.</i> 2010	Occasional	Semi-structured	Walking	NEI (e.g., tree-line footpath along a river)	NEI

(Continued)

Table 2. (Continued).

Authors	Type of intervention	Activities' typology	Outdoor nature activities	Settings	Season
Silva <i>et al.</i> 2018	Occasional	Structured	Nature-based holistic development program (e.g., group games, green exercise, nature immersion, relaxation, arts and crafts, environmental awareness) Walking, viewing	Civilized natural, quasi-natural, and semi-natural environments (e.g., urban park with water features, national park, beach)	Spring, Summer, Fall
Simkin, Ojala, and Tyrväinen 2020	Occasional	Structured	Walking, viewing	Totally natural, civilized natural, quasi-natural and semi-natural environments (pristine, commercial and recreation forests)	Spring, Summer, Fall
South <i>et al.</i> 2018	Occasional	Semi-structured	Greening and trash cleanup interventions	Semi-natural environment (urban green lots)	All seasons
Stigsdotter <i>et al.</i> 2017	Occasional	Semi-structured	Walking	Quasi-natural and non-natural environments (health forest located in an arboretum; downtown)	Spring, Fall
van den Berg and Custers 2011	Occasional	Semi-structured	Gardening	Quasi-natural and non-natural environments (ornamental gardens; indoor room)	Spring
Wolf and Housley 2017	Continuous	Structured	Conservation work (e.g., planting, removal of invasive vegetation, biological monitoring)	Totally natural and civilized natural environments (e.g., wildlife habitats, riparian corridors, urban forests)	Spring, Summer and Fall
Yi <i>et al.</i> 2019	Occasional	Structured	Forest therapy program (e.g., walking, muscle training, guided-breathing meditation)	NEI (urban forests)	Summer, Fall
Yu and Hsieh 2020	Occasional	Structured structured Non-structured	Forest therapy program (e.g., walking, observation, meditation, listening to nature sounds, aromatherapy)	Quasi-natural environment (urban park with ponds, trails, animals, and several amenities)	Spring

Note: NEI – not enough information; NI – no information.

Table 3. Evaluation procedures and quantitative results.

Authors	Measures	Instruments*	Parameters*	Results*
Anderson, Monroy, and Keltner 2018	Psychological	1) Diary (single-item questions and short narratives);	1) Positive emotions (awe, amusement, contentment, gratitude, joy, and pride);	1) ↑
		2) Perceived Stress Scale (PSS);	2) Stress symptoms;	2) ↓
Arbuthnott and Sutter 2019	Psychological Nature interaction	3) Post-traumatic Stress Disorder Checklist (PCL);	3) Post-traumatic stress disorder;	3) ↓
		4) Mental Health Checklist; Mental Health Continuum (MHC-SF);	4) Mental health;	4) =
Berman, Jonides, and Kaplan 2008	Psychological	5) Satisfaction with Life Scale (SWLS).	5) Satisfaction with life.	5) ↑
		1) Nature Relatedness Scale (NRS);	1) Connection with nature;	1) ↑
Bratman <i>et al.</i> 2015a	Psychological	2) Positive and Negative Affect Schedule (PANAS);	2) Mood (positive and negative affect);	2) Positive affect ↑; negative affect =
		3) Elevating Experience Scale (EES; nine items);	3) Eudemonia (personal meaning in life, satisfaction, and high levels of elevating experiences);	3) ↑
Berman, Jonides, and Kaplan 2008	Psychological	4) Depression and Anxiety Stress Scales (short-form);	4) Depression, anxiety and stress;	4) Depression ↓; anxiety ↓; stress ↓
		5) Remote Associates Test (RAT).	5) Creative and divergent thinking.	5) =
Bratman <i>et al.</i> 2015a	Psychological	1) Positive and Negative Affect Schedule (PANAS);	1) Mood (positive and negative affect);	1) =
		2) Backwards digit-span task (BDS).	2) Directed-attention performance.	2) ↑
Bratman <i>et al.</i> 2015a	Psychological	1) State-Trait Anxiety Inventory (STAI);	1) Anxiety;	1) ↓
			2) Rumination;	2) ↓

(Continued)

Table 3. (Continued).

Authors	Measures	Instruments*	Parameters*	Results*
Bratman <i>et al.</i> 2015b	Psychological Physiological	2) Rumination-Reflection Questionnaire (RRQ); 3) Positive and Negative Affect Schedule (PANAS); 4) Operation span task (OSPAN); 5) Change detection task; 6) Attention network test (ANT); Backwards digit-span task (BDS).	3) Mood (positive and negative affect); 4) Working memory; 5) Visuospatial working memory; 6) Executive attention.	3) Positive affect ↑; negative affect ↓ 4) ↑ 5) ↑ 6) ↑
		1) Rumination-Reflection Questionnaire (RRQ); 2) Arterial spin label (ASL; neuroimaging method).	1) Rumination; 2) Neural activity (sgPFC).	1) ↓ 2) ↓
Cervinka, Schwab, and Haluza 2020	Psychological Nature interaction	1) Perceived Restorativeness Scale (PRS; short-form); 2) SF-36 vitality scale (3 items from the German version); 3) Widen One's Mind scale (WOM); 4) Positive and Negative Affect Schedule (PANAS; short-form); 5) Single-item questionnaire; 6) Restoration Outcome Scale (ROS); 7) Inclusion of Nature in Self (INS); 8) Freiburg Mindfulness	1) Perceived restorativeness; 2) Vitality; 3) Potential for widening one's mind; 4) Mood (positive and negative affect); 5) Perceived Stress; 6) Restoration; 7) Connection with nature; 8) Mindfulness.	1) ↑ 2) = 3) ↑ 4) Positive affect ↑; negative affect ↓ 5) ↓ 6) Restoration ↑ 7) Connection with nature ↑ 8) Mindfulness ↑

(Continued)

Table 3. (Continued).

Authors	Measures	Instruments*	Parameters*	Results*
Chen, He, and Yu 2020	Psychological Physiological	Inventory (8-item version).		
		1) Profile of Mood States (POMS); 2) Necker Cube Pattern Control task (NCPCT); 3) Perceived Restorativeness Scale (PRS); 4) Electroencephalography (EEG).	1) Subjective feeling of fatigue and vigor; 2) Attention; 3) Perceived restorativeness; 4) Brain activity (alpha and theta brain waves).	1) Subjective feeling of fatigue ↓; vigor ↑; 2) =; 3) ↑ 4) ↑
de Brito <i>et al.</i> 2019	Psychological	1) State-Trait Anxiety Inventory (STAI; 20-item state anxiety subscale); 2) Positive and Negative Affect Schedule (PANAS); 3) Backward digit-span task (BDS).	1) Anxiety; 2) Mood (positive and negative affect); 3) Directed-attention.	1) ↓ 2) Positive affect ↑; negative affect ↓ 3) =
		1) Profile of Mood States (POMS-SF; short-form); 2) Landscape Perceived Restorativeness Scale (LPRS); 3) Sphygmomanometer; 4) Blood glucose meter; 5) Electroencephalography (EEG).		
Deng <i>et al.</i> 2020	Psychological Physiological			

Canglang Area

- 1) Tension anxiety =; depression =; anger-hostility =; fatigue ↓; confusion =; total mood disturbance ↓; vigor scores ↑
- 3) Diastolic pressure ↓; systolic pressure =; pulse rate ↓
- 4) =
- 5) =

Lawn Area

- 1) Tension anxiety ↓; depression ↓; anger-hostility ↓; fatigue ↓; confusion ↓; total mood disturbance ↓; vigor scores =

(Continued)

Table 3. (Continued).

Authors	Measures	Instruments*	Parameters*	Results*
Diessner <i>et al.</i> 2015	Psychological Nature interaction	1) Engagement with Beauty Scale 2.0 (EBS); Engagement with Natural Beauty (ENB; subscale of the EBS); 2) Generalized Anxiety Disorder Scale (GAD); 3) The Center for Epidemiological Studies- Depression Scale (CES-D).	1) Cognitive and emotional engagement with natural beauty; 2) Anxiety; 3) Depression associated symptoms.	3) Diastolic pressure ↓; systolic pressure ↓; pulse rate ↓ 4) ↓ 5) =
				Wanshu Mountain 1) Tension anxiety ↓; depression ↓; anger- hostility ↓; fatigue ↓; confusion ↓; total mood disturbance ↓; vigor scores ↑ 3) Diastolic pressure ↓; systolic pressure ↓; pulse rate ↓ 4) = 5) =
Gatersleben and Andrews (only study 2 was included) 2013	Psychological Physiological	1) Self-rating Restoration Scale (SRRS); 2) Inventory of Personal Reactions (ZIPERS); 3) Necker Cube Pattern Control Task (NCPCT); 4) Digital blood pressure and heart rate monitor.	1) Fear; 2) Affect; 3) Attention; 4) Heart rate (physiological restoration).	1) ↓ (high prospect-low refuge); ↑ (low prospect-high refuge) 2) Positive affect ↑ 3) ↑ (high prospect-low refuge); ↓ (low prospect-high refuge) 4) ↑

(Continued)

Table 3. (Continued).

Authors	Measures	Instruments*	Parameters*	Results*
Hartig <i>et al.</i> 2003	Psychological Physiological	1) Ambulatory blood pressure monitor; 2) Inventory of Personal Reactions (ZIPERS); 3) Overall Happiness Scale (OHS); 4) Necker Cube Pattern Control task (NCPCT); Search and memory test (adapted).	1) Blood pressure (physiological stress recovery); 2) Emotion (positive affect, attentiveness, fear, anger/aggression); 3) Happiness; 4) Attention.	1) = (↓SBP at 30 minutes) 2) Positive affect ↑; attentiveness ↓; fear, anger and aggression ↓ 3) = 4) ↑
Hinds 2011	Psychological Nature interaction	1) International Personality Item Pool; 2) and 3) Children's Environmental Response; 4) Inventory Rosenberg's Self-Esteem scale; 5) Basic Need Satisfaction Scale; 6) Scale developed by Stets and Biga (2003).	1) Sociability; 2) Attitudes towards the natural environment; 3) Attitudes towards the urban environment; 4) Self-esteem; 5) Competence; 6) Environmental identity.	1) = 2) ↑ 3) = 4) = 5) ↑ 6) ↑
Hitter <i>et al.</i> 2019	Psychological	1) Beck Depression Inventory (BDI); 2) Levels of biomarkers - kynurenine and kynurenic acid.	1) Depression; 2) Kynurenine pathway.	1) ↓ 2) kynurenine =; kynurenic acid =
Hoag <i>et al.</i> 2013	Psychological	1) Outcome Questionnaire-45.2 (OQ-45.2); 2) Life Effectiveness Questionnaire (LEQ); 3) Dysfunctional Attitudes Scale (DAS);	1) Psychological adjustment; 2) Life effectiveness; 3) Cognitive distortions; 4) Alliance between patient and therapist; 5) Motivation for therapy.	1) ↑ (overall score ↓, which indicates a significant improvement in psychological adjustment) 2) ↑ 3) ↓

(Continued)

Table 3. (Continued).

Authors	Measures	Instruments*	Parameters*	Results*
Ibes and Forestell 2022	Psychological	4) Helping Alliance Questionnaire (HAQ-II); 5) Client Motivation for Therapy Scale (CMOTS). 1) Profile of Mood States (POMS-SF; short-form); 2) Self-report - closed questions.	1) Mood; 2) Frequency of outdoor and meditation habits**	4) ↑ 5) ↓ 1) Total Mood disturbance ↓
Irvine <i>et al.</i> 2020	Psychological	1) Self-Assessment of Change (mSAC; 16-item modified version).	1) Holistic biopsychosocial-spiritual health and wellbeing.	1) Physical dimensions (sleeping ↑; energized ↑; vibrant senses ↑); affective or emotional dimensions (joyful, calm) ↑; cognitive dimension (focused) ↑; spiritual dimensions (whole) ↑
Jeon, Yeon, and Shin 2018	Psychological Physiological	1) Electrocardiogram (recorded with a portable electrocardiograph); 2) Modified Semantic Differential (SD) method; 3) Profile of Mood States (POMS).	1) Heart rate variability (HRV; parasympathetic nerve activity); 2) Emotional impact; 3) Mood (tension and anxiety, depression, anger and hostility, vigour, fatigue, and confusion).	1) ↑ 2) Emotional impact (↑ pleasure; ↑ natural; = calm) 3) Mood (tension and anxiety, depression, anger and hostility, vigour, fatigue, and confusion) ↓
Johnson <i>et al.</i> 2019	Psychological Nature interaction	1) Combined Attention System Test (CAST); 2) Wechsler Abbreviated Scale of Intelligence (WASI); 3) Connectedness to Nature Scale (CNS; 10-item modified version).	1) Attention; 2) Intellectual ability**; 3) Connection with nature**.	1) Endogenous attention: alerting RT ↑; orienting ER ↑; exogenous attention: alerting X =; orienting X =
Koselka <i>et al.</i> 2019	Psychological	1) Positive and Negative Affect Schedule (PANAS);	1) Mood (positive and negative affect); 2) Anxiety;	1) Positive affect ↑; negative affect ↓ 2) ↓

(Continued)

Table 3. (Continued).

Authors	Measures	Instruments*	Parameters*	Results*
Lee <i>et al.</i> 2009	Psychological Physiological	2) State and Trait Anxiety Inventory (STAI); 3) Cohen's Perceived Stress Scale (PSS-10); 4) Visual Backward Digit Span Test (vBDS). 1) Salivettes (salivary cortisol); 2) Digital blood pressure monitor; 3) Self-report - closed questions.	3) Stress; 4) Attention and working memory. 1) Cortisol levels (stress); 2) Blood pressure (BP) and pulse rate (activity of the autonomic nervous system); 3) Psychological response to the environment ("comfortable", "uncomfortable", "soothing-awakening" and "refreshment").	3) ↓ 4) = 1) Cortisol ↓; 2) Diastolic BP ↓; systolic BP =; pulse rate ↓; 2) Comfortable-uncomfortable ↑; "soothing-awakening" ↑; "refreshment" ↑
Lee, Park, and Choi 2020	Psychological	1) to 5) Survey (includes questions from the Symptom Checklist-90-Revision (SCL-90-R) mental health questionnaire).	1) Depression (DEP; 11 questions); 2) Anxiety (ANX; 11 questions); 3) Stress vulnerability–interpersonal sensitivity (STV–IN-S; 5 questions); 4) Stress vulnerability–self-regulation problems (ST–RG-P; 5 questions); 5) Aggression (AGG; 7 questions).	1) = 2) = 3) ↓ 4) ↓ 5) =
Marselle <i>et al.</i> 2014	Psychological Nature interaction	1) Positive and Negative Affect Schedule (PANAS);	1) Mood (positive and negative affect); 2) Happiness;	1) Positive affect ↑; negative affect ↓ 2) Happiness ↑

(Continued)

Table 3. (Continued).

Authors	Measures	Instruments*	Parameters*	Results*
Maud et al. 2019	Psychological	2) Single-item; 3) Closed question (select on from a list of 10 categories); 4) Closed question (single item); 5) Closed questions (three items); 6) Perceived Restorativeness Scale (PRS).	3) Environment type**; 4) Perceived naturalness**; 5) Perceived biodiversity**; 6) Perceived restorativeness**.	
		1) Warwick Edinburgh Mental Wellbeing Scale (WEMWBS); 2) Perceived Stress Scale (PSS); 3) Generalised Anxiety Disorder Scale (GAD-7); 4) Positive and Negative Affect Schedule (PANAS).	1) Mental well-being; 2) Stress; 3) Anxiety; 4) Mood (positive and negative affect);	1) ↑ 2) ↓ 3) ↓ 4) Positive ↑; negative affect ↓
Mutz, Müller, and Göringa 2019	Psychological	1) Perceived Stress Questionnaire (PSQ); 2) Single-item question; 3) Single-item question.	1) Perceived stress; 2) Life satisfaction (to assess subjective well-being); 3) Hedonic balance (to assess short-term wellbeing).	High media consumers 1) Worry ↓; tension ↓; demand ↓; joy ↑ 2) ↑ 3) ↑ Low-to-moderate media consumers 1) Worry ↓; tension ↓; demand ↓; joy ↑ 2) = 3) ↑ 1) = 2) =
		1) Profile of Mood States (POMS); 2) Electroencephalography (EEG).	1) Mood; 2) Brain activity.	

(Continued)

Table 3. (Continued).

Authors	Measures	Instruments*	Parameters*	Results*
Pasanen <i>et al.</i> 2018	Psychological	1) Restoration Outcome Scale (ROS); 2) Two-dimensional affect grid; 3) Random version of the Sustained Attention to Response Task (SART); 4) Perceived Stress Scale (PSS).	1) Restoration; 2) Mood; 3) Sustained attention; 4) Stress.	1) ↑ 2) = 3) ↑ 4) ↓
Pretty <i>et al.</i> 2007	Psychological Physiological	1) Rosenberg Self-Esteem Scale (RSES); 2) Profile of Mood States (POMS); 3) Calorie consumption. 1) Perceived Stress Score (PSS10); 2) Modified UCLA Loneliness Score; 3) Single-item (self-report); 4) Saliva collection devices (salivary cortisol); 5) Love and Care for Nature Scale (LCN); 6) Four validated items.	1) Self-esteem; 2) Mood; 3) Calorie consumption (physical health) 1) Stress; 2) Loneliness; 3) Physical activity; 4) Cortisol levels (physiologic stress); 5) Nature affinity; 6) Neighbourhood social support**.	1) ↑ 2) Total mood disturbance ↓; anger ↓; confusion ↓; depression ↓; fatigue ↑; tension ↓; vigour-activity = 3) ↑ 1) ↓ 2) ↓ 3) ↑ 4) ↓ 5) ↑
Razani <i>et al.</i> 2018	Psychological Physiological Nature interaction	1) Subjective Vitality Scale (SVS); 2) Diener & Emmon's (1984) 9-item hedonic valence scale; 3) Single-item questions.	1) Subjective vitality; 2) Emotions (positive and negative)**; 3) Satisfaction**.	1) ↑

(Continued)

Table 3. (Continued).

Authors	Measures	Instruments*	Parameters*	Results*
Silva <i>et al.</i> 2018	Psychological Nature interaction	1) World Health Organization Quality of Life (WHOQL-BREF);	1) Life quality;	1) ↑
		2) Outcome Questionnaire (OQ-45.2)	2) Individual functioning;	2) ↑ (overall score ↓, which indicates a significant improvement in psychological adjustment)
Simkin, Ojala, and Tyrväinen 2020	Psychological	3) Rosenberg Self-Esteem Scale (RSES);	3) Self-esteem;	3) ↑
		4) Nature Relatedness Scale (NRS).	4) Connection with nature.	4) =
South <i>et al.</i> 2018	Psychological	1) Restoration Outcome Scale (ROS);	1) Restoration;	1) ↑
		2) Subjective Vitality Scale (SVS);	2) Subjective vitality;	2) ↑
Stigsdotter <i>et al.</i> 2017	Psychological Physiological	3) Positive and Negative Affect Schedule (PANAS).	3) Mood (positive and negative affect).	3) Positive ↑; negative affect ↓
		1) Kessler-6 Psychological Distress Scale (K6)	1) Mental health	1) Depression ↓; feeling worthless ↓
Stigsdotter <i>et al.</i> 2017	Psychological Physiological	1) Portable heart rate monitor;	1) Heart rate variability (HRV);	1) HRV =;
		2) Automated blood pressure devices;	2) Blood pressure (BP; state of arousal or relaxation);	2) Systolic BP ↓, diastolic BP =;
Stigsdotter <i>et al.</i> 2017	Psychological Physiological	3) Profile of Mood States (POMS);	3) Mood;	3) Total mood disturbance ↓
		4) Perceived Restorativeness Scale (PRS);	4) Perceived restorativeness;	4) ↑
Stigsdotter <i>et al.</i> 2017	Psychological Physiological	5) Perceived Stress Scale (PSS);	5) Perceived stress**;	
		6) EuroQol-visual analogue scales (EQ-VAS).	6) Perceived health**.	

(Continued)

Table 3. (Continued).

Authors	Measures	Instruments*	Parameters*	Results*
van den Berg and Custers 2011	Psychological Physiological	1) Sarstedt Salivettes® (salivary cortisol); 2) Positive and Negative Affect Schedule (PANAS). 1) Perceived Stress Scale (PSS); 2) 36-Item Short Form Survey from the RAND Medical Outcomes Study; Review of Personal Effectiveness with Locus of Control (ROPELOC); 4) New Ecological Paradigm (NEP). 1) Mini Mental-Status Examination for Dementia Screening (MMSE-DS; cognitive test); 2) Neurocognitive test with the resting-state EEG; 3) Photoplethysmography (PPG) device; 4) Bioimpedance analysis (BIA) device (InBody S-10).	1) Cortisol levels (physiologic stress); 2) Mood. 1) Perceived stress; 2) Perceived health; 3) Personal effectiveness/resiliency; 4) Pro-environmental orientation.	1) ↓ 2) ↑ 1) ↓ 2) ↑ 3) = 4) =
Wolf and Housley 2017	Psychological Nature interaction			
Yi <i>et al.</i> 2019	Physiological		1) Global cognitive status**; 2) Neurocognitive function; 3) Heart rate variability (HRV; activation of the autonomic nervous system); 4) Bioimpedance – general body composition factors (e.g., body fat mass, fat-free mass, body water level).	Breathing Program 2) Median Frequency (MEF) =; Power of the alpha band =; Power of the Beta band =; ATR = 3) High Frequency ↓; Low frequency =; Total power =; Heart rate ↑ 4) Fat Free Mass =; Body Fat Mass =; % Body Mass =; Phase angles body ↑; Impedance arm ↑; Impedance leg =; Reactance –arm ↑; Reactance leg =; Phase angle arm ↑; Phase angle leg = Walking Program 2) Median Frequency (MEF) ↓; Power of the alpha band =; Power of the Beta band =; ATR ↓

(Continued)

Table 3. (Continued).

Authors	Measures	Instruments*	Parameters*	Results*
Yu and Hsieh 2020	Psychological Physiological	1) Profile of Mood States (POMS-SF; short-form) scale; 2) Chinese Word RAT (CWRAT); 3) Electronic blood pressure monitor HEM-1000.	1) Mood; 2) Creativity; 3) Heart rate variability (HRV) and blood pressure (BP).	3) High Frequency =; Low frequency =; Total power =; Heart rate = 4) Fat Free Mass =; Body Fat Mass =; % Body Mass =; Phase angles body ↑; Impedance arm =; Impedance leg ↑; Reactance –arm =; Reactance leg ↑; Phase angle arm =; Phase angle leg ↑ 1) Tension–anxiety ↓; anger–hostility ↓; fatigue–inertia =; depression–dejection ↓; confusion–bewilderment ↓; vigor–activity ↑; total mood disturbance ↓; 2) Creativity ↑; 3) HRV =; BP =

Note: ↑significant increase; ↓ significant decrease; = no significant changes
*The numbering of parameters, instruments and results provides a direct correspondence among columns.
**Data evaluated only at one moment (e.g. baseline, post-intervention).

Table 4. Quality assessment components and rating scale.

Component	Description	Scale
Hypothesis/aim/objectives	Is the hypothesis/aim/objective of the study clearly described?	1: Yes 0: No
Selection bias	Are the individuals selected to participate in the study likely to be representative of the target population?	1: Yes 0: No
Outcome measure	Was the outcome objectively measured or self-reported? (If the study applied both type of measures, classify as 0 if there is a clear prevalence of self-report measures)	1: Objectively 0: Self-reported
Type of natural space	Was the type of natural space clearly indicated?	1: Yes 0: No
Natural space use	Was the use of natural space measured?	1: Yes 0: No or unclear
Data collection methods	Were valid and reliable tools used to assess participant outcomes?	1: Yes 0: No
Level of analysis	Was analysis of green space in relation to outcome carried out at individual level or at ecological (area) level	1: Individual 0: Ecological
Precision of the results	Were confidence intervals or p-values given?	1: Yes 0: No

3.4. Methodological quality assessment

The Cochrane Review guidelines indicate the need to assess risk of bias in the studies included in a systematic review (Higgins *et al.* 2022). We recognize that there is a risk of bias in the selected studies, especially selection bias due to non-representative sample populations and to the fact that many were non-randomized trials. When compared with randomized controlled trials, non-randomized trials are likely to have a greater risk of bias (Britton *et al.* 2020; Higgins *et al.* 2022). In addition, the diversity of research designs in the included studies made it difficult to identify a quality assessment instrument adequate for all individual studies. Hence, we structured an 8-item checklist (Table 4) based on the quality assessment tools applied by Hanson and Jones (2015), Lachowycz and Jones (2011), and Thomas *et al.* (2004). Studies that scored five or higher were classified as good quality.

3.5. Search and screening process

After completing the screening process for the 1,324 identified studies, 38 were considered eligible (Figure 1). Regarding quality assessment, all studies obtained scores of five or higher, being rated of good methodological quality. Hence, no study was excluded due to a low-quality score. The most represented fragilities concerned the

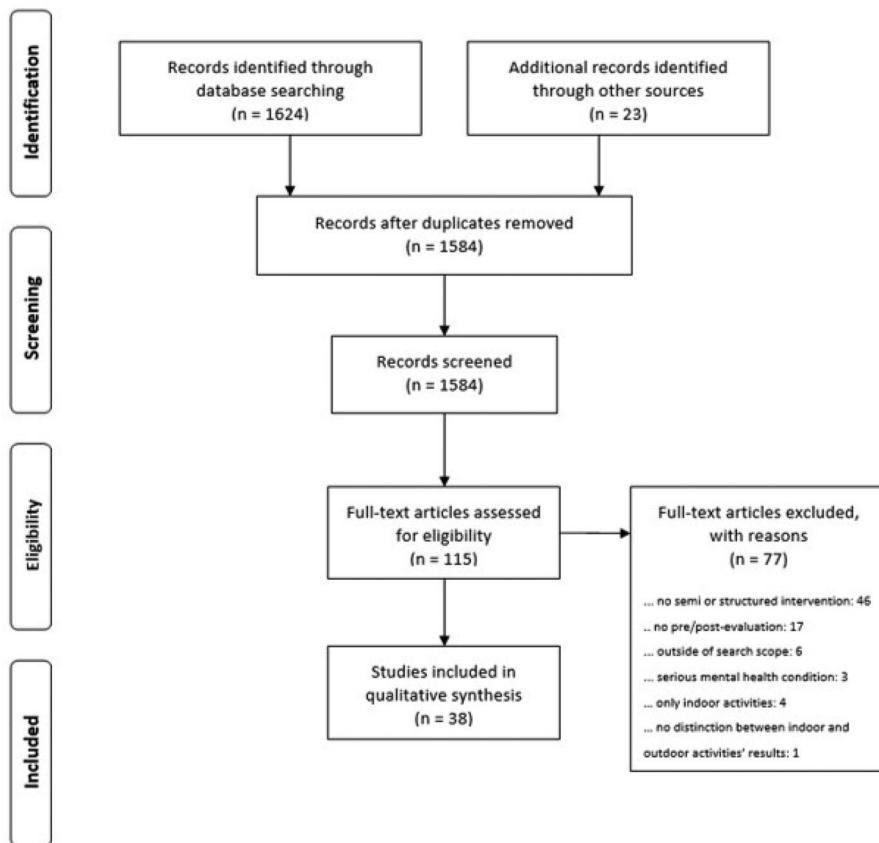


Figure 1. Flowchart of the literature search process.

Note: Adapted from the PRISMA flow Diagram (Moher *et al.* 2009).

possibility of bias regarding population selection ($n = 38$; 100%) and prevalence of self-reporting measures ($n = 21$; 55.3%).

The 38 included studies were analyzed taking into account five levels: i) study characteristics (year of publication, country, main goals, participants, and evaluation method(s)); ii) intervention characteristics (duration, level of structure, settings, and season); iii) evaluation procedures (measures, instruments and parameters,); iv) outcomes (quantitative and qualitative); and v) limitations and recommendations. When information only allowed for a partial classification (e.g. description of some but not all settings), the parameters were classified as “not enough information” (NEI).

4. Results

4.1. Study characterization

Figure 2 shows the study distribution per country, being possible to identify a predominance of studies developed in the USA ($n = 13$; 34.2%) and UK ($n = 6$; 15.8%). Despite no limit regarding the year of publication, all selected studies were relatively recent (publication dates ranging from 2003 to 2020), with the majority being published between 2018 and 2020 ($n = 23$; 60.5%).

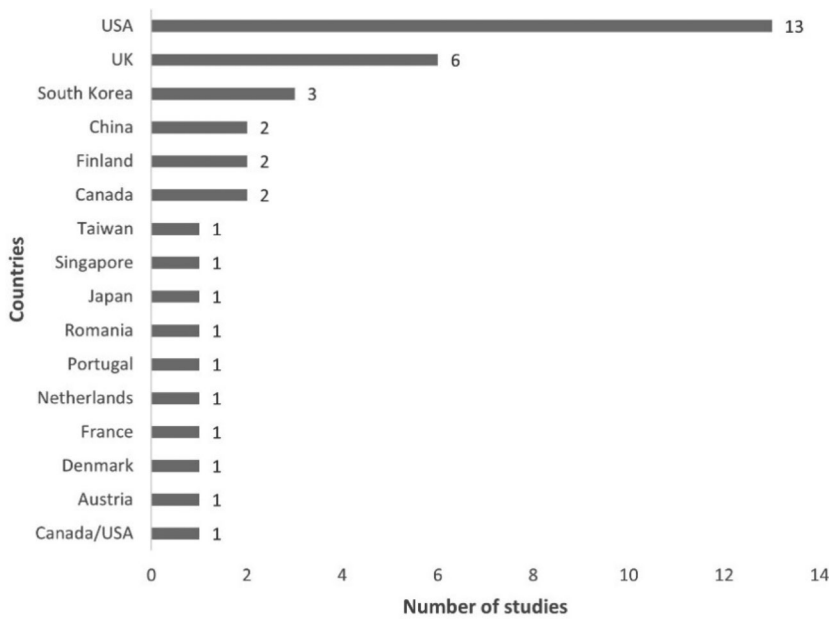


Figure 2. Studies' distribution per country.

4.1.1. Main objectives

The studies' main goals were related to four general types of outcome: i) psychological (e.g. affect, mood states, attention, stress, restoration); ii) physiological (e.g. blood pressure, heart rate, cortisol levels, neural activity); iii) nature interaction (e.g. pro-environmental behavior, connection with nature); and iv) pathways that link nature to well-being. Besides the impact of nature contact, several of the studies also established as a goal the assessment of the possible effect of factors such as: awe (e.g. Anderson, Monroy, and Keltner 2018), directed attention (e.g. Bratman *et al.* 2015a), mindfulness meditation (e.g. Ibes and Forestell 2022), environmental quality (e.g. Marselle *et al.* 2014), and environment type (e.g. Deng *et al.* 2020). Comparison between different types of environments was performed in fifteen studies (39.5%), that verified impact variations between urban and natural environments (e.g. Berman, Jonides, and Kaplan 2008; Johnson *et al.* 2019), and among different types of natural environments (e.g., Gatersleben and Andrews 2013; Lee *et al.* 2009; Simkin, Ojala, and Tyrväinen 2020).

4.1.2. Participants

Overall, the studies reported data regarding a total of 3,653 participants, with sample size ranging from 8 to 342 participants, of which 57.5% were women. The 16-30 age group¹ was the most represented ($n = 1\,672$; 45.8%), while the 0 – 15 age group was the least represented ($n = 85$, 2.3%). University students, the general population (mainly residents of urban and suburban areas), participants in therapy programs (nature-based or occurring in nature settings) and in outdoor activities (e.g. walking, adventure activities) were the more represented categories (Figure 3). A relevant number of participants ($n = 1\,244$; 34.1%) were more nature-oriented than the general population and/or were already participating in activities that promoted direct contact

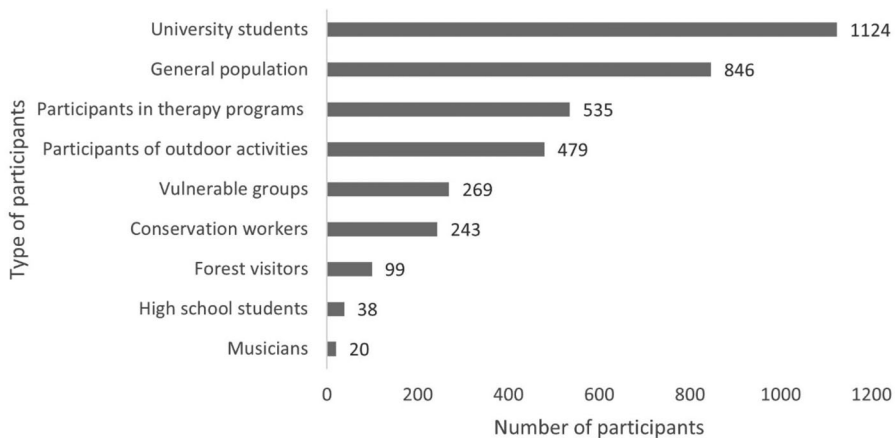


Figure 3. Type of participants.

with natural environments (e.g. regular participants of a group walk program, green exercise practitioners). Vulnerable groups, including domestic violence victims, war veterans, youth from underprivileged communities and elderly participants over 70 years old, were present in four studies (10.5%).

4.1.3. Type of studies

All studies were longitudinal; the majority being quasi-experimental ($n = 29$; 76.3%). Nine studies (23.7%) were experimental, having a control group and randomization procedures (e.g. Diessner *et al.* 2015; Ryan *et al.* 2010); eight (25.5%) were crossover trials, with participants being subjected to two or more different conditions (e.g. de Brito *et al.* 2019; Deng *et al.* 2020); and 19 (50%) performed random selection and/or assignment of participants. In most cases, the evaluation method was quantitative ($n = 30$; 78.9%). Mixed-methods evaluation was applied in eight studies (21.1%) and no study presented only qualitative methods.

4.2. Interventions and setting characteristics

Table 2 features the included studies, intervention characteristics, including information regarding outdoor activities performed, settings, activities' typology and type of intervention, and season.

4.2.1. Outdoor nature activities

Walking and viewing nature were the prevalent activities (Figure 4), with 12 studies (31.6%) assessing the impact of walking as the sole activity (e.g. Bratman *et al.* 2015b; Hartig *et al.* 2003; Irvine *et al.* 2020) and 6 (15.8%) of only viewing (e.g. Chen, He, and Yu 2020; Ibes and Forestell 2022). Adding to the indicated number of studies, it is important to stress that walking and viewing were activities also included in the outdoor and nature-based programs (e.g. education, conservation and therapy programs). Seven studies (18.4%) assessed the effects of nature-based therapy programs,

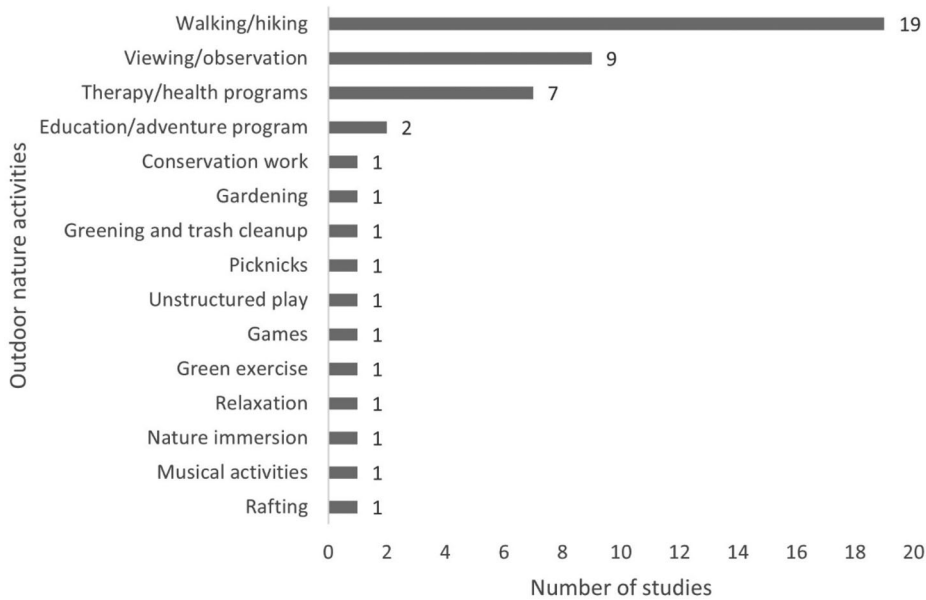


Figure 4. Outdoor nature activities performed.

including forest therapy programs and nature-based health and holistic development programs (e.g. Hitter *et al.* 2019; Hoag *et al.* 2013; Lee, Park, and Choi 2020; Silva *et al.* 2018). These programs included several activities, including meditation, artistic activities, walking, viewing, arts and crafts, aromatherapy and listening to nature sounds.

4.2.2. Settings and season

In the majority of studies ($n = 23$, 60.5%), activities took place in two or more types of settings. Civilized ($n = 16$, 41%) and quasi-natural ($n = 17$, 44.7%) environments were the most represented type of natural environment. Only two studies (5.1%) performed activities in totally natural environments (e.g. Simkin, Ojala, and Tyrväinen 2020; Wolf and Housley 2017). Forests/woodlands and urban parks are the most prevalent nature settings ($n = 21$; 55.3%). Protected natural areas include national wildlife areas, national and regional parks, wetlands, wildlife preserves, being areas that provide direct access to well-conserved nature and biodiversity. Authors also highlighted characteristics that can contribute to increasing the restorative potential of natural environment, as the presence of water features, plants, topography landscape, and of aesthetic values (e.g. Deng *et al.* 2020; Silva *et al.* 2018).

Twenty-nine (76.3%) gave information about the time of year when the activities and/or data collection took place. Winter was the less studied season, while the majority of studies ($n = 19$; 52.6%) took place, completely or partially, during the Spring. Of the studies that cover more than one season ($n = 18$; 40.2%), only one (Berman, Jonides, and Kaplan 2008) verified whether a seasonal effect occurred, concluding that the season had no effect. Although not assessing a seasonal effect, Olszewska-Guizzo *et al.* (2020) obtained stronger effects after controlling for environmental conditions, which led the authors to suggest that weather conditions may constitute a serious confounding factor (Figure 5).

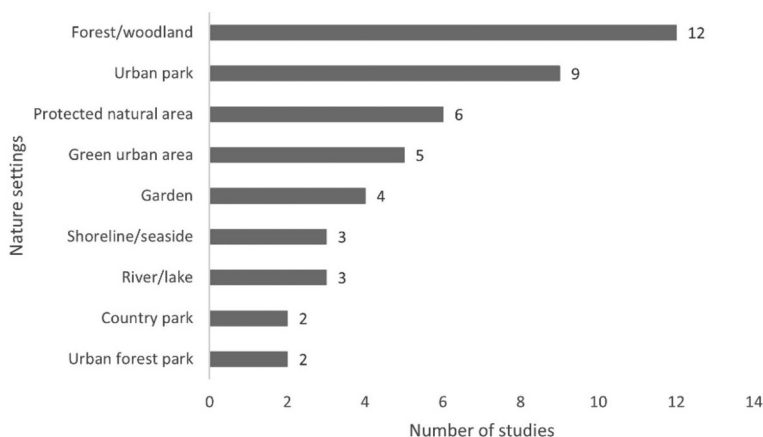


Figure 5. Nature settings.

Note: The category “Green urban area” corresponds to other green urban areas besides urban parks, as tree corridors or lawns.

4.2.3. Activities' typology and type of intervention

Structured activities were featured in 21 studies (55.3%) and semi-structured activities in 22 (57.9%). Four studies (10.5%) featured mixed typologies.

The majority of the interventions ($n = 37$; 97.4%) had an occasional character, with only one study assessing the impact of a continuous intervention (Wolf and Housley 2017). Total exposure time to natural environments ranged from less than 10 min (e.g. Olszewska-Guizzo *et al.* 2020) to one year (e.g. Wolf and Housley 2017).

5. Evaluation procedures

Evaluation procedures and statistically significant quantitative results are presented in Table 3. As in the review by Bowler *et al.* (2010), we also verified a high variability in evaluation methodology, with the assessment of different outcomes through different measuring instruments and techniques. Frequently, the same parameter was assessed by distinct instruments. For example, connection with nature was assessed by the Nature Relatedness Scale (NRS; Nisbet *et al.* 2009) and by the Inclusion of Nature in Self (INS; Schultz 2001). Within the studies that performed follow-up evaluation (e.g. Anderson, Monroy, and Keltner 2018; Hoag *et al.* 2013; Razani *et al.* 2018; South *et al.* 2018), follow-up periods after intervention completion were quite diverse, ranging from one week (e.g. Anderson, Monroy, and Keltner 2018) up to 18 months (South *et al.* 2018).

Psychological outcomes (e.g. mood states, rumination, anxiety, mental health) were assessed in all of the included studies, mainly through self-reported measures. The most commonly applied were the Positive and Negative Affect Scale (PANAS, full or short form; $n = 10$; 26.3%), the Perceived Stress Scale (PSS; $n = 4$; 10.5%) and the Profile of Mood States (POM, full or short form; $n = 7$; 18.4%). Physiological measures (e.g. blood pressure, heart rate, salivary cortisol, brain activity,) were assessed in 14 (36.8%) studies, while only seven (18.4%) analyzed the impact of NBIs in nature-interaction features, as pro-environmental behavior and nature connection.

5.1. Quantitative outcomes

Quantitative analysis provided data regarding psychological, physiological and nature interaction outcomes. There was a clear emphasis in self-reported measures in the majority of the studies ($n=21$, 55.3%). Despite this prevalence, it is important to underline that 22 studies (57.9%) used, at least, one objective measure.

5.1.1. Psychological outcomes

The mainly assessed psychological outcomes were related to mental health, mood and cognitive function. Except for two studies (Diessner *et al.* 2015; Olszewska-Guizzo *et al.* 2020), all the studies reported significant improvements regarding mental health and/or mood outcomes. Perceived stress was assessed in nine studies (23.7%), with all reporting a significant reduction after the NBI (e.g. Anderson, Monroy, and Keltner 2018; Arbuthnott and Sutter 2019; Koselka *et al.* 2019; Wolf and Housley 2017). Twelve studies (31.6%) reported data about the participants' cognitive functioning. In the majority of those ($n=8$), significant positive improvements were reported (e.g. Berman, Jonides, and Kaplan 2008; Bratman *et al.* 2015a; Hartig *et al.* 2003; Hoag *et al.* 2013).

5.1.2. Physiological outcomes

Fifteen studies (39.5%) included physiological measurements. Cortisol levels were assessed in three studies, all of which verified a significant reduction after the nature experience (Lee *et al.* 2009; Razani *et al.* 2018; van den Berg and Custers 2011). Other parameters, such as heart rate variability (HRV), brain and neural activity, and blood pressure obtained mixed results, with some studies reporting significant improvements (e.g. Bratman *et al.* 2015a; Chen, He, and Yu 2020; Jeon, Yeon, and Shin 2018), while others verified no significant changes (e.g. Olszewska-Guizzo *et al.* 2020; Stigsdotter *et al.* 2017; Yu and Hsieh 2020). The studies by Deng *et al.* (2020) and Yi *et al.* (2019) also suggest that the type of natural setting and activities performed influence the physiological outcomes. For example, in the study by Yi *et al.* (2019), heart rate variability increased significantly in the breathing program and not in the walking program. Olszewska-Guizzo *et al.* (2020) stressed that weather conditions may be a potential confounding factor, especially in regions where they suffer a strong variation.

5.1.3. Nature interaction outcomes

Of the seven studies that assessed nature interaction outcomes before and after the intervention, four reported significant improvements in levels of nature connection (e.g. Arbuthnott and Sutter 2019; Cervinka, Schwab, and Haluza 2020), attitudes towards the natural environment (e.g. Hinds 2011), and of nature affinity (e.g. Razani *et al.* 2018). In the study by Silva *et al.* (2018), while there was no significant variation in the NRS total score, there was an increase in the post-intervention values and a significant improvement in one of the NRS's dimensions: the NR-Self (internalized identification with nature, i.e. how strongly people identify with the natural environment, reflecting feelings and thoughts).

5.2. Qualitative outcomes

Of the studies included, seven (18.4%) presented qualitative data whose analysis allowed conclusions about the interventions' impact and characteristics (settings, activities performed, format, duration), and also infer pathways through which contact with nature relates to human well-being.

5.2.1. Intervention impact on overall well-being and components

Different nature experiences (e.g. green exercise, outdoor adventure activities, conservation work, leisure, therapeutic) led to an increase in positive feelings such as joy, gratitude, amusement, calm, awe, security, and being away from stress, as well as stress reduction (Anderson, Monroy, and Keltner 2018; Hinds 2011; Maund *et al.* 2019; Silva *et al.* 2018). For many participants, the lived nature experiences led to a strong sense of belonging and companionship, providing opportunities for constructive group interaction and strengthening social support networks (Hinds 2011; Maund *et al.* 2019; Silva *et al.* 2018; Wolf and Housley 2017). The acquisition of new working and social skills (e.g. capacity to interact with others, development of coping strategies) and knowledge about nature (e.g. species identification) and new places, was also pointed out by participants (Hinds 2011; Silva *et al.* 2018; Wolf and Housley 2017). Increased sense of self-efficacy (e.g. higher self-esteem, confidence and accomplishment; Hinds 2011; Maund *et al.* 2019; Silva *et al.* 2018; Wolf and Housley 2017), and of place (Silva *et al.* 2018) were reported. Contact with nature also promoted the development of positive feelings towards the natural environment and environmentally friendly behaviors (e.g. animal rescue, litter picking; Maund *et al.* 2019; Hinds 2011; Silva *et al.* 2018). In the study by Lee *et al.* (2009), participants also identified several advantages of therapy in natural environments, including: easier rapport, lower aversion to the term "psychotherapy," strong levels of immersion and reduced self-defense.

5.2.2. Nature-based intervention characteristics

Participants highlighted several intervention characteristics that were important to them. In the studies by Maund *et al.* (2019), Silva *et al.* (2018), and Wolf and Housley (2017) group format provided an opportunity to reinforce participants' social support network, to make new friends and develop interpersonal skills. The inclusion of activities that allowed for personal growth and learning opportunities was also relevant for several participants (e.g. Hinds 2011; Silva *et al.* 2018; Wolf and Housley 2017). Natural settings characterized by an appealing natural beauty, biodiversity (species of fauna and flora), and with water features appear to be indicated to promote overall well-being and/or have a positive impact on specific well-being features (e.g. Maund *et al.* 2019; Silva *et al.* 2018). Silva *et al.* (2018) verified that the opportunity to participate in the activities with children was identified by several participants (mothers whose children were also integrated in the nature-based intervention) as a strong point.

5.2.3. Pathways

In the study by Anderson, Monroy, and Keltner (2018), participants highlighted experiences of awe and of positive feelings, suggesting that positive emotions, such as awe,

contentment, and gratitude, are mediators of the effect of nature on well-being. Individual experience of nature comprehended contemplation (e.g. watching the sunset, watching water flow, appreciating beauty), sensorial engagement (e.g. smelling plants, listening to birds, touching grass or water), and directed attention (e.g. noticing blooming flowers; paying attention to details, sounds and sights; noticing surrounding nature). The findings of Chen, He, and Yu (2020), which indicated a significant increase in functional connectivity after exposure to a natural environment, also reinforce the role of directed attention in restorative processes.

5.3. Limitations and recommendations

Authors pointed out important limitations that require results to be cautiously interpreted. The most commonly mentioned limitation was non-representative samples due to type of participants or small sample size (e.g. Arbuthnott and Sutter 2019; Jeon, Yeon, and Shin 2018; Lee *et al.* 2009; Mutz, Müller, and Göring 2019; Hitter *et al.* 2019; Pretty *et al.* 2007; Silva *et al.* 2018; Simkin, Ojala, and Tyrväinen 2020; South *et al.* 2018; Stigsdotter *et al.* 2017). Evaluation procedures – lack of follow-up evaluation (e.g. Bratman *et al.* 2015a; Gatersleben and Andrews 2013; Mutz, Müller, and Göring 2019; Silva *et al.* 2018; South *et al.* 2018), instruments' fragilities (e.g. Diessner *et al.* 2015; Hinds 2011; Silva *et al.* 2018; South *et al.* 2018; Stigsdotter *et al.* 2017) and prevalence of subjective outcomes through self-reporting instruments (e.g. Cervinka, Schwab, and Haluza 2020; de Brito *et al.* 2019; Silva *et al.* 2018) – was the second most mentioned limitation. Settings also constituted an important limitation due to, for example, the presence of dominant urban features (e.g. Diessner *et al.* 2015), reduced number of environments tested (e.g. Lee *et al.* 2009) and insufficient attention to constituent elements (e.g. Chen, He, and Yu 2020). The lack of control of extraneous factors with a potential influence on the results was also highlighted as a limitation by several authors. Previous life experiences (e.g. Silva *et al.* 2018), lifestyle during the time of the experience (e.g. Hitter *et al.* 2019), weather conditions (seasonal effect; e.g. Stigsdotter *et al.* 2017), social approval or social desirability (e.g. Diessner *et al.* 2015), and the role of company (e.g., Gatersleben and Andrews 2013) were the most cited factors, with authors stressing the need for further investigation regarding their influence. Pasanen *et al.* (2018), whose study featured a semi-structured intervention, mentioned that different routes led to some difficulty in wayfinding that may have caused participants to have different experiences of the natural settings. Other limitations were i) intervention's short duration (e.g. Johnson *et al.* 2019); ii) drop-out rates (e.g. Hoag *et al.* 2013); iv) lack of control/comparison group (e.g. Mutz, Müller, and Göring 2019; Razani *et al.* 2018; Silva *et al.* 2018; Yu and Hsieh 2020); and v) no separation between effects of nature and of exercise (e.g. van den Berg and Custers 2011).

Larger and more diversified, and thus more representative, sample populations were frequent recommendations (e.g. Deng *et al.* 2020; Gatersleben and Andrews 2013; Hoag *et al.* 2013; Lee *et al.* 2009; Pasanen *et al.* 2018; Ryan *et al.* 2010; van den Berg and Custers 2011). Regarding the participants' diversity, de Brito *et al.* (2019) highlighted the need to include participants from multiple geographical locations and from high-risk groups. Future research with larger and more diverse samples, including with different vulnerable groups, was also suggested (e.g. Deng *et al.* 2020; Silva *et al.* 2018). Authors such as Hinds (2011), Razani *et al.* (2018), and

Silva *et al.* (2018), recommended the inclusion of control groups in future research, with Yi *et al.* (2019) stressing the importance of performing similar interventions, although in a different setting, with the control group. Authors such as Johnson *et al.* (2019), whose study featured an NBI with a duration of 30 min, questioned whether the amount of time spent in nature was sufficient to lead to significant improvements. Therefore, and regarding the nature experiences, the authors recommended that future research should assess the effect of different durations, especially of longer interventions (e.g. Bratman *et al.* 2015b; Gatersleben and Andrews 2013; Pasanen *et al.* 2018; Yi *et al.* 2019). Studies assessing the benefits of different types of natural environments, the relevance of environments' key features and links to expected outcomes and specific target audiences were also indicated as a need (e.g. Bratman *et al.* 2015a, Bratman *et al.* 2015b; Gatersleben and Andrews 2013; Silva *et al.* 2018). Regarding the settings, Stigsdotter *et al.* (2017) stressed the importance of more research on how specific urban environments can be beneficial for human health, and de Brito *et al.* (2019) recommended that future research should try to better understand what green environment characteristics most provide beneficial impacts. The use of more adequate and comprehensive measurement instruments, including behavioral and physiological (e.g., Gatersleben and Andrews 2013; Hinds 2011; Pasanen *et al.* 2018); and continuous and follow-up evaluation to assess long-term effects (e.g. Bratman *et al.* 2015a; Hoag *et al.* 2013; Razani *et al.* 2018; Silva *et al.* 2018; van den Berg and Custers 2011) were also highly recommended. Pasanen *et al.* (2018) reinforce the need to integrate qualitative approaches. Bratman *et al.* (2015a) and Marselle *et al.* (2014) also highlighted the need to carefully design experiments that allow for effects to be isolated (e.g. in a green exercise intervention, differentiating the effects of exercise and of being in nature. The role of participants' characteristics (e.g. Bratman *et al.* 2015a), variations in frequency and type of nature experience (e.g. Bratman *et al.* 2015b), and causal mechanisms (e.g. Bratman *et al.* 2015a), were recommended as topics for future research. While group format was perceived as an advantage by several participants (e.g. Maund *et al.* 2019; Silva *et al.* 2018; Wolf and Housley 2017), Johnson *et al.* (2019) stressed that group-based exposure designs should assess the participants' comfort associated with participation in groups. Mutz, Müller, and Göring (2019) stressed that outdoor experiences should have a stronger integration in school curricula; and would be more available for adolescents from disadvantaged backgrounds.

6. Discussion

With the majority of the world's population living in urban areas, the increasing detachment from the natural world may be negatively impacting several dimensions of human life and well-being, as well as levels of engagement with pro-environmental initiatives and behaviors (Capaldi *et al.* 2015; Martin *et al.* 2020; Nisbet and Zelenski 2013; Twohig-Bennett and Jones 2018). Thus, for both public health and nature conservation, the "extinction of experience" is one of the major obstacles to overcome (Soga *et al.* 2018).

Since 2020, the pandemic by SARS-COV-2 (COVID-19) has caused profound impacts on all dimensions of human life, including mobility patterns, overall physical and psychological health, and social interactions and behaviour (Bates *et al.* 2020; Chu *et al.* 2020; Kitukutha, Vasa, and Oláh 2021). During the COVID-19 pandemic, nature

was an important predictor, and promotor, of physical and psychological health (e.g. Hubbard *et al.* 2021; Javelle *et al.* 2021; Quarta *et al.* 2022; Poortinga *et al.* 2021; Robinson *et al.* 2021). In the aftermath of this pandemic, understanding the role of nature on human well-being and how it can be used to mitigate the negative impacts of the COVID-19 pandemic has gained renewed importance.

This review focused on studies that assessed the impact of outdoor nature on human well-being, identifying 38 relevant studies that reported a plethora of psychological, physiological and nature interaction outcomes. Overall, the evidence strongly suggests that outdoor nature has a significant beneficial impact on human well-being, leading, for example, to improved mental health and cognitive function, positive mood states, and reduced levels of stress. Nature-based interventions (NBIs) seem to be beneficial to both subjective and psychological well-being, contributing, for example, to an increase in positive emotions and life satisfaction (e.g. Anderson, Monroy, and Keltner 2018), as well as to an improvement in personal psychological and social functioning (e.g. Hoag *et al.* 2013).

The studies' results relate to the theories proposed by Kaplan and Kaplan (ART; 1989) and Ulrich (SRT; 1981, 1983, 1984), stressing the restorative potential of natural environments through attention fatigue restoration processes and by reducing stress levels. Qualitative and quantitative results emphasize how nature experiences have led to increased levels of attention and fascination (e.g. Pasanen *et al.* 2018; Silva *et al.* 2018). Stress reduction was shown not only through perceived stress levels (e.g. Anderson, Monroy, and Keltner 2018; Koselka *et al.* 2019), but also in the analysis of psychological parameters as salivary cortisol (e.g. Lee *et al.* 2009; Razani *et al.* 2018).

The findings from the studies included provide relevant information for the development of programs and activities aiming to promote human well-being through access to nature-derived benefits. The type of environment, the type of contact, and activities performed are aspects that influence the effect of contact with nature on human well-being.

6.1. Nature settings: environments and relevant features

Regarding the comparison of different environments, the data suggest that i) natural environments are significantly more restorative than urban environments (e.g. Bratman *et al.* 2015a; Bratman *et al.* 2015b; de Brito *et al.* 2019; Koselka *et al.* 2019), ii) natural environments with high levels of prospect and low levels of refuge are restorative, while exposure to environments with low levels of prospect and high levels of refuge may increase stress and attention fatigue levels (e.g., Gatersleben and Andrews 2013), an idea also reinforced by Deng *et al.* (2020), who defended that a topography landscape type, with balanced levels of prospect and refuge, has higher restorative benefits; and that iii) older forests have more restorative benefits than younger ones (e.g. Simkin, Ojala, and Tyrväinen 2020). Natural areas with an appealing natural beauty, high biodiversity and water features, as well as with high levels of prospect and low levels of refuge seem to be more effective in promoting human well-being (e.g. Deng *et al.* 2020; Gatersleben and Andrews 2013; Silva *et al.* 2018). Areas with reduced human influence appear to be more beneficial to both human well-being and CWN. As Hailwood (2014) stated, a thoughtful immersion with nature in places where human influence is less imposing is important to reduce estrangement from non-human nature.

Adding to the type of environment, it is important to take into account its conservation status and quality, as encounters with nature with perceivable degrees of degradation or destruction may have negative effects (e.g. sadness, anger, fear; Martin *et al.* 2020; Soga and Gaston 2016).

6.2. Contact with nature: types and duration

In the included studies, contact with nature was intentional, i.e. participants were required to be physically present and have the intention to interact with nature (Keniger *et al.* 2013). This type of interaction appears to be more beneficial than, for example, incidental interactions that may occur through incidental contact with neighborhood greenspace (Martin *et al.* 2020). Spending time in nature also seems to be relevant for a stronger connection and engagement with the natural world, and for the development of pro-environmental behaviors (e.g. Howell *et al.* 2011; Nisbet, Zelenski, and Murphy 2011). More recently, Martin *et al.* (2020) also found positive associations between nature connectedness and pro-environmental behaviors. These findings are in accordance with the results of the studies developed by Razani *et al.* (2018), Silva *et al.* (2018) and Wolf and Housley (2017), which reported significant higher levels of nature affinity, internalized identification with nature, pro-environmental orientation, and environmental concern, respectively. Thus, nature-derived benefits extend beyond direct impact on human well-being, assuming a holistic impact of extreme importance for the development of healthier and sustainable societies (Ives *et al.* 2017).

Studies that assess the impact of long-term continuous contact with nature are quite scarce and the information regarding effective duration and frequency of contact are sparse and not unanimous. Whereas White *et al.* (2019) suggested 120 min as a threshold below which contact with nature was not sufficient to produce significant benefits. A review by Meredith *et al.* (2020) concluded that time in nature has a positive effect on several aspects of well-being and that benefits can be felt with 10-20 min of sitting or walking in a vast array of nature settings. In the included studies, benefits are reported in interventions as brief as 2 min (Olszewska-Guizzo *et al.* 2020), but there is no information regarding how long the identified positive effects remain. The same limitation is present in the study by Johnson *et al.* (2019). The authors concluded that a 30-40 min exposure to nature would be beneficial, while alerting to the need for increasing time in nature, but no information about the durability of the beneficial effects is provided. The same limitation was identified in the Ibes and Forestell (2022) study, with the authors stating that it was unclear how long the beneficial effects of meditation and spending time outdoors would last.

6.3. Sustainability and social inclusion

The Sustainable Development Goals framework operates through a comprehensive perspective of development, human rights and well-being, and responsible interaction with the natural environment (Silva 2021). The findings of this review reinforce the SDGs' integrative framework, connecting CWN to all dimensions of human well-being and highlighting its importance for nature conservation and vulnerable social groups.

Although there is not a high number of studies that address the impact of NBIs on the well-being of vulnerable populations, in the review by Twohig-Bennett and Jones

(2018) stronger associations were identified between greenspace exposure and health, birth outcomes and morbidity in participants from lower socioeconomic status groups and most deprived areas, as well as in those with under ten years of education. The authors defended that greenspaces may be an important resource in mitigating health inequalities and that developing strategies and interventions for vulnerable groups is needed (Twhig-Bennett and Jones 2018).

In this context, it is important to highlight the studies undertaken by Anderson, Monroy, and Keltner (2018), Hinds (2011) and Silva *et al.* (2018) that reinforced the benefits of nature for vulnerable social groups (e.g. marginalized youth, domestic violence victims), strengthening the importance of including nature as a resource in community intervention projects aiming towards participants' empowerment and capacity to face adverse situations. In the review by Hartig *et al.* (2014), physical activity and social cohesion were highlighted as possible relevant components of nature experiences. These components were also valued by several participants of the studies included in the current review. The results, especially those derived from qualitative evaluation, show that several nature experiences (e.g. green exercise, leisure) appear to be beneficial, especially if performed in group format, and in natural areas with little or no urban features (e.g. Hinds 2011; Silva *et al.* 2018; Wolf and Housley 2017).

6.4. Methodological strengths and weaknesses

Several studies performed randomization processes, control group and/or comparison between different environments. All were longitudinal, with evaluation being performed at, at least, two moments – before and after the trial. While these features may contribute to increase the studies' internal validity, several methodological fragilities were identified, cautioning against the generalization of the results to other contexts.

A pre/post-test design may cause the non-detection of some effects and the absence of post-test effects may not indicate that the NBI had no impact on the assessed variables (Bowler *et al.* 2010). In the study by Hartig *et al.* (2003), measures of blood pressure were taken before and after the trial, but also at 10-minute intervals throughout the experience. Although no significant effect was detected in the post-walk test, there were significant variations in blood pressure during the experience (e.g. significant reduction in systolic blood pressure at the 30-minute mark).

The majority of the studies assessed the effects of occasional activities and short-term effects. There was a very small amount of data regarding continuous interventions and long-term follow-up evaluation. Continuous evaluation was not a prevailing trend, possibly contributing to missing relevant information regarding effects and mediators. According to Frattaroli (2006), follow-up periods are an important moderator of psychological health outcomes. In his review, follow-up periods of less than one month reported larger overall and psychological effect sizes than longer periods, supporting the conclusion that benefits tend to fade after some time (Frattaroli 2006). There are several methods to calculate follow-up periods, which should be determined taking into account the characteristics of the intervention, including duration and participants (Xue *et al.* 2017).

From the participants' perception, structured activities appear to have more benefits, including the reinforcement of the social support network, personal growth, and acquisition of new skills. However, semi-structured activities were present in the majority of studies, with 17 studies assessing only the impact of this typology. Studies

that presented more than one typology did not evaluate a differentiated impact. Semi-structured activities comprise a certain degree of uncertainty as the researcher is not present throughout the majority of the nature-based experience, increasing the probability of missing important information.

As in other reviews (e.g. Bowler *et al.* 2010; Britton *et al.* 2020), we also verified that the description of the settings tends to be rather scarce or even non-existent. Little attention is given to characterize the environment's biodiversity, vegetation coverage, degree of human presence or urban influence, among other features. For example, the term "urban park" includes a wide variety of settings that may be completely different, varying how they are perceived and valued by the public, as well in restorative potential, size and shape (Carrus *et al.* 2015; Schebella *et al.* 2019). Some may be quite large, having spaces where the urban influence is reduced, others may possess water features and/or recreation facilities, while others may not. Researchers also frequently provide an overall description of the natural area but not of the specific route, or path, undertaken by participants. Without a proper description, it is quite difficult to understand features that enhance or mitigate benefits, and these can be important mediators. Although in the majority of cases we were able to classify the settings, it took a great effort, including online research, to learn more about specific projects referred to in some of the studies and have access to photos of the settings. It is important to provide a good description of the intervention's settings in order to allow the comparison of results between studies and to understand which settings, and specific features, are more prone to positively impact human well-being and why. In studies where the participants chose the setting in which the nature experience would take place, it was not clear whether the natural settings selected by the participants were due to their preferences, what could lead to more significant positive results, or, for example, due to easier access/proximity, which could result in a weaker positive impact. The randomized placement of participants in different environments is an important procedure to overcome this limitation, eliminating the possibility of choice (Bowler *et al.* 2010).

6.5. Sources of bias

Three major sources of possible bias, transversal to the majority of the studies, were also identified: geographical location, sample population, and high frequency of self-report measures.

6.5.1. Geographical location

As in the review by Keniger *et al.* (2013), a clear predominance of higher latitudes (North America, especially the USA, and Europe, especially the UK) was observed. The human-nature relationship is quite complex, comprehending a continuous interaction between cultural and biotic systems (Gual and Norgaard 2010; Seymour 2016). As highlighted by Seymour (2016), the human-centered dimensions are determinant in the development of the relationships between individuals and communities with nature. Thus, this relatively narrow geographical provenance of data does not allow for the necessary cross-cultural understanding of the impact of nature on human well-being, and of how human-nature interaction occurs. As Gual and Norgaard (2010, 708) stated, "we urgently need to understand the co-evolutionary character of culture and nature

and incorporate it into our technology and social organization.” Besides limiting a better understanding of cultural effects, bias towards higher latitudes can also be responsible for masking the effect of different ecosystems. In tropical regions, there is greater concern with venomous animals and disease vectors, a characteristic that may cause different responses to spending time in nature (Keniger *et al.* 2013).

6.5.2. Sample population

As most authors pointed out, sample populations were not representative, due to their characteristics and/or dimensions. There was a prevalence of female participants, university students and more nature-oriented people than the general population, as well as of participants aged 16–30 years old. In many cases, participants were volunteers recruited from Facebook groups (e.g. members of nature or Psychology-related groups), universities (e.g. students from Psychology courses), or green exercise programs, which may have led to self-selection bias. Again, the sample population characteristics reduced the possibility of extending the findings to the general population and creates a knowledge gap that needs to be urgently addressed.

6.5.3. Self-reporting measures

Due to the subjective character of well-being, research on this construct has been emphasizing the use of self-reporting measures (Lucas 2018). This emphasis also occurred in the studies analyzed, most of which strongly relied on self-reporting measures. Subjective self-reports are highly dependent on social, cultural and psychological factors, varying according to the respondents’ characteristics (McNabb 1990). Participants’ prior self-beliefs, especially taking into account the type of the participants described above (e.g. more nature-oriented than the general population), may have led to biased answers based, for example, on prior beliefs and not on the actual nature experience. Cervinka, Schwab, and Haluza (2020) and de Brito *et al.* (2019) stressed the lack of physiological measures to support the data gathered through self-reporting measures on outcomes such as anxiety, directed attention, and stress.

During the nature experiences, participants may also have felt internal feelings they could not easily translate into meaningful responses (Lucas 2018). The current level of environmental awareness, or social pressure towards sustainability and nature conservation (even if only at a theoretical level), as well as individual reasons, may have led participants to provide socially desirable answers and to an unwillingness to provide an honest answer (Lucas 2018). Despite the prevalence of self-reporting measures in the analyzed studies, it is important to underline that the majority used at least one objective measure. Furthermore, existing research that provides information regarding the psychometric properties of well-being measures tend to report high levels of reliability and validity (Lucas 2018). Besides the three mentioned possible sources of bias, care is required when explaining the study to enrolled participants, avoiding directing or influencing their opinion. For example, in the study by Razani *et al.* (2018), after enrollment, participants received information about nature and well-being, including a list of benefits of spending time in nature. This could have conditioned the participants’ opinions and perceptions, and, consequently, led to biased results.

6.6. Recommendations

The recommendations and limitations of the studies included are important guidelines that should be taken into account in the planning of NBIs and of their respective impact evaluation plans. This information is already detailed in the results section, but we would like to emphasize the need i) for greater diversity of participants, including vulnerable social groups, ii) to include follow-up evaluation, and iii) to assess the impact of interventions with different durations, especially longer ones. Assessing previous life experiences, although always relevant, assumes increased importance when working with vulnerable social groups, allowing not only a better understanding of mechanisms and mediating factors, but also the planning of more adequate interventions. Further research is required regarding this topic.

Overcoming the main sources of bias is also a priority. There is a pressing need for data for countries other than the USA and the UK, especially from world regions with a concentration of several social and environmental vulnerabilities and whose population is in greater need of interventions that support promoting their well-being. It would be quite important to understand how to structure and implement NBIs aiming towards human well-being in, for example, vulnerable regions of African, Asian and Caribbean countries. Sample selection is also a key issue, with convenience sampling being still the most frequently used sampling method and resulting in non-representative results. We recommend the development of partnerships that promote collaboration among representatives of different areas (e.g. social, health, environmental, planning and governance), ensuring access to different audiences and a stronger dissemination and valorization of research findings. In order to strengthen the (perceived) validity of results, it is essential to complement the use of self-reporting measures with objective measures, thus providing data independent of individuals' perceptions, beliefs and previous life experiences.

More information about the impact of wild and urban natural environments on human well-being is also required, as well about key features that may contribute to potentiate nature-derived benefits. More thorough descriptions of the natural environments should be provided. For larger areas, the specific places where participants performed the activity, or activities, should be specifically described. Along with the identification of specific features (e.g. vegetation coverage, biodiversity – levels, predominant species, water features, human/urban influence), the quality of the natural environments (state of conservation/degradation) should also be reported (Bowler *et al.* 2010). As lack of safety may have a negative influence on the impact of nature on human well-being (Calogiuri and Chroni 2014), safety features and the participants' perception of safety would also be interesting aspects to take into account. Besides characteristics, it would also be important to better understand the reasons for not visiting natural environments and how to address them in order to promote more frequent visits. Calogiuri and Chroni (2014) listed several reasons such as: lack of time, personal barriers (e.g. poor health) and environmental barriers (e.g. traffic, poor lighting, lack of safety, air pollution). Linked to users' perceptions and specific locations, these reasons may present strong variation, requiring updated and specific assessments.

Multidisciplinary approaches should be favored when researching the human-nature relationship, as it comprehends biological/ecological, geographical and human-centered dimensions. Thus, co-operation between biology/ecology, geography, health and social sciences is essential to better establish a holistic overview of this relationship, including pathways, mediators, and effects, and to generate evidence that will benefit not

only human well-being but also the conservation of our planet's natural ecosystem. This resulting symbiotic cycle is determinant for the development of sustainable societies where human well-being is perceived as directly linked with the planet's well-being and actions are taken to ensure both.

It would be important to have more information regarding behavioral aspects in order to understand to what extent participation in an NBI led to changes in the participants' daily behaviors. The assessment of behavioral aspects in follow-up evaluation could help to verify whether, for example, participation in an NBI led to increased levels of intentional contact with nature, development of pro-environmental behaviors, or to higher social participation.

While common preferences can be identified, the way individuals perceive and relate to nature is quite subjective (Nisbet, Zelenski, and Murphy 2009; Moura *et al.* 2017). Due to the subjective character of this relationship and the complexity of the concept of well-being, identifying the mechanisms that mediate individual and collective responses to natural surroundings and stimuli has not been an easy task (Cleary *et al.* 2017; Bowler *et al.* 2010). Although more prone to bias and error, carefully designed observational studies could be relevant to better understand long-term outcomes, associated mechanisms and confounders (McCrindle 2010). Retrospective and prospective observational studies are expensive and time intensive, but allow for the control of multiple confounders, and for the assessment of multiple exposures and outcomes (Thiese 2014). Additionally, and in line with Lucas (2018), we also recommend greater emphasis on the assessment of the psychometric properties of self-reporting measures, as a way to strengthen results and conclusions.

NBIs aiming to promote human well-being should include an awareness component, in order to avoid the reinforcement of an anthropocentric perspective, where natural areas and ecosystems are instrumentalized with the prevalence of a human domineering attitude (Hailwood 2014). Nature interaction parameters such as CWN and pro-environmental attitudes and behaviors should be part of the interventions' goals and evaluation procedures. Neglecting these aspects can lead to further increasing levels of detachment and negatively impact environmental efforts towards sustainability.

Despite growing interest in the relationship between nature and human well-being, there are still several knowledge gaps that are important to overcome. Considering the state of the art about nature and well-being, outlined in this review, we considered that there are relevant topics, especially in the aftermath of a pandemic, that are understudied. Thus, we suggest that future studies deepen research on the impact of contact with nature (outdoor/indoor settings; direct/indirect contact; intentional/incidental exposure) on the i) recovery process of patients with physical and/or psychological conditions that require ongoing treatment, including hospitalized patients for medium to long-term periods; ii) burnout prevention of professionals subjected to high levels of stress, as essential workers (e.g. health and social-care workers; police forces); and iii) sleep quality of different social groups (e.g. students, people suffering from stress and anxiety, essential workers, victims of violence and other potential traumatic experiences). Adding, the generational effect mentioned in the introduction (Chawla 2015) is an alert for the need of further research to deepen knowledge about a possible mediation effect of family/caretakers in children's nature experiences.

Finally, and in line with the recommendations by Chawla (2020) and Dean *et al.* (2018), we also highlight the need for better comprehension of non-positive nature contacts (e.g. degraded environments) and environmental fears. The current scenario of

global environmental changes (GEC) and environmental degradation, as well as the information handled in the media and social networks, makes the research about environmental fears and how to cope with them of the utmost importance. Without guidance, children, adolescents and even adults may cope with these fears through inaction, denial in accepting information regarding GEC and just devote their time and efforts towards other endeavors than environmental preservation and nature conservation, becoming even more detached from nature.

Conclusions

This systematic review aimed to provide a comprehensive overview of the impact of nature, especially outdoor nature, on human well-being. The current body of knowledge firmly recognizes a positive impact, highlighting several nature-derived benefits for psychological, physical and social well-being, including improved mental health, cognitive function and mood states, lower levels of stress, and higher levels of nature connection.

Nevertheless, there are methodological fragilities and information gaps that must still be addressed. Well-tailored interventions, integrating more diverse sample populations, thorough descriptions of the natural environments and weather conditions, and performing long-term follow-up are required. A better understanding of environmental fears, and how to cope with them, and of non-positive contacts with nature is highly important. This information is essential for preventing inaction towards nature conservation and avoidance of contact with nature and to the development of planning efforts aiming to minimize non-positive nature experiences. In the aftermath of a pandemic, and considering the nature-derived benefits to human well-being, studying the impact of contact with nature on the burnout levels of professionals subjected to high levels of stress, and on the recovery process of patients with long-term or chronic health conditions is a priority.

Although there are still several gaps to overcome, the existing evidence is sound enough to validate the integration of nature-based interventions in health and social practices. This would be beneficial not only for these specific fields, but also for nature conservation and public environmental awareness, being essential for the development of sustainable societies.

Disclosure statement

No potential conflict of interest was reported by the authors.

Note

1. Age groups were defined according to the proposal by Yarlagadda *et al.* (2015): child age (0 – 15), young age (16 – 30), middle age (31 – 50), and senior age (>50).

Funding

This study was partially conducted at the Psychology Research Centre (CIPsi), School of Psychology, University of Minho, supported by the Foundation for Science and Technology (FCT) through the Portuguese State Budget (Ref.: UIDB/PSI/01662/2020).

References

- *Anderson, Craig L., Maria Monroy, and Dacher Keltner. 2018. "Awe in Nature Heals: Evidence from Military Veterans, At-Risk Youth, and College Students." *Emotion (Washington, D.C.)* 18 (8): 1195–1202. doi:10.1037/emo0000442.
- Annerstedt, Matilda, and Peter Währborg. 2011. "Nature-Assisted Therapy: Systematic Review of Controlled and Observational Studies." *Scandinavian Journal of Public Health* 39 (4): 371–388. doi:10.1177/1403494810396400.
- *Arbuthnott, Katherine D., and Glenn C. Sutter. 2019. "Songwriting for Nature: Increasing Nature Connection and Well-Being through Musical Creativity." *Environmental Education Research* 25 (9): 1300–1318. doi:10.1080/13504622.2019.1608425.
- Barton, Hugh, and Marcus Grant. 2006. "A Health Map for the Local Human Habitat." *The Journal of the Royal Society for the Promotion of Health* 126 (6): 252–253. doi:10.1177/1466424006070466.
- Bates, Amanda E., Richard B. Primack, Paula Moraga, and Carlos M. Duarte. 2020. "Covid-19 Pandemic and Associated Lockdown as a 'Global Human Confinement Experiment' to Investigate Biodiversity Conservation." *Biological Conservation* 248: 108665. doi:10.1016/j.biocon.2020.108665.
- Beery, Thomas H., Christopher M. Raymond, Marketta Kyttä, Anton Stahl Olafsson, Tobias Plieninger, Mattias Sandberg, Marie Stenseke, Maria Tengö, and K. Ingemar Jönsson. 2017. "Fostering Incidental Experiences of Nature through Green Infrastructure Planning." *Ambio* 46 (7): 717–730. doi:10.1007/s13280-017-0920-z.
- Berck, Peter, Amnon Levy, and Khorshed Chowdhury. 2012. "An Analysis of the World's Environment and Population Dynamics with Varying Carrying Capacity, Concerns and Skepticism." *Ecological Economics* 73: 103–112. doi:10.1016/j.ecolecon.2011.09.019.
- *Berman, Marc G., John Jonides, and Stephen Kaplan. 2008. "The Cognitive Benefits of Interacting with Nature." *Psychological Science* 19 (12): 1207–1212. doi:10.1111/j.1467-9280.2008.02225.x.
- Berto, Rita. 2005. "Exposure to Restorative Environments Helps Restore Attentional Capacity." *Journal of Environmental Psychology* 25 (3): 249–259. doi:10.1016/j.jenvp.2005.07.001.
- Biedenweg, Kelly, Ryan P. Scott, and Tyler A. Scott. 2017. "How Does Engaging with Nature Relate to Life Satisfaction? Demonstrating the Link between Environment-Specific Social Experiences and Life Satisfaction." *Journal of Environmental Psychology* 50: 112–124. doi:10.1016/j.jenvp.2017.02.002.
- Bowler, Diana E., Lisette M. Buyung-Ali, Teri M. Knight, and Andrew S. Pullin. 2010. "A Systematic Review of Evidence for the Added Benefits to Health of Exposure to Natural Environments." *BMC Public Health* 10: 456. doi:10.1186/1471-2458-10-456.
- *Bratman, Gregory N., Gretchen C. Daily, Benjamin J. Levy, and James J. Gross. 2015a. "The Benefits of Nature Experience: Improved Affect and Cognition." *Landscape and Urban Planning* 138: 41–50. doi:10.1016/j.landurbplan.2015.02.005.
- *Bratman, Gregory N., J. Paul Hamilton, Kevin S. Hahn, Gretchen C. Daily, and James J. Gross. 2015b. "Nature Experience Reduces Rumination and Subgenual Prefrontal Cortex Activation." *Proceedings of the National Academy of Sciences of the United States of America* 112 (28): 8567–8572. doi:10.1073/pnas.1510459112.
- Britton, Easkey, Gesche Kindermann, Christine Domegan, and Caitriona Carlin. 2020. "Blue Care: A Systematic Review of Blue Space Interventions for Health and Wellbeing." *Health Promotion International* 35 (1): 50–69. doi:10.1093/heapro/day103.
- Calogiuri, Giovanna, and Stilian Chroni. 2014. "The Impact of the Natural Environment on the Promotion of Active Living: An Integrative Systematic Review." *BMC Public Health* 14: 873. doi:10.1186/1471-2458-14-873.
- Capaldi, Colin, Holli-Anne Passmore, Elizabeth Nisbet, John Zelenski, and Raelyn Dopko. 2015. "Flourishing in Nature: A Review of the Benefits of Connecting with Nature and Its Application as a Wellbeing Intervention." *International Journal of Wellbeing* 5 (4): 1–16. doi:10.5502/ijw.v5i4.449.
- Carrus, Giuseppe, Massimiliano Scopelliti, Raffaele Laforteza, Giuseppe Colangelo, Francesco Ferrini, Fabio Salbitano, Mariagrazia Agrimi, Luigi Portoghesi, Paolo Semenzato, and Giovanni Sanesi. 2015. "Go Greener, Feel Better? The Positive Effects of Biodiversity on

- the Well-Being of Individuals Visiting Urban and Peri-Urban Green Areas.” *Landscape and Urban Planning* 134: 221–228. doi:[10.1016/j.landurbplan.2014.10.022](https://doi.org/10.1016/j.landurbplan.2014.10.022).
- *Cervinka, Renate, Markus Schwab, and Daniela Haluza. 2020. “Investigating the Qualities of a Recreational Forest: Findings from the Cross-Sectional Hallerwald Case Study.” *International Journal of Environmental Research and Public Health* 17 (5): 1676. doi:[10.3390/ijerph17051676](https://doi.org/10.3390/ijerph17051676).
- Chawla, Louise. 2015. “Benefits of Nature Contact for Children.” *Journal of Planning Literature* 30 (4): 433–452. doi:[10.1177/0885412215595441](https://doi.org/10.1177/0885412215595441).
- Chawla, Louise. 2020. “Childhood Nature Connection and Constructive Hope: A Review of Research on Connecting with Nature and Coping with Environmental Loss.” *People and Nature* 2 (3): 619–642. doi:[10.1002/pan3.10128](https://doi.org/10.1002/pan3.10128).
- *Chen, Zheng, Yujia He, and Yuguang Yu. 2020. “Attention Restoration during Environmental Exposure via Alpha-Theta Oscillations and Synchronization.” *Journal of Environmental Psychology* 68: 101406. doi:[10.1016/j.jenvp.2020.101406](https://doi.org/10.1016/j.jenvp.2020.101406).
- Chu, Isaac Yen-Hao, Prima Alam, Heidi J. Larson, and Leesa Lin. 2020. “Social Consequences of Mass Quarantine during Epidemics: A Systematic Review with Implications for the COVID-19 Response.” *Journal of Travel Medicine* 27 (7): taaa192. doi:[10.1093/jtm/taaa192](https://doi.org/10.1093/jtm/taaa192).
- Clatworthy, Jane, Joe Hinds, and Paul M. Camic. 2013. “Gardening as a Mental Health Intervention: A Review.” *Mental Health Review Journal* 18 (4): 214–225. doi:[10.1108/MHRJ-02-2013-0007](https://doi.org/10.1108/MHRJ-02-2013-0007).
- Cleary, Anne, Kelly S. Fielding, Sarah L. Bell, Zoe Murray, and Anne Roiko. 2017. “Exploring Potential Mechanisms Involved in the Relationship between Eudaimonic Wellbeing and Nature Connection.” *Landscape and Urban Planning* 158: 119–128. doi:[10.1016/j.landurbplan.2016.10.003](https://doi.org/10.1016/j.landurbplan.2016.10.003).
- Dallimer, Martin, Katherine N. Irvine, Andrew M. Skinner, Zoe G. Davies, James R. Rouquette, Lorraine L. Maltby, Philip H. Warren, Paul R. Armsworth, and Kevin J. Gaston. 2012. “Biodiversity and the Feel-Good Factor: Understanding Associations between Self-Reported Human Well-Being and Species Richness.” *BioScience* 62 (1): 47–55. doi:[10.1525/bio.2012.62.1.9](https://doi.org/10.1525/bio.2012.62.1.9).
- Dean, Julie, Danielle Shanahan, Robert Bush, Kevin Gaston, Brenda Lin, Elizabeth Barber, Lara Franco, and Richard Fuller. 2018. “Is Nature Relatedness Associated with Better Mental and Physical Health?” *International Journal of Environmental Research and Public Health* 15 (7): 1371. doi:[10.3390/ijerph15071371](https://doi.org/10.3390/ijerph15071371).
- *de Brito, Junia N. de., Zachary C. Pope, Nathan R. Mitchell, Ingrid E. Schneider, Jean M. Larson, Teresa H. Horton, and Mark A. Pereira. 2019. “Changes in Psychological and Cognitive Outcomes after Green versus Suburban Walking: A Pilot Crossover Study.” *International Journal of Environmental Research and Public Health* 16 (16): 2894. doi:[10.3390/ijerph16162894](https://doi.org/10.3390/ijerph16162894).
- *Deng, Li, Xi Li, Hao Luo, Er-Kang Fu, Jun Ma, Ling-Xia Sun, Zhuo Huang, Shi-Zhen Cai, and Yin Jia. 2020. “Empirical Study of Landscape Types, Landscape Elements and Landscape Components of the Urban Park Promoting Physiological and Psychological Restoration.” *Urban Forestry & Urban Greening* 48: 126488. doi:[10.1016/j.ufug.2019.126488](https://doi.org/10.1016/j.ufug.2019.126488).
- *Diessner, Rhett, Destiny Woodward, Shawnee Stacy, and Saman Mobasher. 2015. “Ten Once-a-Week Brief Beauty Walks Increase Appreciation of Natural Beauty.” *Ecopsychology* 7 (3): 126–133. doi:[10.1089/eco.2015.0001](https://doi.org/10.1089/eco.2015.0001).
- Di Nardo, Francesco, Rosella Saulle, and G. Giuseppe La Torre. 2010. “Green Areas and Health Outcomes: A Systematic Review of the Scientific Literature.” *Italian Journal of Public Health* 7 (4): 402–413. doi:[10.2427/5699](https://doi.org/10.2427/5699).
- Fjørtoft, Ingunn. 2004. “Landscape as Playscape: The Effects of Natural Environments on Children’s Play and Motor Development.” *Children, Youth and Environments* 14 (2): 21–44. <http://www.jstor.org/stable/10.7721/chilyoutenvi.14.2.0021>.
- Frattaroli, Joanne. 2006. “Experimental Disclosure and Its Moderators: A Meta-Analysis.” *Psychological Bulletin* 132 (6): 823–865. doi:[10.1037/0033-2909.132.6.823](https://doi.org/10.1037/0033-2909.132.6.823).
- Fuller, R. A., K. N. Irvine, P. Devine-Wright, P. H. Warren, and K. J. Gaston. 2007. “Psychological Benefits of Greenspace Increase with Biodiversity.” *Biology Letters* 3 (4): 390–394. doi:[10.1098/rsbl.2007.0149](https://doi.org/10.1098/rsbl.2007.0149).

- Gascon, Mireia, Margarita Triguero-Mas, David Martínez, Payam Dadvand, Joan Fornés, Antoni Plasència, and Mark Nieuwenhuijsen. 2015. "Mental Health Benefits of Long-Term Exposure to Residential Green and Blue Spaces: A Systematic Review." *International Journal of Environmental Research and Public Health* 12 (4): 4354–4379. doi:10.3390/ijerph120404354.
- Gascon, Mireia, Wilma Zijlema, Cristina Vert, Mathew P. White, and Mark J. Nieuwenhuijsen. 2017. "Outdoor Blue Spaces, Human Health and Well-Being: A Systematic Review of Quantitative Studies." *International Journal of Hygiene and Environmental Health* 220 (8): 1207–1221. doi:10.1016/j.ijheh.2017.08.004.
- *Gatersleben, Birgitta, and Matthew Andrews. 2013. "When Walking in Nature is Not Restorative: The Role of Prospect and Refuge." *Health & Place* 20: 91–101. doi:10.1016/j.healthplace.2013.01.001.
- Gill, Tim. 2014. "The Benefits of Children's Engagement with Nature: A Systematic Literature Review." *Children, Youth and Environments* 24 (2): 10–34. doi:10.7721/chilyoutenvi.24.2.0010.
- Gual, Miguel A., and Richard B. Norgaard. 2010. "Bridging Ecological and Social Systems Coevolution: A Review and Proposal." *Ecological Economics* 69 (4): 707–717. doi:10.1016/j.ecolecon.2008.07.020.
- Hailwood, Simon. 2014. "Estrangement, Nature and 'the Flesh.'" *Ethical Theory and Moral Practice* 17 (1): 71–85. <http://www.jstor.org/stable/24478701>. doi:10.1007/s10677-013-9468-6.
- Hanson, Sarah, and Andy Jones. 2015. "Is There Evidence That Walking Groups Have Health Benefits? A Systematic Review and Meta-Analysis." *British Journal of Sports Medicine* 49 (11): 710–715. doi:10.1136/bjsports-2014-094157.
- *Hartig, Terry, Gary W. Evans, Larry D. Jamner, Deborah S. Davis, and Tommy Gärling. 2003. "Tracking Restoration in Natural and Urban Field Settings." *Journal of Environmental Psychology* 23 (2): 109–123. doi:10.1016/s0272-4944(02)00109-3.
- Hartig, Terry, Richard Mitchell, Sierp de Vries, and Howard Frumkin. 2014. "Nature and Health." *Annual Review of Public Health* 35 (1): 207–228. doi:10.1146/annurev-publhealth-032013-182443.
- Higgins, Julian P. T., James Thomas, Jacqueline Chandler, Miranda Cumpston, Tianjing Li, Matthew J. Page, Vivian A. Welch, eds. 2022. *Cochrane Handbook for Systematic Reviews of Interventions version 6.3 (updated February 2022)*. www.training.cochrane.org/handbook.
- *Hinds, Joe. 2011. "Woodland Adventure for Marginalized Adolescents: Environmental Attitudes, Identity and Competence." *Applied Environmental Education & Communication* 10 (4): 228–237. doi:10.1080/1533015X.2011.669689.
- Hine, Rachel, Carly Wood, Jo Barton, and Jules Pretty. 2011. *The Mental Health and Wellbeing Effects of a Walking and Outdoor Based Therapy Project*. Essex: University of Essex. <http://www.greenexercise.org/pdf/Discovery%20Quest%20Report%202011%20FINAL.pdf>
- *Hitter, Timea, Éva Kállay, Loredana E. Olar, Răzvan Ștefan, Erzsebet Buta, Silvia Chiorean, Maria Cantor, and Ionel Papuc. 2019. "The Effect of Therapeutic Horticulture on Depression and Kynurenine Pathways." *Notulae Botanicae Horti Agrobotanici Cluj-Napoca* 47 (3): 804–812. doi:10.15835/nbha47311544.
- *Hoag, Matthew J., Katie E. Massey, Sean D. Roberts, and Patrick Logan. 2013. "Efficacy of Wilderness Therapy for Young Adults: A First Look." *Residential Treatment for Children & Youth* 30 (4): 294–305. doi:10.1080/0886571X.2013.852452.
- Howell, Andrew J., Raelene L. Dopko, Holli-Anne Passmore, and Karen Buro. 2011. "Nature Connectedness: Associations with Well-Being and Mindfulness." *Personality and Individual Differences* 51 (2): 166–171. doi:10.1016/j.paid.2011.03.037.
- Hubbard, Gill, Chantal den Daas, Marie Johnston, Peter Murchie, Catharine Ward Thompson, and Diane Dixon. 2021. "Are Rurality, Area Deprivation, Access to Outside Space, and Green Space Associated with Mental Health during the COVID-19 Pandemic? A Cross Sectional Study (Charis-E)." *International Journal of Environmental Research and Public Health* 18 (8): 3869. doi:10.3390/ijerph18083869.
- *Ibes, Dorothy C., and Catherine A. Forestell. 2022. "The Role of Campus Greenspace and Meditation on College Students' Mood Disturbance." *Journal of American College Health : J of ACH* 70 (1): 99–106. doi:10.1080/07448481.2020.1726926.
- *Irvine, Katherine N., Melissa R. Marselle, Alan Melrose, and Sara L. Warber. 2020. "Group Outdoor Health Walks Using Activity Trackers: Measurement and Implementation Insight

- from a Mixed Methods Feasibility Study.” *International Journal of Environmental Research and Public Health* 17 (7): 2515. doi:[10.3390/ijerph17072515](https://doi.org/10.3390/ijerph17072515).
- Ives, Christopher D., Matteo Giusti, Joern Fischer, David J. Abson, Kathleen Klaniecki, Christian Dorninger, Josefine Laudan, et al. 2017. “Human–Nature Connection: A Multidisciplinary Review.” *Current Opinion in Environmental Sustainability* 26–27: 106–113. doi:[10.1016/j.cosust.2017.05.005](https://doi.org/10.1016/j.cosust.2017.05.005).
- Javelle, Florian, Sylvain Laborde, Thomas Jean Hosang, Alan James Metcalfe, and Philipp Zimmer. 2021. “The Importance of Nature Exposure and Physical Activity for Psychological Health and Stress Perception: Evidence from the First Lockdown Period during the Coronavirus Pandemic 2020 in France and Germany.” *Frontiers in Psychology* 12: 623946. doi:[10.3389/fpsyg.2021.623946](https://doi.org/10.3389/fpsyg.2021.623946).
- *Jeon, Jin Young, Pong Sik Yeon, and Won Sop Shin. 2018. “The Influence of Indirect Nature Experience on Human System.” *Forest Science and Technology* 14 (1): 29–32. doi:[10.1080/21580103.2017.1420701](https://doi.org/10.1080/21580103.2017.1420701).
- *Johnson, Shannon A., Stephanie Snow, Michael A. Lawrence, and Daniel G. Rainham. 2019. “Quasi-Randomized Trial of Contact with Nature and Effects on Attention in Children.” *Frontiers in Psychology* 10: 2652. doi:[10.3389/fpsyg.2019.02652](https://doi.org/10.3389/fpsyg.2019.02652).
- Kaplan, Rachel, and Stephen Kaplan. 1989. *The Experience of Nature: A Psychological Perspective*. Cambridge: Cambridge University Press.
- Kaplan, Stephen. 2001. “Meditation, Restoration and the Management of Mental Fatigue.” *Environment and Behavior* 33 (4): 480–506. doi:[10.1177/00139160121973106](https://doi.org/10.1177/00139160121973106).
- Kellert, Stephen R. 2002. “Experiencing Nature: Affective, Cognitive, and Evaluative Development in Children.” In *Children and Nature: Psychological, Sociocultural, and Evolutionary Investigations*, edited by P. H. Kahn, Jr. and S. R. Kellert, 117–151. Cambridge, MA: MIT Press.
- Keniger, Lucy, Kevin Gaston, Katherine Irvine, and Richard Fuller. 2013. “What Are the Benefits of Interacting with Nature?” *International Journal of Environmental Research and Public Health* 10 (3): 913–935. doi:[10.3390/ijerph10030913](https://doi.org/10.3390/ijerph10030913).
- Keyes, Corey L. M., Dov Shmotkin, and Carol D. Ryff. 2002. “Optimizing Well-Being: The Empirical Encounter of Two Traditions.” *Journal of Personality and Social Psychology* 82 (6): 1007–1022. doi:[10.1037//0022-3514.82.6.1007](https://doi.org/10.1037//0022-3514.82.6.1007).
- Kingsley, Jonathan ‘Yoti’, and Mardie Townsed. 2006. ‘Dig in’ to Social Capital: Community Gardens as Mechanisms for Growing Urban Social Connectedness.” *Urban Policy and Research* 24 (4): 525–537. doi:[10.1080/08111140601035200](https://doi.org/10.1080/08111140601035200).
- Kitukutha, Nicodemus M., László Vasa, and Judit Oláh. 2021. “The Impact of COVID-19 on the Economy and Sustainable e-Commerce.” *Forum Scientiae Oeconomia* 9 (2): 47–72. doi:[10.23762/FSO_VOL9_NO2_3](https://doi.org/10.23762/FSO_VOL9_NO2_3).
- *Koselka, Elizabeth P. D., Lucy C. Weidner, Arseniy Minasov, Marc G. Berman, William R. Leonard, Marianne V. Santoso, Junia N. de Brito, Zachary C. Pope, Mark A. Pereira, and Teresa H. Horton. 2019. “Walking Green: Developing an Evidence Base for Nature Prescriptions.” *International Journal of Environmental Research and Public Health* 16 (22): 4338. doi:[10.3390/ijerph16224338](https://doi.org/10.3390/ijerph16224338).
- Kuo, Frances E., and William C. Sullivan. 2001a. “Environment and Crime in the Inner City.” *Environment & Behavior* 33 (3): 343–367. doi:[10.1177/0013916501333002](https://doi.org/10.1177/0013916501333002).
- Kuo, Frances E., and William C. Sullivan. 2001b. “Aggression and Violence in the Inner City: Effects of Environment via Mental Fatigue.” *Environment and Behavior* 33 (4): 543–571. doi:[10.1177/00139160121973124](https://doi.org/10.1177/00139160121973124).
- Lachowycz, K., and A. P. Jones. 2011. “Greenspace and Obesity: A Systematic Review of the Evidence.” *Obesity Reviews: An Official Journal of the International Association for the Study of Obesity* 12 (5): E 183–e189. doi:[10.1111/j.1467-789x.2010.00827.x](https://doi.org/10.1111/j.1467-789x.2010.00827.x).
- Lackey, Nancy Qwynne, Deborah A. Tysor, G. David McNay, Leah Joyner, Kensey H. Baker, and Camilla Hodge. 2021. “Mental Health Benefits of Nature-Based Recreation: A Systematic Review.” *Annals of Leisure Research* 24 (3): 379–393. doi:[10.1080/11745398.2019.1655459](https://doi.org/10.1080/11745398.2019.1655459).
- Larson, L., E. Bowers, and L. Stephens. 2017. “Connection to Nature and Positive Youth Development.” Paper Presented at Pathways 2017: Integrating Human Dimensions into Fisheries and Wildlife Management, Estes Park, November, 17–20.
- *Lee, Juyoung, Bum-Jin Park, Yuko Tsunetsugu, Takahide Kagawa, and Yoshifumi Miyazaki. 2009. “Restorative Effects of Viewing Real Forest Landscapes, Based on a Comparison with

- Urban Landscapes.” *Scandinavian Journal of Forest Research* 24 (3): 227–234. doi:10.1080/02827580902903341.
- *Lee, Ju-hyoung, Ji-sook Park, and Sunnam Choi. 2020. “Environmental Influence in the Forested Area toward Human Health: Incorporating the Ecological Environment into Art Psychotherapy.” *Journal of Mountain Science* 17 (4): 992–1000. doi:10.1007/s11629-019-5774-3.
- Liberati, Alessandro, Douglas G. Altman, Jennifer Tetzlaff, Cynthia Mulrow, Peter C. Gøtzsche, John P. Ioannidis, Mike Clarke, P. J. Devereaux, Jos Kleijnen, and David Moher. 2009. “The PRISMA Statement for Reporting Systematic Reviews and Meta-Analyses of Studies That Evaluate Health Care Interventions: Explanation and Elaboration.” *PLoS Medicine* 6 (7): E 1000100. doi:10.1371/journal.pmed.1000100.
- Lovell, Rebecca, Benedict W. Wheeler, Sahran L. Higgins, Katherine N. Irvine, and Michael H. Depledge. 2014. “A Systematic Review of the Health and Well-Being Benefits of Biodiverse Environments.” *Journal of Toxicology and Environmental Health. Part B, Critical Reviews* 17 (1): 1–20. doi:10.1080/10937404.2013.856361.
- Lucas, R. E. 2018. “Reevaluating the Strengths and Weaknesses of Self-Report Measures of Subjective Well-Being.” In *Handbook of Well-Being*, edited by E. Diener, S. Oishi, and L. Tay. Salt Lake City, UT: DEF Publishers.
- Maas, Jolanda, Peter Spreeuwenberg, Marijke van Winsum-Westra, Robert A. Verheij, Sjerp Vries, and Peter P. Groenewegen. 2009. “Is Green Space in the Living Environment Associated with People’s Feelings of Social Safety?” *Environment and Planning A: Economy and Space* 41 (7): 1763–1777. doi:10.1068/a4196.
- Maller, Cecily, Mardie Townsend, Anita Pryor, Peter Brown, and Lawrence St Leger. 2006. “Healthy Nature Healthy People: ‘Contact with Nature’ as an Upstream Health Promotion Intervention for Populations.” *Health Promotion International* 21 (1): 45–54. doi:10.1093/heapro/dai032.
- Maller, C., M. Townsend, L. Leger, C. Henderson-Wilson, A. Pryor, L. Prosser, and M. Moore. 2009. “Healthy Parks, Healthy People: The Health Benefits of Contact with Nature in a Park Context.” *The George Wright Forum* 26 (2): 51–83. <http://www.georgewright.org/262maller.pdf>.
- *Marselle, Melissa, Katherine Irvine, Altea Lorenzo-Arribas, and Sara Warber. 2014. “Moving beyond Green: Exploring the Relationship of Environment Type and Indicators of Perceived Environmental Quality on Emotional Well-Being following Group Walks.” *International Journal of Environmental Research and Public Health* 12 (1): 106–130. doi:10.3390/ijerph120100106.
- Martin, Leanne, Mathew P. White, Anne Hunt, Miles Richardson, Sabine Pahl, and Jim Burt. 2020. “Nature Contact, Nature Connectedness and Associations with Health, Wellbeing and pro-Environmental Behaviours.” *Journal of Environmental Psychology* 68: 101389. doi:10.1016/j.jenvp.2020.101389.
- *Maund, Phoebe R., Katherine N. Irvine, Jonathan Emily Reeves, Emily Strong, Ruth Cromie, Martin Dallimer, and Zoe G. Davies. 2019. “Wetlands for Wellbeing: Piloting a Nature-Based Health Intervention for the Management of Anxiety and Depression.” *International Journal of Environmental Research and Public Health* 16 (22): 4413. doi:10.3390/ijerph16224413.
- Mausner, Claudia. 1996. “A Kaleidoscope Model: Defining Natural Environments.” *Journal of Environmental Psychology* 16 (4): 335–348. doi:10.1006/jevp.1996.0028.
- Mayer, F. Stephan, and Cynthia McPherson Frantz. 2004. “The Connectedness to Nature Scale: A Measure of Individuals’ Feeling in Community with Nature.” *Journal of Environmental Psychology* 24 (4): 503–515. doi:10.1016/j.jenvp.2004.10.001.
- McCordle, Brian W. 2010. “Description and Analysis of Data, and Critical Appraisal of the Literature.” Chap. 21 in *Paediatric Cardiology*, edited by Robert H. Anderson, Edward J. Baker, Daniel J. Penny, Andrew N. Redington, Michael L. Rigby, Gil Wernovsky, Gemma Price, 437–459. Philadelphia, PA: Churchill Livingstone.
- McNabb, Steven. 1990. “Self-Reports in Cross-Cultural Contexts.” *Human Organization* 49 (4): 291–299. doi:10.17730/humo.49.4.p26p4u58nmn44054.
- McKinnon, Madeleine C., Samantha H. Cheng, Samuel Dupre, Janet Edmond, Ruth Garside, Louise Glew, Margaret B. Holland, et al. 2016. “What Are the Effects of Nature Conservation on Human Well-Being? A Systematic Map of Empirical Evidence from Developing Countries.” *Environmental Evidence* 5: 8. doi:10.1186/s13750-016-0058-7.

- Meredith, Genevive R., Donald A. Rakow, Erin R. Eldermire, Cecelia G. Madsen, Steven P. Shelley, and Naomi A. Sachs. 2020. "Minimum Time Dose in Nature to Positively Impact the Mental Health of College-Aged Students, and How to Measure It: A Scoping Review." *Frontiers in Psychology* 10: 2942. doi:10.3389/fpsyg.2019.02942.
- Millennium Ecosystem Assessment. 2005. *Ecosystems and Human Well-Being: Synthesis*. Washington, DC: Island Press. <http://www.millenniumassessment.org/documents/document.356.aspx.pdf>
- Moher, David, Alessandro Liberati, Jennifer Tetzlaff, and Douglas G. Altman. 2009. "Preferred Reporting Items for Systematic Reviews and Meta-Analyses: The PRISMA Statement." *PLoS Medicine* 6 (7): e1000097. doi:10.1371/journal.pmed.1000097.
- Moura, Joelson Moreno Brito, Washington Soares Ferreira Júnior, Taline Cristina da Silva, and Ulysses Paulino Albuquerque. 2017. "Landscapes Preferences in the Human Species: Insights for Ethnobiology from Evolutionary Psychology." *Ethnobiology and Conservation* 6 (10): 1–7. doi:10.15451/ec2017-07-6.10-1-7.
- *Mutz, Michael, Johannes Müller, and Arne Göring. 2019. "Outdoor Adventures and Adolescents' Mental Health: Daily Screen Time as a Moderator of Changes." *Journal of Adventure Education and Outdoor Learning* 19 (1): 56–66. doi:10.1080/14729679.2018.1507830.
- Mygind, Lærke, Mette Kurtzhals, Clare Nowell, Paulina S. Melby, Matt P. Stevenson, Mark Nieuwenhuijsen, Jarrad A. G. Lum, Trine Flensburg-Madsen, Peter Bentsen, and Peter G. Enticott. 2021. "Landscapes of Becoming Social: A Systematic Review of Evidence for Associations and Pathways between Interactions with Nature and Socioemotional Development in Children." *Environment International* 146: 106238. doi:10.1016/j.envint.2020.106238.
- Ng, E. C., and A. T. Fisher. 2013. "Understanding Well-Being in Multi-Levels: A Review." *Health, Culture and Society* 5 (1): 308–323. doi:10.5195/hcs.2013.142.
- Nisbet, Elizabeth K., John M. Zelenski, and Steven A. Murphy. 2009. "The Nature Relatedness Scale." *Environment and Behavior* 41 (5): 715–740. doi:10.1177/0013916508318748.
- Nisbet, Elizabeth K., John M. Zelenski, and Steven A. Murphy. 2011. "Happiness is in Our Nature: Exploring Nature Relatedness as a Contributor to Subjective Well-Being." *Journal of Happiness Studies* 12 (2): 303–322. doi:10.1007/s10902-010-9197-7.
- Nisbet, Elizabeth K., and John M. Zelenski. 2013. "The NR-6: A New Brief Measure of Nature Relatedness." *Frontiers in Psychology* 4: 813. doi:10.3389/fpsyg.2013.00813.
- Ohly, Heather, Mathew P. White, Benedict W. Wheeler, Alison Bethel, Obioha C. Ukoumunne, Vasilis Nikolaou, and Ruth Garside. 2016. "Attention Restoration Theory: A Systematic Review of the Attention Restoration Potential of Exposure to Natural Environments." *Journal of Toxicology and Environmental Health. Part B, Critical Reviews* 19 (7): 305–343. doi:10.1080/10937404.2016.1196155.
- *Olszewska-Guizzo, Agnieszka, Angelia Sia, Anna Fogel, and Roger Ho. 2020. "Can Exposure to Certain Urban Green Spaces Trigger Frontal Alpha Asymmetry in the Brain?: Preliminary Findings from a Passive Task EEG Study." *International Journal of Environmental Research and Public Health* 17 (2): 394. doi:10.3390/ijerph17020394.
- *Pasanen, Tytti, Katherine Johnson, Kate Lee, and Kalevi Korpela. 2018. "Can Nature Walks with Psychological Tasks Improve Mood, Self-Reported Restoration, and Sustained Attention? Results from Two Experimental Field Studies." *Frontiers in Psychology* 9: 2057. doi:10.3389/fpsyg.2018.02057.
- Pedretti-Burls, Ambra. 2007. "Ecotherapy: A Therapeutic and Educative Model." *Journal of Mediterranean Ecology* 8: 19–25.
- Piccininni, Caroline, Valerie Michaelson, Ian Janssen, and William Pickett. 2018. "Outdoor Play and Nature Connectedness as Potential Correlates of Internalized Mental Health Symptoms among Canadian Adolescents." *Preventive Medicine* 112: 168–175. doi:10.1016/j.ypmed.2018.04.020.
- Poortinga, Wouter, Natasha Bird, Britt Hallingberg, Rhiannon Phillips, and Denitza Williams. 2021. "The Role of Perceived Public and Private Green Space in Subjective Health and Wellbeing during and after the First Peak of the COVID-19 Outbreak." *Landscape and Urban Planning* 211: 104092. doi:10.1016/j.landurbplan.2021.104092.
- Pretty, Jules, Murray Griffin, Martin Sellens, and Chris Pretty. 2003. "Green Exercise: Complementary Role of Nature, Exercise and Diet in Physical and Emotional Wellbeing and

- Implications for Public Health Policy.” Occasional Papers: 2003-1, Centre for Environment and Society, University of Essex.
- *Pretty, J., J. Peacock, R. Hine, M. Sellens, N. South, and M. Griffin. 2007. “Green Exercise in the UK Countryside: Effects on Health and Psychological Well-Being, and Implications for Policy and Planning.” *Journal of Environmental Planning and Management* 50 (2): 211–231. doi:[10.1080/09640560601156466](https://doi.org/10.1080/09640560601156466).
- Pyle, Robert Michael. 1993. *The Thunder Tree: Lessons from an Urban Wildland*. Boston, MA: Houghton Mifflin.
- Quarta, Stefano, Annalisa Levante, María-Teresa García-Conesa, Flavia Lecciso, Egeria Scoditti, Maria Annunziata Carluccio, Nadia Calabriso, et al. 2022. “Assessment of Subjective Well-Being in a Cohort of University Students and Staff Members: Association with Physical Activity and Outdoor Leisure Time during the COVID-19 Pandemic.” *International Journal of Environmental Research and Public Health* 19 (8): 4787. doi:[10.3390/ijerph19084787](https://doi.org/10.3390/ijerph19084787).
- Raney, Marcella A., Colette F. Hendry, and Samantha A. Yee. 2019. “Physical Activity and Social Behaviors of Urban Children in Green Playgrounds.” *American Journal of Preventive Medicine* 56 (4): 522–529. doi:[10.1016/j.amepre.2018.11.004](https://doi.org/10.1016/j.amepre.2018.11.004).
- Ray, Heather, and Sonya L. Jakubec. 2014. “Nature-Based Experiences and Health Cancer Survivors.” *Complementary Therapies in Clinical Practice* 20 (4): 188–192. doi:[10.1016/j.ctcp.2014.005](https://doi.org/10.1016/j.ctcp.2014.005).
- *Razani, Nooshin, Saam Morshed, Michael A. Kohn, Nancy M. Wells, Doug Thompson, Maoya Alqassari, Amaka Agodi, and George W. Rutherford. 2018. “Effect of Park Prescriptions with and without Group Visits to Parks on Stress Reduction in Low-Income Parents: SHINE Randomized Trial.” *PloS One* 13 (2): e0192921. doi:[10.1371/journal.pone.0192921](https://doi.org/10.1371/journal.pone.0192921).
- Renner, Michael. 2015. “The Seeds of Modern Threats.” In *World Watch Institute. State of the World Report 2015: Confronting Hidden Threats to Sustainability*, edited by Lisa Mastny, 3–17. Washington, DC: Island Press.
- Robinson, Jake M., Paul Brindley, Ross Cameron, Danielle MacCarthy, and Anna Jorgensen. 2021. “Nature’s Role in Supporting Health during the COVID-19 Pandemic: A Geospatial and Socioecological Study.” *International Journal of Environmental Research and Public Health* 18 (5): 2227. doi:[10.3390/ijerph18052227](https://doi.org/10.3390/ijerph18052227).
- Ryan, Richard M., and Edward L. Deci. 2001. “On Happiness and Human Potentials: A Review of Research on Hedonic and Eudaimonic Well-Being.” *Annual Review of Psychology* 52 (1): 141–166. doi:[10.1146/annurev.psych.52.1.141](https://doi.org/10.1146/annurev.psych.52.1.141).
- *Ryan, Richard M., Netta Weinstein, Jessey Bernstein, Kirk Warren Brown, Louis Mistretta, and Marylène Gagné. 2010. “Vitalizing Effects of Being Outdoors and in Nature.” *Journal of Environmental Psychology* 30 (2): 159–168. doi:[10.1016/j.jenvp.2009.10.009](https://doi.org/10.1016/j.jenvp.2009.10.009).
- Schebella, Morgan, Delene Weber, Lisa Schultz, and Philip Weinstein. 2019. “The Wellbeing Benefits Associated with Perceived and Measured Biodiversity in Australian Urban Green Spaces.” *Sustainability* 11 (3): 802. doi:[10.3390/su11030802](https://doi.org/10.3390/su11030802).
- Schultz, P. Wesley. 2001. “The Structure of Environmental Concern: Concern for Self, Other People, and the Biosphere.” *Journal of Environmental Psychology* 21 (4): 327–339. doi:[10.1006/jevps.2001.0227](https://doi.org/10.1006/jevps.2001.0227).
- Scopelliti, M., G. Carrus, C. Adinolfi, G. Suarez, G. Colangelo, R. Laforteza, A. Panno, and G. Sanesi. 2016. “Staying in Touch with Nature and Well-Being in Different Income Groups: The Experience of Urban Parks in Bogotá.” *Landscape and Urban Planning* 148: 139–148. doi:[10.1016/j.landurbplan.2015.11.002](https://doi.org/10.1016/j.landurbplan.2015.11.002).
- Seymour, Valentine. 2016. “The Human–Nature Relationship and Its Impact on Health: A Critical Review.” *Frontiers in Public Health* 4: 260. doi:[10.3389/fpubh.2016.00260](https://doi.org/10.3389/fpubh.2016.00260).
- Shanahan, Danielle, Thomas Astell–Burt, Elizabeth Barber, Eric Brymer, Daniel Cox, Julie Dean, Michael Depledge, et al. 2019. “Nature–Based Interventions for Improving Health and Wellbeing: The Purpose, the People and the Outcomes.” *Sports* 7 (6): 141. doi:[10.3390/sports7060141](https://doi.org/10.3390/sports7060141).
- Sheldrake, Richard, Ruth Amos, and Michael J. Reiss. 2019. *Children and Nature: A Research Evaluation for the Wildlife Trusts*. Newark: The Wildlife Trusts.
- Shin, Won Sop., Chang Seob Shin, Pounng Sik Yeoun, and Jae Joon Kim. 2011. “The Influence of Interaction with Forest on Cognitive Function.” *Scandinavian Journal of Forest Research* 26 (6): 595–598. doi:[10.1080/02827581.2011.585996](https://doi.org/10.1080/02827581.2011.585996).

- *Silva, A., J. Antunes, J. Peixoto, M. Gonçalves, F. Alves, J. Silva, M. Garrido, and M. Matos. 2018. "Domestic Violence: The Impact of a Nature-Based Holistic Development Program on Victims' Well-Being." *Ecopsychology* 10 (3): 158–172. doi:[10.1089/eco.2018.0019](https://doi.org/10.1089/eco.2018.0019).
- Silva, A. 2021. "Towards and Effective Change: A Reflection about the past, Present and Future of Environmental Education." PhD diss., University of Aveiro.
- *Simkin, Jenni, Ann Ojala, and Liisa Tyrväinen. 2020. "Restorative Effects of Mature and Young Commercial Forests, Pristine Old-Growth Forest and Urban Recreation Forest: A Field Experiment." *Urban Forestry & Urban Greening* 48: 126567. doi:[10.1016/j.ufug.2019.126567](https://doi.org/10.1016/j.ufug.2019.126567).
- Smythe, Kathleen R. 2014. "An Historian's Critique of Sustainability." *Culture Unbound* 6 (5): 913–929. doi:[10.3384/cu.2000.1525.146913](https://doi.org/10.3384/cu.2000.1525.146913).
- Sobko, Tanja, Zhenzhen Jia, and Gavin Brown. 2018. "Measuring Connectedness to Nature in Preschool Children in an Urban Setting and Its Relation to Psychological Functioning." *PloS One* 13 (11): e0207057. doi:[10.1371/journal.pone.0207057](https://doi.org/10.1371/journal.pone.0207057).
- Soga, Masashi, and Kevin J. Gaston. 2016. "Extinction of Experience: The Loss of Human-Nature Interactions." *Frontiers in Ecology and the Environment* 14 (2): 94–101. doi:[10.1002/fee.1225](https://doi.org/10.1002/fee.1225).
- Soga, Masashi, Takahiro Yamanoi, Kazuaki Tsuchiya, Tomoyo F. Koyanagi, and Tadashi Kanai. 2018. "What Are the Drivers of and Barriers to Children's Direct Experiences of Nature?" *Landscape and Urban Planning* 180: 114–120. doi:[10.1016/j.landurbplan.2018.08.015](https://doi.org/10.1016/j.landurbplan.2018.08.015).
- *South, Eugenia C., Bernadette C. Hohl, Michelle C. Kondo, John M. MacDonald, and Charles C. Branas. 2018. "Effect of Greening Vacant Land on Mental Health of Community-Dwelling Adults." *JAMA Network Open* 1 (3): e180298. doi:[10.1001/jamanetworkopen.2018.0298](https://doi.org/10.1001/jamanetworkopen.2018.0298).
- Stets, Jan E., and Chris F. Biga. 2003. "Bringing Identity Theory into Environmental Sociology*." *Sociological Theory* 21: 398–423. doi:[10.1046/j.1467-9558.2003.00196.x](https://doi.org/10.1046/j.1467-9558.2003.00196.x).
- *Stigsdotter, Ulrika K., Sus Sola Corazon, Ulrik Sidenius, Jesper Kristiansen, and Patrik Grahn. 2017. "It is Not All Bad for the Grey City: A Crossover Study on Physiological and Psychological Restoration in a Forest and an Urban Environment." *Health & Place* 46: 145–154. doi:[10.1016/j.healthplace.2017.05.007](https://doi.org/10.1016/j.healthplace.2017.05.007).
- Taylor, Andrea Faber, Angela Wiley, Frances E. Kuo, and William C. Sullivan. 1998. "Growing up in the Inner City: Green Spaces as Places to Grow." *Environment and Behavior* 30 (1): 3–27. doi:[10.1177/0013916598301001](https://doi.org/10.1177/0013916598301001).
- Taylor, Eleanor M., Noelle Robertson, Courtney J. Lightfoot, Alice C. Smith, and Ceri R. Jones. 2022. "Nature-Based Interventions for Psychological Wellbeing in Long-Term Conditions: A Systematic Review." *International Journal of Environmental Research and Public Health* 19 (6): 3214. doi:[10.3390/ijerph19063214](https://doi.org/10.3390/ijerph19063214).
- Thiese, Matthew S. 2014. "Observational and Interventional Study Design Types; an Overview." *Biochemia Medica* 24 (2): 199–210. doi:[10.11613/bm.2014.022](https://doi.org/10.11613/bm.2014.022).
- Thomas, B. H., D. Ciliska, M. Dobbins, and S. Micucci. 2004. "A Process for Systematically Reviewing the Literature: Providing the Research Evidence for Public Health Nursing Interventions." *Worldviews on Evidence-Based Nursing* 1 (3): 176–184. doi:[10.1111/j.1524475x.2004.04006.x](https://doi.org/10.1111/j.1524475x.2004.04006.x).
- Thompson Coon, J., K. Boddy, K. Stein, R. Whear, J. Barton, and M. H. Depledge. 2011. "Does Participating in Physical Activity in Outdoor Natural Environments Have a Greater Effect on Physical and Mental Wellbeing than Physical Activity Indoors? A Systematic Review." *Environmental Science & Technology* 45 (5): 1761–1772. doi:[10.1021/es102947t](https://doi.org/10.1021/es102947t).
- Triguero-Mas, Margarita, Christopher J. Gidlow, David Martínez, Jeroen de Bont, Glòria Carrasco-Turigas, Tania Martínez-Íñiguez, Gemma Hurst, et al. 2017. "The Effect of Randomised Exposure to Different Types of Natural Outdoor Environments Compared to Exposure to an Urban Environment on People with Indications of Psychological Distress in Catalonia." *PloS One* 12 (3): e0172200. doi:[10.1371/journal.pone.0172200](https://doi.org/10.1371/journal.pone.0172200).
- Tsunetsugu, Yuko, Bum-Jin Park, Hideki Ishii, Hideki Hirano, Takahide Kagawa, and Yoshifumi Miyazaki. 2007. "Physiological Effects of Shinrin-Yoku (Taking in the Atmosphere of the Forest) in an Old-Growth Broadleaf Forest in Yamagata Prefecture, Japan." *Journal of Physiological Anthropology* 26 (2): 135–142. doi:[10.2114/jpa2.26.135](https://doi.org/10.2114/jpa2.26.135).
- Tsunetsugu, Yuko, Juyoung Lee, Bum-Jin Park, Liisa Tyrväinen, Takahide Kagawa, and Yoshifumi Miyazaki. 2013. "Physiological and Psychological Effects of Viewing Urban

- Forest Landscapes Assessed by Multiple Measurements.” *Landscape and Urban Planning* 113: 90–93. doi:10.1016/j.landurbplan.2013.01.014.
- Twohig-Bennett, Caoimhe, and Andy Jones. 2018. “The Health Benefits of the Great Outdoors: A Systematic Review and Meta-Analysis of Greenspace Exposure and Health Outcomes.” *Environmental Research* 166: 628–637. doi:10.1016/j.envres.2018.06.030.
- Ulrich, Roger S. 1981. “Natural versus Urban Scenes: Some Psychophysiological Effects.” *Environment and Behavior* 13 (5): 523–556. doi:10.1177/0013916581135001.
- Ulrich, Roger S. 1983. “Aesthetic and Affective Response to Natural Environment.” In *Human Behavior and Environment: Advances in Theory and Research, Behavior and the Natural Environment*. Vol 6, edited by I. Altman and J. F Wohlwill, 85–125. New York: Plenum.
- Ulrich, Roger S. 1984. “View through a Window May Influence Recovery from Surgery.” *Science (New York, N.Y.)* 224 (4647): 420–421. doi:10.1126/science.6143402.
- Ulrich, Roger S., Robert F. Simons, Barbara D. Losito, Evelyn Fiorito, Mark A. Miles, and Michael Zelson. 1991. “Stress Recovery during Exposure to Natural and Urban Environments.” *Journal of Environmental Psychology* 11 (3): 201–230. doi:10.1016/s0272-4944(05)80184-7.
- UN General Assembly. 2015. “Transforming Our World: The 2030 Agenda for Sustainable Development, 21 October 2015, A/RES/70/1.” <https://www.refworld.org/docid/57b6e3e44.html>.
- *Van Den Berg, Agnes E., and Mariëtte H. G. Custers. 2011. “Gardening Promotes Neuroendocrine and Affective Restoration from Stress.” *Journal of Health Psychology* 16 (1): 3–11. doi:10.1177/1359105310365577.
- Van den Berg, Agnes E., Anna Jorgensen, and Edward R. Wilson. 2014. “Evaluating Restoration in Urban Green Spaces: Does Setting Type Make a Difference?” *Landscape and Urban Planning* 127: 173–181. doi:10.1016/j.landurbplan.2014.04.012.
- Villeneuve, Paul J., Michael Jerrett, Jason G. Su, Richard T. Burnett, Hong Chen, Amanda J. Wheeler, and Mark S. Goldberg. 2012. “A Cohort Study Relating Urban Green Space with Mortality in Ontario, Canada.” *Environmental Research* 115: 51–58. doi:10.1016/j.envres.2012.03.003.
- Völker, Sebastian, and Thomas Kistemann. 2011. “The Impact of Blue Space on Human Health and Well-Being – Salutogenetic Health Effects of Inland Surface Waters: A Review.” *International Journal of Hygiene and Environmental Health* 214 (6): 449–460. doi:10.1016/j.ijheh.2011.05.001.
- Wells, Nancy M. 2000. “At Home with Nature: The Effects of Nearby Nature on Children’s Cognitive Functioning.” *Environment and Behavior* 32 (6): 775–795. doi:10.1177/00139160021972793.
- White, Mathew P., Ian Alcock, James Grellier, Benedict W. Wheeler, Terry Hartig, Sara L. Warber, Angie Bone, Michael H. Depledge, and Lora E. Fleming. 2019. “Spending at Least 120 Minutes a Week in Nature is Associated with Good Health and Wellbeing.” *Scientific Reports* 9: 7730. doi:10.1038/s41598-019-44097-3.
- WHO. 2006. *Basic Documents*. 45th ed. Geneva: World Health Organization. https://cdn.who.int/media/docs/default-source/documents/publications/basic-documents-constitution-of-who179f0d3d-a613-4760-8801-811dfce250af.pdf?sfvrsn=e8fb384f_1&download=true
- WHO. 2013. *Health and the Environment in the WHO European Region. Creating Resilient Communities and Supportive Environments*. Geneva: World Health Organization - Regional Office for Europe. <https://apps.who.int/iris/handle/10665/350540>
- WHO and UN Habitat. 2016. *Global Report on Urban Health: Equitable, Healthier Cities for Sustainable Development*. Geneva: World Health Organization. <https://apps.who.int/iris/handle/10665/204715>
- *Wolf, Kathleen L., and Elizabeth Housley. 2017. “Young Adult Conservation Jobs and Worker Health.” *Journal of Environmental Planning and Management* 60 (10): 1853–1870. doi:10.1080/09640568.2016.1262833.
- Wolsko, Christopher, Kreg Lindberg, and Ryan Reese. 2019. “Nature-Based Physical Recreation Leads to Psychological Well-Being: Evidence from Five Studies.” *Ecopsychology* 11 (4): 222–235. doi:10.1089/eco.2018.0076.
- Xue, Xiaonan, Ilir Agalliu, Mimi Y. Kim, Tao Wang, Juan Lin, Reza Ghavamian, and Howard D. Strickler. 2017. “New Methods for Estimating Follow-up Rates in Cohort Studies.” *BMC Medical Research Methodology* 17: 155. doi:10.1186/s12874-017-0436-z.

- Yarlagadda, Anuradha, J. V. R. Murthy, and M. H. M. Krishna Prasad. 2015. "A Novel Method for Human Age Group Classification Based on Correlation Fractal Dimension of Facial Edges." *Journal of King Saud University - Computer and Information Sciences* 27 (4): 468–476. doi:[10.1016/j.jksuci.2014.10.005](https://doi.org/10.1016/j.jksuci.2014.10.005).
- *Yi, Jiyune, Boncho Ku, Seul Gee Kim, Taegyu Khil, Youngsuwn Lim, Minja Shin, Sookja Jeon, et al. 2019. "Traditional Korean Medicine-Based Forest Therapy Programs Providing Electrophysiological Benefits for Elderly Individuals." *International Journal of Environmental Research and Public Health* 16 (22): 4325. doi:[10.3390/ijerph16224325](https://doi.org/10.3390/ijerph16224325).
- *Yu, Chia-Pin (Simon), and Hsuan Hsieh. 2020. "Beyond Restorative Benefits: Evaluating the Effect of Forest Therapy on Creativity." *Urban Forestry & Urban Greening* 51: 126670. doi:[10.1016/j.ufug.2020.126670](https://doi.org/10.1016/j.ufug.2020.126670).