Natural Resources for Human Health
eISSN: 2583-1194

Original Research

Received 17 July 2026
Revised 15 Aug 2026
Accepted 27 Aug 2026

Natural Resources for Human Health 2026, Vol. 6 (19s): 1196–1214

KEYWORDS:
nature contact; green space; forest therapy; horticultural therapy; green exercise; randomized controlled trials; scoping review; evidence map; public health.

Human–Nature Interaction Types in Randomized Trials of Health: A Scoping Review and Evidence Map

Abdullah Güngör[1]*, Güney Çetinkaya[2], Alkan Uğurlu[2]

[1]Institute of Social Sciences, Akdeniz University, 07058 Antalya, Türkiye
[2]Institute of Sport Sciences, Akdeniz University, 07058 Antalya, Türkiye; gcetinkaya@akdeniz.edu.tr (G.Ç.); augurlu@akdeniz.edu.tr (A.U.)
*Correspondence: abdullahgngr@gmail.com;
ORCID: A.G. 0000-0002-2021-209X; G.Ç. 0000-0002-1757-5105; A.U. 0000-0002-4828-6285

ABSTRACT: Time in nature is linked to better health, but most evidence is observational and rarely shows what people actually do in nature. We mapped randomized controlled trials (RCTs) of direct nature contact by type of interaction and health domain to guide nature-based health programmes. Following JBI guidance and PRISMA-ScR (protocol on OSF Registries), we searched four databases (October 2026) for English-language RCTs published 2010–2026, re-checked records first excluded on title and abstract against the full text, and screened the reference lists of five earlier reviews. Interventions were coded to seven interaction types and outcomes to six health domains. We included 325 reports of 295 RCTs (about 27,600 participants), 70% published since 2020. Most trials involved active (63%), restorative/therapeutic (32%) or passive (29%) interactions and measured mental (86%) or positive psychological (73%) outcomes; social outcomes appeared in 7%. Wildlife activities were tested in 11 trials and conservation activities in 3. Only 17 trials (6%) tested a mediating mechanism; 46% tested a single session and 87% had no follow-up. Randomized evidence is concentrated in a few interaction types and short-term psychological outcomes. Trials of wildlife and conservation activities, social and longer-term outcomes, under-represented populations and pre-specified mediators are needed.

1. INTRODUCTION

People who spend time in natural environments tend to report less stress, better mood and better general health, and they have a lower risk of several chronic conditions [1-3]. Findings like these have led health services to recommend nature-based activities, ranging from green prescriptions to forest therapy. Two theories are usually invoked to explain the benefits. Stress Reduction Theory describes a rapid affective and physiological recovery in natural settings [4], whereas Attention Restoration Theory focuses on the recovery of directed attention [5].

Markevych et al. later grouped the pathways between green space and health into three domains: reducing harm (air pollution, noise, heat), restoring capacities (attention, stress) and building capacities (physical activity, social cohesion) [6]. Bratman et al. added that the type of nature, the dose and the kind of experience all shape mental health effects [7]. Both frameworks assume that the way a person engages with nature matters. Much of the evidence behind them, however, comes from cross-sectional studies of residential greenness, in which we cannot see what people actually did.

Experiments, in contrast, test defined activities such as forest walks, green exercise, therapeutic horticulture or surf therapy, and several meta-analyses have pooled trials of a single activity [8-11]. Two recent syntheses are closer to our question. Kaleta et al. reviewed 61 systematic reviews and described 13 overlapping categories of nature-based interventions, but they did not map the primary trials [12]. Heinen-Stach et al. limited their review to RCTs and identified 47 trials, all in adults and all with

psychometric mental health outcomes [13]. Neither review used a single theory-based typology of interaction, and neither looked at physical, physiological, cognitive and social outcomes alongside mental health.

Several classifications of nature contact already exist. Keniger et al. distinguished indirect, incidental and intentional interactions and listed the intentional activities (recreation, gardening and farming, conservation volunteering) that produce most benefits [14]. Shanahan et al. separated environment-changing from behaviour-changing nature-based interventions and catalogued 27 intervention types by purpose and target group [15]. Kaleta et al. described 13 overlapping intervention categories, from horticulture and green exercise to environmental volunteerism [12]. These schemes classify programmes or settings; none classifies trials by the kind of interaction a participant has with nature across the full range from viewing to conservation work, and none has been applied systematically to randomized trials.

We therefore developed the Human–Nature Interaction for Health (HNIH) typology for this review. It distinguishes seven types of interaction according to what the person does in nature: passive (viewing, sitting), active (exercise), recreational/adventure, restorative/therapeutic, productive (gardening, farming), wildlife/biodiversity and conservation/participatory. The seven types were derived by grouping the intentional activities of Keniger et al. [14] and the behaviour-changing interventions of Shanahan et al. [15] by the dominant activity of the participant, and each type can be mapped onto the categories of Kaleta et al. (crosswalk in Supplementary File S5, Table S5.6). The typology draws on the pathway domains described above and links the seven types to six health domains and seven candidate mechanisms. It has not been published separately; its definitions and coding rules are given in full in Supplementary File S5 and in the registered protocol.

We are not aware of a review that has mapped RCTs across all ages, all six health domains and a full typology of interaction, including the wildlife and conservation activities that earlier reviews have largely left out. Because our aim was to describe how the evidence is distributed rather than to estimate effects, we chose a scoping review design. [16,17]

We mapped RCTs published between 2010 and 2026 that tested direct contact with real natural environments, organizing them by interaction type and health domain. Our questions were: (1) which interaction types have been tested, and how often; (2) which health domains and measures were used; (3) which populations, settings, doses and comparators were studied; (4) which trials formally tested a mechanism; and (5) where the main gaps lie. The map is intended as a resource for public health practitioners and funders who design or evaluate green and nature prescription programmes and need to know which types of nature contact have randomized evidence behind them.

2. METHODS

2.1 Protocol and reporting

The review followed the JBI methodology for scoping reviews [17] and the framework of Arksey and O'Malley [16] as refined by Levac et al. [18] Reporting follows PRISMA-ScR [19] (checklist in Supplementary File S1). The protocol was registered on OSF Registries after the database searches and before full-text screening; deviations are listed in Section 2.9.

2.2 Eligibility criteria

Eligibility followed the Population–Concept–Context format. We included peer-reviewed RCTs (parallel, crossover or cluster) in humans of any age and health status, published in English from 2010 to 2026, in which the intervention involved direct physical contact with a real natural environment (green or blue space, forest, garden, farm, wildlife or conservation work) and at least one outcome fell within the six HNIH health domains. Trials in which every arm took place in nature (for example, two forest types, or guided versus self-guided walks) were eligible, because they compare kinds of nature contact. We excluded non-randomized, pre-post, observational and qualitative designs; exposures limited to virtual reality, images, sounds or indoor plants; residential greenness or proximity measures; studies without a human health outcome; and reviews, protocols, conference abstracts, theses, books, preprints and commentaries.

2.3 Information sources and search

PubMed (4 October 2026), Web of Science Core Collection (5 October 2026), Scopus (5 October 2026) and SPORTDiscus via EBSCOhost (7–8 October 2026) were searched with one Boolean strategy combining natural-setting terms with activity terms, or named nature-based interventions, and health-outcome terms (Supplementary File S2). Truncation was used for word variants (for example walk*, garden*, hik*). Limits were English language and publication years 2010–2026; for SPORTDiscus

these were applied after export because the export lacked language fields. SciSpace, a semantic search tool, was used as a supplementary source with 162 structured queries. PsycINFO could not be searched because the authors' institution has no subscription. As an additional check on search sensitivity, we screened the reference lists of five earlier reviews of nature-based interventions [8-11,13] (Section 2.5).

2.4 Selection of sources of evidence and the role of the authors

Records were deduplicated by DOI and then by normalized title and year. Title/abstract screening was conducted in two stages. In the first stage every record was classified by document type, study design, type of exposure, interaction type and health domain, with a preliminary decision: 6,013 records (all PubMed and SciSpace records and part of the Web of Science, Scopus and SPORTDiscus records) were classified by a large language model (Claude, Anthropic), and the remaining 5,641 Web of Science and Scopus records by a rule-based keyword classifier that applied the same categories (Supplementary File S5, Section S5.7). This stage acted as a classifier that selected records for human screening; it did not make eligibility decisions. In the second stage one author (AG) screened all records classified as a possible RCT, all records classified as non-randomized or of unclear design whose abstracts mentioned random allocation, and all records excluded on design grounds that nevertheless described an experimental or intervention study with real nature contact and a health outcome (Section 2.5). Records that the classification assigned to clearly ineligible categories were not read individually at this stage; those of experimental, intervention, longitudinal or unclear design (stratum A, Section 2.5) were all re-screened later, whereas reviews, protocols, conference papers, cross-sectional and qualitative studies and proximity-only exposures (stratum B) were checked by sampling only. The sensitivity of the procedure was also estimated with a known-item test against the reference lists of five earlier reviews (Sections 2.5 and 3.1). From that point on, every decision was made by the authors: every full-text report was read and judged by at least one author, and uncertain cases (for example, unclear allocation, borderline nature contact or possible duplicate reports) were discussed by two or more authors until consensus. To check the reliability of the full-text decisions, a second author (GÇ or AU) independently assessed a random sample of 40 full-text reports (20 included, 20 excluded, order shuffled) against the same rules without seeing the first decision; agreement was summarized as observed agreement and Cohen's κ, and all disagreements were resolved by discussion among the three authors. Supplementary File S5 (Table S5.1) sets out, step by step, what the AI tool did and what the authors checked.

To audit the classifier within the human-screened set, the decisions of AG on a random 20% sample of the possible RCTs (n = 56) were compared with the classifier's preliminary decisions. Because almost all sampled records were includes, agreement is reported as observed agreement, Cohen's κ, prevalence-adjusted bias-adjusted κ (PABAK) and Gwet's AC1 [20-23]. This comparison describes how closely the classifier agreed with the author on records it had flagged; it does not estimate how many eligible records it failed to flag, and it is not a measure of agreement between two human reviewers.

Eligibility was judged against pre-specified rules. A trial was considered randomized when the report stated random allocation of participants, clusters or condition order; alternation, allocation by site or preference, counterbalancing without a chance mechanism (for example, a fixed Latin-square rotation), and cluster designs with fewer than two clusters per arm were treated as non-randomized. The authors' own design label did not override an explicit statement of random allocation. Nature contact had to be a core component of at least one arm. Reports of the same trial (same registration, or same authors, site, sample and period) were linked to a primary report so that each trial was counted once; pooled re-analyses of the same multi-site field programme were linked to one another in the same way. Reasons for full-text exclusion were recorded (Supplementary File S4).

2.5 Supplementary design verification, reference-list check and screening-check sample

Because many field experiments describe random allocation, or a random order of conditions, only in the full text, a title/abstract decision of "not randomized" can wrongly remove eligible trials. After the main screening we therefore re-examined 1,169 records from Web of Science, Scopus and SPORTDiscus that had been excluded at title/abstract but described an experimental or intervention study with real nature contact and a health outcome. Each abstract was screened again, and every study with a comparison condition (a separate group or a within-person comparison of settings) whose abstract did not already state a non-random allocation was assessed in full text against the same rules. The reference lists of the five earlier reviews were screened in the same way for eligible RCTs that were not among the exported search results. Finally, the records that the stage-1 classification had removed without human screening (10,210) were divided into stratum A (1,256 records classified as primary empirical studies of experimental, intervention, longitudinal or unclear design without a proximity-only exposure) and stratum B (8,954 records: reviews, protocols, conference papers, cross-sectional and qualitative studies,

proximity-only exposures). A second author (GÇ or AU) first re-screened a stratified random sample of 250 stratum-A and 150 stratum-B records blind to the classifier codes. Because this sample identified eligible trials in stratum A, the remaining 1,006 stratum-A records were then all re-screened by the language model with a deliberately lenient rule (any possible experimental or controlled comparison involving real nature contact and a health outcome), and every flagged record was assessed in full text by an author against the same eligibility rules; eligible trials were added to the review and reports of trials already included were linked to them. Stratum B was not re-screened beyond the sample. All four streams are shown in separate columns of the flow diagram (**Figure 1**).

2.6 Data charting

A standardized charting form with predefined categories was used. For each trial we charted bibliographic details, country, design, sample size, population, intervention (HNIH interaction type, setting, activity, guidance, session length, number of sessions, total duration), comparator, outcomes (health domain, instruments, follow-up), the direction of effect reported by the authors, mechanisms formally tested (M1 restoration, M2 physical activity, M3 physiological, M4 social, M5 nature connectedness, M6 psychological needs, M7 environmental), whether results were reported by population subgroups, and the proportion of women as reported by the authors (primary reports rarely distinguished sex from gender, so we use the authors' terms). The AI tool produced a first draft of the charting record from the full text; an author then checked every field of every included trial against the article and corrected it where needed. Consistent with scoping-review guidance, risk of bias was not assessed.

2.7 Classification

Each intervention was assigned one primary and, where needed, one secondary HNIH interaction type: (1) passive – viewing or sitting in nature; (2) active – walking, running or exercise outdoors; (3) recreational/adventure – camping, surfing, climbing, angling and similar; (4) restorative/therapeutic – structured programs such as forest therapy, horticultural therapy or nature-based therapy; (5) productive – gardening or farming; (6) wildlife/biodiversity – activities centered on animals or species; (7) conservation/participatory – environmental volunteering or citizen science. The primary type was the activity that took up most of the intervention time; a secondary type was added when a second activity was a planned, substantial component (for example, a forest therapy program built around guided walking, coded restorative/therapeutic with active as secondary). We limited coding to two types because programs with three or more components were rare and further codes would have inflated the map. The decision rules and examples of boundary cases are given in Supplementary File S5 (Table S5.2). Outcomes were assigned to mental, positive psychological, physiological, physical, cognitive or social domains.

2.8 Synthesis

Results were summarized descriptively at the level of unique trials, using data from the primary report supplemented by linked reports. An evidence map (heat map) cross-tabulated interaction type by health domain, showing the number of trials in each cell and, in Table 2, the percentage of trials of each type. Effect direction was charted as the authors reported it for the comparison of the nature condition with its comparator on the main outcomes: "beneficial" when the authors reported a benefit on all or most main outcomes, "no difference" when they reported none, "mixed" when results differed across outcomes, time points or comparisons, and "harmful" when the nature condition was worse. Where no primary outcome was named, all outcomes reported as main results were considered. Effect direction describes what the trials reported; it was not used to judge effectiveness, and the number of trials in a cell says nothing about the strength of the evidence. Because crossover trials of brief setting comparisons form a large part of the literature, the map was repeated with parallel-group trials only (Supplementary File S5). Mediation analyses were classified as testing the randomized contrast when the mediator was examined as a pathway from the randomized condition to a health outcome; analyses that pooled arms, used a non-randomized predictor or had a non-health outcome were reported separately.

2.9 Deviations from the protocol and use of artificial intelligence

The deviations from the protocol were as follows. (1) The review restricted the earlier HNIH scope to RCTs to give a higher-certainty map. (2) Registration took place after the searches had been run but before full-text screening. (3) The decision rules on randomization, nature-versus-nature trials and linked reports were written down during full-text screening, before charting, and were applied to all records. (4) The supplementary design verification and the reference-list check were added after the main screening, in response to the possibility that abstracts understate randomization. AI tools assisted with translating search

strings across databases, writing deduplication scripts, the title/abstract pre-screen, locating full texts, and first drafts of eligibility assessments and charting records. In every step the AI output was a suggestion that an author verified; no record was included or excluded, and no data item was charted, on the basis of AI output alone. The authors take full responsibility for the content.

3. RESULTS

3.1 Selection of sources of evidence

The searches identified 19,777 database records (PubMed 2,419; Web of Science 8,413; Scopus 8,628; SPORTDiscus 317) and 907 unique SciSpace records. After removing 9,030 duplicates and records outside the language and date limits, 11,654 unique records were screened, of which 282 were possible RCTs and 274 were sought in full text; 10 could not be retrieved, and of 264 reports assessed, 79 were excluded and 185 included. The supplementary design verification re-examined 1,169 records; 230 were sought in full text, 1 could not be retrieved, 135 were excluded (most often because allocation was not random) and 94 reports were included. The reference-list check identified 13 further eligible reports. In the re-screen of stratum A, the second author's sample of 250 records yielded 40 possibly eligible records, of which 3 proved eligible in full text; none of the 150 stratum-B records was eligible (one-sided 97.5% upper bound 2.5%). The language-model re-screen of the remaining 1,006 stratum-A records flagged 176 records; after the full texts that were initially inaccessible had been obtained through institutional access, 145 were excluded in full text (most often because allocation was not random), 30 were eligible and 1 could not be retrieved. Together the re-screen added 33 eligible reports: 29 trials not previously identified and 4 further reports of trials already included (pooled re-analyses of the Japanese forest field experiments, a secondary analysis of the surf-versus-hike trial and a pooled analysis that includes an included park-walk trial). Almost all of the newly identified trials were PubMed-only records, which the supplementary design verification had not covered. In total, 325 reports describing 295 unique RCTs were included (**Figure 1**); 30 reports were secondary or companion publications of 17 trials. Reasons for exclusion are given in **Figure 1** and Supplementary File S4. In the dual full-text check, the two authors agreed on 31 of 40 reports (77.5%; $\varkappa = 0.55$); all 9 disagreements concerned reports already flagged as borderline at the first assessment (alternation or quasi-random allocation, nature connectedness as the only outcome, or a single walk with a randomized route), and consensus led to the exclusion of two previously included reports, which the counts above reflect. In the 20% audit sample, observed agreement between the author and the AI-assisted pre-screen was 92.9% (52 of 56); Cohen's $\varkappa$ was −0.03 because of the kappa paradox (52 of 56 records were includes), while PABAK was 0.86 and Gwet's AC1 0.92.

Natural Resources for Human Health
eISSN: 2583-1194

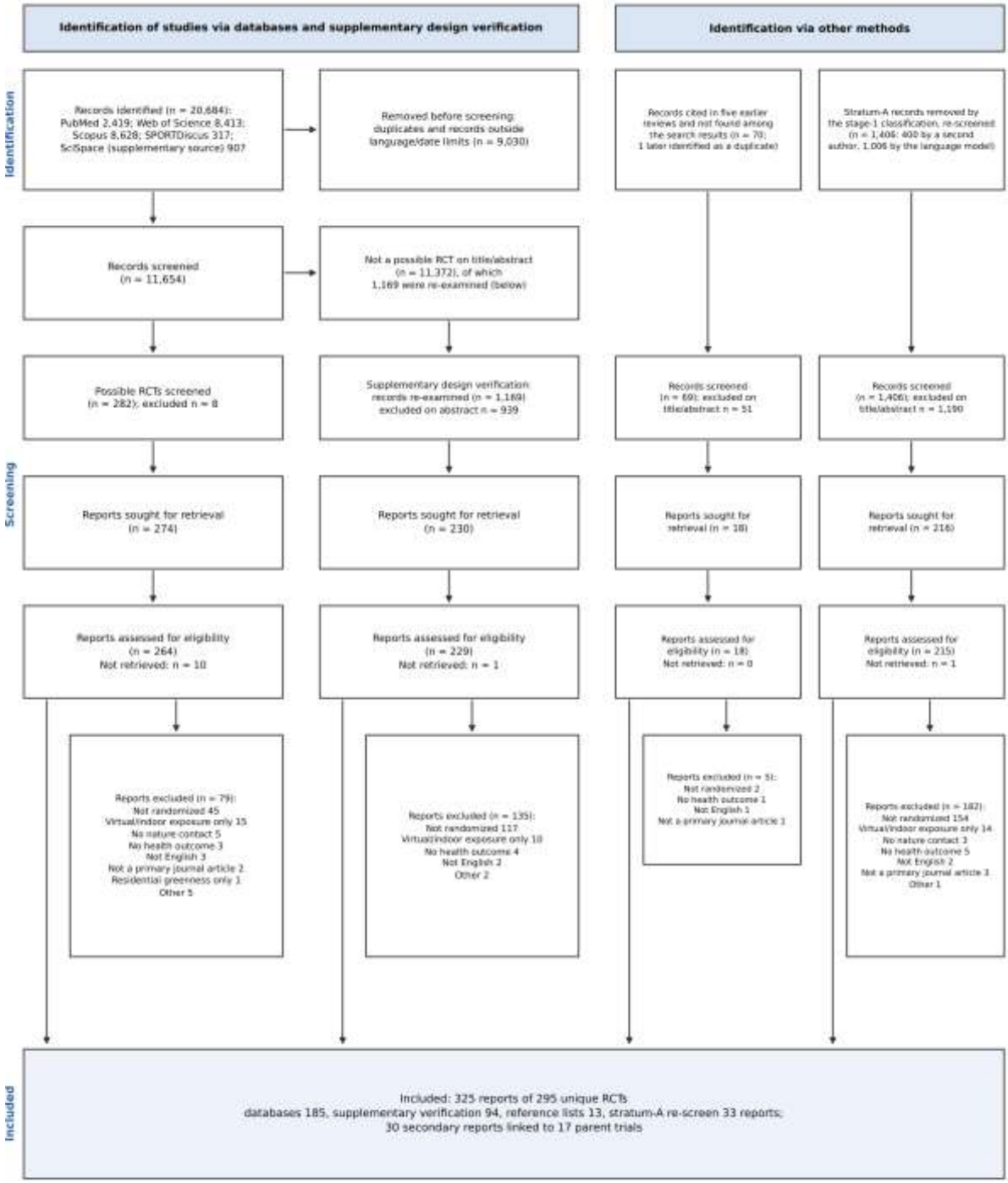


Figure 1. PRISMA-ScR flow diagram of the selection of sources of evidence, including the supplementary design verification and the reference-list check.

The reference-list check also served as a known-item test of the search and screening. Of 57 eligible RCT reports cited by the five earlier reviews, 44 were among the database records: the main screening had identified 33 of them (sensitivity 75%) and the supplementary verification recovered the remaining 11, while 13 had not been retrieved by our database searches at all (Supplementary File S5). All 57 are now included.

3.2 Characteristics of included trials

Trials were published between 2010 and 2026, with 207 (70%) published since 2020 and 38 in 2026 alone. They were conducted in 40 countries, most often China (60, including Hong Kong), the USA (41) and South Korea (22); 77 trials (26%) came from low- and middle-income countries, 56 of them from China. Designs were parallel-group (200), crossover (91) and cluster (4). The median number randomized was 60 (IQR 31–100; range 9–1,295), about 27,600 participants in total. Across trials, the median of mean participant ages was 30 years and the median proportion of women was 55%. Participants were students in 95 trials, healthy adults in 76, clinical groups in 55 (for example depression, schizophrenia, post-traumatic stress disorder, chronic obstructive pulmonary disease, heart failure and fibromyalgia), older adults in 28, employees in 18 and children or adolescents in 12 (Table 1; Supplementary File S3).

Table 1. Characteristics of included trials (N = 295)

Characteristic	Category	n (%)
Design	Parallel / crossover / cluster	200 (67.8) / 91 (30.8) / 4 (1.4)
Region	Asia / Europe / North America / Oceania / South America / Africa or multiple	133 (45.1) / 102 (34.6) / 48 (16.3) / 7 (2.4) / 4 (1.4) / 1 (0.3)
Population	Students / healthy adults / clinical / older adults / employees / children or adolescents / other	95 (32.2) / 76 (25.8) / 55 (18.6) / 28 (9.5) / 18 (6.1) / 12 (4.1) / 11 (3.7)
Setting	Forest / urban park or green space / garden or farm / mixed / coast or water / mountain or wilderness / other	96 (32.5) / 104 (35.3) / 40 (13.6) / 30 (10.2) / 12 (4.1) / 7 (2.4) / 6 (2.0)
Comparator	Urban or built setting / other active control (incl. another natural setting) / indoor activity / wait-list or no intervention / usual care	120 (40.7) / 67 (22.7) / 52 (17.6) / 38 (12.9) / 18 (6.1)
Exposure length	Single session / repeated < 4 weeks / 4–12 weeks / > 12 weeks / repeated, duration not reported	136 (46.1) / 45 (15.3) / 62 (21.0) / 16 (5.4) / 36 (12.2)
Follow-up after intervention	None / ≤ 1 month / > 1 month	258 (87.5) / 15 (5.1) / 22 (7.5)

Turkey and Israel were counted as Asia. Exposure length: trials whose number of sessions was not reported are included in "repeated, duration not reported".

3.3 Evidence map: interaction type by health domain

Active (185 trials, 63%), restorative/therapeutic (95, 32%) and passive (85, 29%) interactions accounted for most of the evidence. One hundred and thirty-one trials (44%) were coded with two types, usually active with restorative/therapeutic (38) or passive with active (36). Productive (26), recreational/adventure (14), wildlife/biodiversity (11) and conservation/participatory (3) activities were much less common. Mental outcomes were measured in 253 trials (86%) and positive psychological outcomes in 215 (73%), followed by physiological (146), cognitive (70) and physical (56) outcomes; only 21 trials measured a social outcome. The largest cell in the map was active × mental (154 trials). Five of the 42 cells were empty, all of them in the wildlife and conservation rows (Table 2; **Figure 2**). Restricting the map to the 200 parallel-group trials did not change the ranking of types or domains (Supplementary File S5, Table S5.8); crossover designs were concentrated in the passive and active rows, where they are mostly short comparisons of a natural and an urban setting. Within types, the profile differed: social outcomes were measured in 5 of 14 recreational/adventure trials and 5 of 26 productive trials, but in only 6 of 185 active trials.

Natural Resources for Human Health
eISSN: 2583-1194

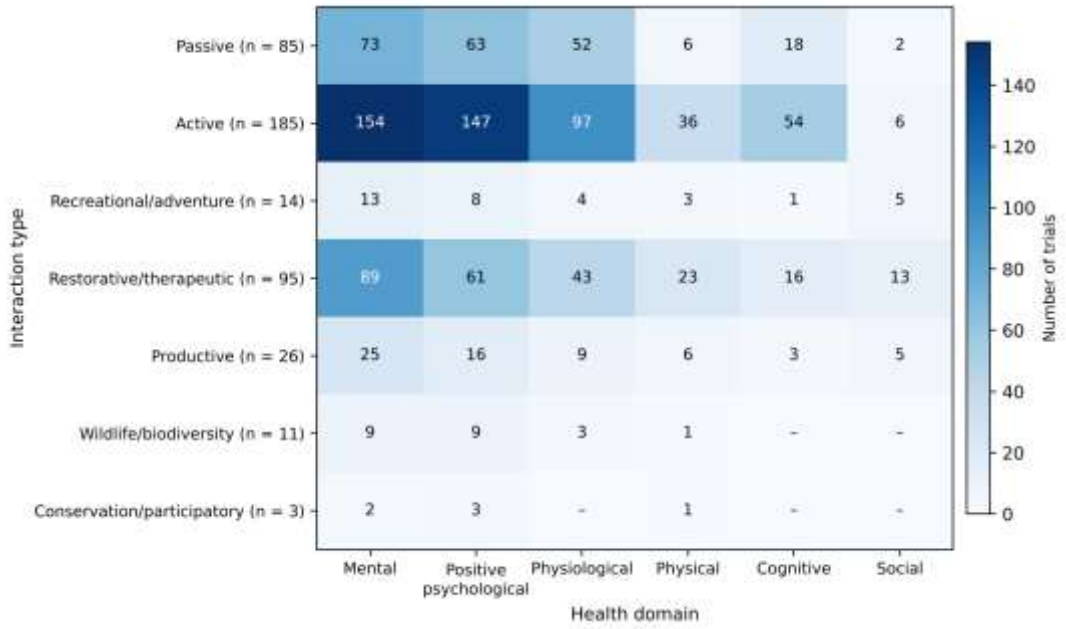


Figure 2. Evidence map of 295 randomized controlled trials by human–nature interaction type and health domain. Cell values show the number of trials measuring each domain; darker cells contain more trials. A trial can appear in several cells; "–" indicates no trial.

Table 2. Number (percentage within interaction type) of trials by interaction type and health domain

Interaction type	Mental	Positive	Physiological	Physical	Cognitive	Social	Total
1 Passive	73 (86)	63 (74)	52 (61)	6 (7)	18 (21)	2 (2)	85
2 Active	154 (83)	147 (79)	97 (52)	36 (19)	54 (29)	6 (3)	185
3 Recreational/adventure	13 (93)	8 (57)	4 (29)	3 (21)	1 (7)	5 (36)	14
4 Restorative/therapeutic	89 (94)	61 (64)	43 (45)	23 (24)	16 (17)	13 (14)	95
5 Productive	25 (96)	16 (62)	9 (35)	6 (23)	3 (12)	5 (19)	26
6 Wildlife/biodiversity	9 (82)	9 (82)	3 (27)	1 (9)	–	–	11
7 Conservation/participatory	2 (67)	3 (100)	–	1 (33)	–	–	3

Percentages are of all trials of that interaction type. A trial can appear in several cells, and a trial coded with two interaction types appears in both rows. Seven further trials tested unspecified time in nature and are not shown.

3.4 Interventions and outcomes by interaction type

Passive. Eighty-five trials tested viewing or sitting in nature, typically a single session of about 15 minutes in a forest (36) or urban park (34), compared with an urban setting (39) or another natural setting (26). Most participants were students (44). Outcomes were mostly mental (73), positive (63) and physiological (52); authors reported a benefit on the main outcomes in 43 trials, mixed results in 30 and no difference in 12.

Active. One hundred and eighty-five trials tested outdoor walking, running or exercise, usually a single session of about 30 minutes in an urban park (81) or forest (62). The comparator was most often the same activity in an urban setting (92) or indoors (36). Participants were mainly students (64), healthy adults (53) and clinical groups (25). Most of these trials measured mental (154), positive (147) or physiological (97) outcomes; 90 reported a benefit, 65 mixed results and 30 no difference.

Recreational/adventure. Fourteen trials tested surf therapy, group or mountain hiking, sailing, canoeing, angling, a therapeutic forest camp, family park outings and a multi-day nature journey. Programs were longer (median 6 sessions of about 150 minutes) and mostly targeted clinical groups (8) or young people. Nine trials reported a benefit, 3 mixed results and 2 no difference; the surf-versus-hike trial found no difference between two outdoor activities.

Restorative/therapeutic. Ninety-five trials tested structured programs, most often forest therapy and horticultural therapy. The median program was 5 sessions of about 90 minutes, and 39 trials enrolled clinical groups. Comparators were an urban setting (21), wait-list or no intervention (21), another active condition (23) or usual care (17). Mental (89) and positive (61) outcomes were the most common; 55 trials reported a benefit, 30 mixed results and 10 no difference.

Productive. Twenty-six trials tested hands-on gardening or farm work, from a single 30-minute allotment session to a season-long community garden plot or home vegetable garden; one tested work with farm animals. Programs were the longest of any type (median 12 sessions of about 80 minutes) and mostly enrolled clinical groups (12) or older adults (5), compared with wait-list (8) or usual care (8). Results were more often mixed (12) than clearly beneficial (10); 4 trials reported no difference.

Wildlife/biodiversity. Eleven trials centered on animals or biodiversity: birdwatching or bird-focused walks (5), farm animals (1), forest patches of differing tree diversity, nature-engagement cues, a guided interpretation trail and citizen-science observation. Sessions were short (typically one session of about 30 minutes) and mostly with healthy adults (7). Only 3 trials reported a clear benefit, and none measured cognitive or social outcomes.

Conservation/participatory. Only three trials fitted this type, all brief citizen-science tasks (camera-trap monitoring, insect counts, bird observation). No RCT tested hands-on environmental volunteering such as habitat restoration. Seven further trials tested unspecified time in nature, such as nature coaching or peer-group excursions.

The most common measures were the Profile of Mood States (84), heart rate (72), blood pressure (69), the Positive and Negative Affect Schedule (61), perceived restorativeness / restoration scales (52), salivary cortisol (45), cognitive tests (44), heart rate variability (39) and the State–Trait Anxiety Inventory (38) (Table 3).

Table 3. Most frequently used outcome measures (N = 295 trials; a trial can use several)

Measure	Domain	Trials, n (%)
Profile of Mood States (POMS)	Mental / positive	84 (28.5)
Heart rate	Physiological	72 (24.4)
Blood pressure	Physiological	69 (23.4)
Positive and Negative Affect Schedule (PANAS)	Positive	61 (20.7)
Perceived restorativeness / restoration scales	Mechanism (M1)	52 (17.6)
Salivary cortisol	Physiological	45 (15.3)
Cognitive tests (e.g., digit span, Stroop, Attention Network Test)	Cognitive	44 (14.9)
Heart rate variability	Physiological	39 (13.2)
State–Trait Anxiety Inventory (STAI)	Mental	38 (12.9)
Depression scales (BDI, PHQ, HADS, GDS, CES-D)	Mental	36 (12.2)
Nature connectedness scales	Mechanism (M5)	23 (7.8)
Quality of life (e.g., SF-36, WHOQOL)	Positive / physical	21 (7.1)

Measure	Domain	Trials, n (%)
Perceived Stress Scale (PSS)	Mental	20 (6.8)
Electroencephalography (EEG)	Physiological	18 (6.1)
Sleep (e.g., PSQI)	Physical	15 (5.1)

BDI, Beck Depression Inventory; CES-D, Center for Epidemiologic Studies Depression Scale; GDS, Geriatric Depression Scale; HADS, Hospital Anxiety and Depression Scale; PHQ, Patient Health Questionnaire; PSQI, Pittsburgh Sleep Quality Index; SF-36, 36-Item Short Form Survey; WHOQOL, World Health Organization Quality of Life. Perceived restorativeness and nature connectedness scales are listed because they measure candidate mechanisms.

3.5 Dose, guidance and comparators

Sessions lasted a median of 30 minutes (range 2–300). One hundred and thirty-six trials (46%) used a single exposure and 146 used repeated sessions, over a median of 4 weeks where duration was reported; 13 trials of repeated programmes did not report the number of sessions. Interventions were guided or facilitated in 146 trials (49%). The comparator was an urban or built environment in 120 trials, an indoor activity in 52, and wait-list, no intervention or usual care in 56. In the remaining 67 the control was another active condition, often in a different natural setting, so these trials compare kinds of nature contact rather than nature with its absence. Only 37 trials (13%) followed participants after the intervention ended, 22 of them for more than one month.

3.6 Mechanisms

Seventeen trials (6%) tested whether a candidate mechanism mediated the randomized effect on a health outcome (Table 4). Restoration (M1, 6 trials) and psychological needs (M6, 4) were tested most often, followed by physical activity (M2, 3), nature connectedness (M5, 2), environmental pathways (M7, 2), social contact (M4, 1) and a physiological pathway (M3, 1). The single test of a physiological mediator found that systolic blood pressure did not mediate the effect of a nature walk on creativity [24], although 146 trials measured physiological outcomes. Five further trials reported mediation analyses that did not test the randomized contrast on a health outcome: two used a non-health outcome (pro-environmental donation; time perception) [25,26], one pooled the trial arms [27], and two modelled perceived biodiversity, a non-randomized variable, as the predictor [28,29]. Five trials tested moderators only, such as attitudes to green exercise, nature orientedness or baseline distress [30-34].

Table 4. Trials that tested whether a mechanism mediated the randomized effect on a health outcome (n = 17)

Trial	Country	Interaction type	Population	Mechanism	Mediation finding	Main effect (authors)
Triguero-Mas et al. (2017) [35]	Spain	Unspecified time in nature	Adults with psychological distress	M1, M2, M7	Physical activity and restoration partly mediated mood effects; physical activity and air pollution partly mediated HRV effects	Beneficial

Trial	Country	Interaction type	Population	Mechanism	Mediation finding	Main effect (authors)
Ng et al. (2018); Ng et al. (2021) [36,37]	Singapore	Restorative/therapeutic	Older adults	M4	Social connectedness fully mediated the effect on IL-6	Mixed
Saadi et al. (2018) [38]	Israel	Passive	Healthy women	M7	Noise, thermal load and air pollution partly mediated setting effects on HRV in one ethnic group	Beneficial
Serrat et al. (2020) [39]	Spain	Restorative/therapeutic	Fibromyalgia	M6	Changes in kinesiophobia and perceived competence mediated program effects	Beneficial
Colléony et al. (2020) [40]	Israel	Wildlife/biodiversity	Students	M5	Quality of nature interaction mediated the effect of engagement cues on positive affect	No difference
Lopes et al. (2020) [41]	Portugal	Active	Adults	M1	Awe and lower negative affect serially mediated the effect of a park walk on rumination	Beneficial
Müller-Riemenschneider et al. (2020); Petrunoff et al. (2021) [42,43]	Singapore	Active	Healthy adults	M2	Park-based physical activity mediated effects on recreational activity and	Mixed

Trial	Country	Interaction type	Population	Mechanism	Mediation finding	Main effect (authors)
					psychological quality of life	
Byrka and Ryczko (2018) [44]	Poland	Active	Adult salsa dancers	M2	Physical activity (MVPA) mediated the effect of dancing in a park versus a dance room on positive emotions	Beneficial
Samus et al. (2022) [45]	Germany	Active	Healthy adults	M5	State nature connectedness did not mediate setting effects	No difference
Hyvönen et al. (2023) [46]	Finland	Restorative/therapeutic	Depression	M1	Restorative experiences mediated the decrease in depression	Mixed
Harris et al. (2025) [47]	Belgium	Active	Students	M1	Walking pleasure partly mediated the effect of a forest walk on state anxiety	Beneficial
Luo and Zhang (2025) [48]	China	Restorative/therapeutic	Park visitors	M6	Flow mediated the effect of in-person versus online delivery on life hope	Beneficial
Meng et al. (2025) [49]	China	Restorative/therapeutic	Healthy adults	M6	Grit and meaning in life mediated the effect on thriving	Beneficial
Noushad et al. (2025) [50]	Pakistan	Restorative/therapeutic	Breast cancer survivors	M6	Psychological well-being	Beneficial

Trial	Country	Interaction type	Population	Mechanism	Mediation finding	Main effect (authors)
					mediated the effect on post-traumatic growth	
Lim et al. (2026) [24]	Singapore	Active	Students	M3	Systolic blood pressure did not mediate the effect of setting on creativity	Mixed
Wang et al. (2026a, 2026b) [51,52]	China	Restorative/therapeutic	Students	M1	Pleasant deactivation partly mediated the reduction in anxiety	Beneficial
Yan et al. (2026) [53]	China	Active	Students	M1	Reduced negative affect partly mediated cognitive restoration	Beneficial

HRV, heart rate variability; IL-6, interleukin 6. M1 restoration; M2 physical activity; M3 physiological; M4 social contact; M5 nature connectedness; M6 psychological needs; M7 environmental. Where a mediation analysis was published in a secondary report, both reports are cited. Five further mediation analyses that did not test the randomized contrast on a health outcome are described in the text.

3.7 Equity and population coverage

Twenty-four trials (8%) reported results by a participant subgroup, most often by sex or age; one examined socioeconomic position and one ethnicity. Trials from low- and middle-income countries numbered 77 (26%), 56 of them from China; 4 trials came from South America and one trial included participants in Africa (Egypt). Children and adolescents were studied in 12 trials and older adults in 28.

4. DISCUSSION

4.1 Principal findings

We identified 295 RCTs of direct nature contact and classified them across seven types of human–nature interaction. The evidence is lopsided. Most trials tested walking, running, seated viewing or structured therapy programs, whereas activities centered on wildlife (11 trials) or conservation (3 trials) have barely been studied. The outcomes are narrow as well: trials mostly measured mood, anxiety and stress straight after the intervention, almost half after a single session, and 87% stopped observing participants once the intervention ended. Only 17 trials tested whether a proposed mechanism carried the randomized effect, so the pathways described in the theoretical literature remain largely untested in experiments.

This imbalance probably reflects what is easy to study rather than what theory would prioritize. A single walk or a period of seated viewing can be standardized, randomized and compared with an urban route, and mood scales can be completed on site.

Forest therapy, for its part, has established delivery models and institutional support in East Asia. Wildlife and conservation activities are harder to standardize, depend on season and site, and are expected to work through slower processes such as social connection or nature connectedness, which a single-session trial cannot capture.

The supplementary verification showed how easily this literature is undercounted. Many field experiments, particularly the forest-versus-city studies from Japan, South Korea, China and Poland, state in the abstract only that participants visited both settings, and report the random order of visits in the methods. Re-checking these records added 94 reports, mainly short passive and active exposures. The additions increased the size of the map but did not change its shape: the same interaction types and outcome domains dominate, and the same gaps remain.

4.2 Comparison with previous reviews

Meta-analyses of single activities, such as gardening [8] and forest bathing [9,10], and of outdoor nature-based activities more broadly [11] have reported benefits for mental health and stress. Our map suggests that these conclusions rest on a fairly narrow part of the range of possible interactions. Heinen-Stach et al. [13] included 47 RCTs of adults with mental health outcomes; we found 295 because we included all ages, all six health domains, non-clinical as well as clinical samples, and randomized crossover field experiments. Kaleta et al. [12] called for direct comparisons between intervention types, and **Figure 2** shows where current trials could support such comparisons and where they could not. Clinical samples were concentrated in therapeutic and productive programs, and single-session walking and viewing studies relied heavily on students. Observational reviews [2] cover a wider range of exposures, but they cannot separate the type of interaction from residential and socioeconomic factors; trials in the empty cells of our map could help to do so.

4.3 Evidence gaps and research priorities

The clearest gap concerns wildlife and conservation activities. Theory links them closely to nature connectedness and social outcomes, yet we found only 11 and 3 RCTs respectively, and none involved hands-on habitat work. Feasibility trials of environmental volunteering and wildlife watching would be a useful next step.

Dose and duration are a second problem. With 46% of trials testing one session and 87% ending observation when the intervention ended, little is known about how long effects last or how much exposure is needed. Trials that vary the dose deliberately and follow participants for at least three months could answer both questions.

The choice of comparator determines what a trial can show, and the comparators in this literature answer different questions. Trials that compared the same walk or period of sitting in a natural and an urban setting (120 trials) isolate the setting while holding the activity constant; they tell us whether the place matters. Trials that compared a nature program with wait-list, no intervention or usual care (56) estimate the effect of the whole package, including guidance, social contact and expectations, and cannot separate nature from these elements. Trials with another active control (67), often in a different natural setting, compare kinds of nature contact. Reading the map by comparator therefore matters: the many short urban-comparison trials in the passive and active rows speak to setting effects, whereas most evidence on therapeutic and productive programs comes from package comparisons. Factorial designs that vary the setting and the activity independently would allow the two to be separated.

Mechanisms need more attention. Future trials should name their mediators in advance, match them to theory (for example perceived restorativeness for restoration, or nature connectedness for M5) and test them as pathways from the randomized condition, rather than pooling arms or modelling perceptions as predictors. Only one trial has tested a physiological mediator, although 146 trials measured physiological outcomes.

Finally, children and adolescents (12 trials), low- and middle-income countries other than China (21 trials) and Africa (1 trials) were rarely represented. Because we searched mainly international databases and English-language reports, this partly reflects where and how trials are published; it does not show that such studies have not been done. It nonetheless limits what can be said about equity.

4.4 Strengths and limitations

The review has several strengths. The protocol was registered, four bibliographic databases and a semantic search tool were searched, one theory-based classification was applied to every trial, explicit rules were used for randomization, nature contact and duplicate reports, records excluded on title and abstract were re-checked against the full text, the reference lists of earlier

reviews were screened, and 30 secondary publications were linked to their parent trials so that no trial was counted twice. There are also limitations. Registration followed the searches. PsycINFO was not searched, and the reference-list check found 13 eligible reports that our database searches had not retrieved, so other trials, particularly older ones described with different terms, are likely to have been missed. A further 11 reports (2.1% of those sought) could not be retrieved, most of them field experiments behind paywalls; they are listed in Supplementary File S4. Restricting to English and to RCTs may have missed relevant trials and excludes quasi-experimental field studies that are common in this area. Title/abstract screening relied on an automated first stage (a language model for about half of the records and a keyword classifier for the other half) to select records for human screening, so records that the classifiers assigned to clearly ineligible categories were not read individually at that stage; the known-item test suggests that the main screening alone would have missed about a quarter of eligible reports among the database records, which the supplementary verification was designed to recover, and the subsequent re-screen of all 1,256 experimental-type records that the classification had removed added 33 eligible reports, mostly PubMed-only records that the supplementary verification had not covered. That re-screen relied on the language model for 1,006 of the records (with lenient flagging and full-text assessment of every flagged record by an author), and one flagged report could not be retrieved; the 8,954 stratum-B records were checked by sampling only (150 records, none eligible). The audit of the classifier is not equivalent to dual independent screening by two people. We limited this risk by keeping every decision with the authors, by having at least one author read every full text and check every charted field, by discussing uncertain cases among two or more authors, and by the supplementary verification described above. Effect direction was recorded as reported by authors, without vote counting or synthesis of effect sizes. Few trials reported sex- or gender-disaggregated results, which limits conclusions about whether effects differ between women and men. As in all scoping reviews, risk of bias was not assessed, so the map shows where evidence exists, not how strong it is.

4.5 Implications for practice and policy

For practitioners and policymakers, the randomized evidence is most plentiful for short-term outcomes of outdoor walking, seated exposure and structured forest or horticultural therapy on mood and stress. Plentiful is not the same as strong: this review did not assess effect sizes or risk of bias, and the number of trials in a cell should not be read as evidence that an intervention works. For wildlife, conservation and volunteering activities, for social outcomes and for effects that outlast the program, randomized evidence is thin or missing. Green and nature prescription schemes often bundle several types of interaction, so evaluations should report which components were actually delivered. For public health agencies that commission such schemes, the map indicates where a randomized evidence base already exists (short outdoor walks, seated exposure, forest and horticultural therapy for mood and stress), where feasibility and pilot trials are the appropriate next step (wildlife, conservation and volunteering activities, social outcomes), and where existing programmes should build in follow-up measurement.

5. CONCLUSIONS

Randomized trials of nature contact have become more numerous, but they cover the seven types of human–nature interaction unevenly. Most test walking, seated exposure or structured therapy and measure short-term psychological change, while wildlife and conservation activities, long-term effects, diverse populations and formal tests of mechanisms have received little attention. Classifying trials by interaction type makes these gaps visible and can help researchers and funders decide where new trials are most needed.

SUPPLEMENTARY MATERIALS

The following supporting information can be downloaded at the journal website: Supplementary File S1, PRISMA-ScR checklist; Supplementary File S2, full search strategies; Supplementary File S3, characteristics of the 295 included trials and references of the 325 included reports; Supplementary File S4, reports excluded at full text and reports not retrieved, with reasons; Supplementary File S5, methods supplement (roles of the AI tool and the authors, HNIH coding manual and crosswalk to earlier classifications, effect-direction rules, supplementary verification, known-item test, classifier rules, sensitivity analysis restricted to parallel-group trials, stratum-A re-screen).

AUTHOR CONTRIBUTIONS

Conceptualization, A.G., G.Ç. and A.U.; methodology, A.G., G.Ç. and A.U.; investigation, A.G.; data curation, A.G.; formal analysis, A.G.; validation, A.G., G.Ç. and A.U.; visualization, A.G.; writing—original draft preparation, A.G.; writing—review

and editing, G.Ç. and A.U.; supervision, G.Ç. and A.U. All authors have read and agreed to the published version of the manuscript.

FUNDING

This research received no external funding.

INSTITUTIONAL REVIEW BOARD STATEMENT

Not applicable. The review analyzed published data only and involved no human participants. The protocol was registered on OSF Registries (https://doi.org/10.17605/OSF.IO/6BVCF).

INFORMED CONSENT STATEMENT

Not applicable.

DATA AVAILABILITY STATEMENT

The search strategies, the lists of included, excluded and unretrieved reports, the charting data and the coding manual are provided in Supplementary Files S2–S5. The registered protocol is available on OSF Registries (https://doi.org/10.17605/OSF.IO/6BVCF).

ACKNOWLEDGMENTS

During the preparation of this work the authors used Claude (Anthropic) to translate search strings between databases, write deduplication scripts, classify title/abstract records for human screening, locate full texts, draft first-pass eligibility assessments and charting records, prepare figures from the charted data, and edit the language of the manuscript. Every AI suggestion was checked by the authors, and no eligibility decision or charted value rests on AI output alone. The authors reviewed and edited the content and take full responsibility for the content of the published article.

CONFLICTS OF INTEREST

The authors declare no conflicts of interest.

REFERENCES

[1] Hartig, T.; Mitchell, R.; de Vries, S.; Frumkin, H. Nature and health. *Annu Rev Public Health* **2014**, *35*, 207-228. https://doi.org/10.1146/annurev-publhealth-032013-182443

[2] Twohig-Bennett, C.; Jones, A. The health benefits of the great outdoors: a systematic review and meta-analysis of greenspace exposure and health outcomes. *Environ Res* **2018**, *166*, 628-637. https://doi.org/10.1016/j.envres.2018.06.030

[3] White, M.P.; Alcock, I.; Grellier, J.; et al. Spending at least 120 minutes a week in nature is associated with good health and wellbeing. *Sci Rep* **2019**, *9*, 7730. https://doi.org/10.1038/s41598-019-44097-3

[4] Ulrich, R.S.; Simons, R.F.; Losito, B.D.; Fiorito, E.; Miles, M.A.; Zelson, M. Stress recovery during exposure to natural and urban environments. *J Environ Psychol* **1991**, *11*, 201-230. https://doi.org/10.1016/S0272-4944(05)80184-7

[5] Kaplan, S. The restorative benefits of nature: toward an integrative framework. *J Environ Psychol* **1995**, *15*, 169-182. https://doi.org/10.1016/0272-4944(95)90001-2

[6] Markevych, I.; Schoierer, J.; Hartig, T.; et al. Exploring pathways linking greenspace to health: theoretical and methodological guidance. *Environ Res* **2017**, *158*, 301-317. https://doi.org/10.1016/j.envres.2017.06.028

[7] Bratman, G.N.; Anderson, C.B.; Berman, M.G.; et al. Nature and mental health: an ecosystem service perspective. *Sci Adv* **2019**, *5*, eaax0903. https://doi.org/10.1126/sciadv.aax0903

[8] Soga, M.; Gaston, K.J.; Yamaura, Y. Gardening is beneficial for health: a meta-analysis. *Prev Med Rep* **2017**, *5*, 92-99. https://doi.org/10.1016/j.pmedr.2016.11.007

[9] Antonelli, M.; Barbieri, G.; Donelli, D. Effects of forest bathing (shinrin-yoku) on levels of cortisol as a stress biomarker: a systematic review and meta-analysis. *Int J Biometeorol* **2019**, *63*, 1117-1134. https://doi.org/10.1007/s00484-019-01717-x

[10] Kotera, Y.; Richardson, M.; Sheffield, D. Effects of shinrin-yoku (forest bathing) and nature therapy on mental health: a systematic review and meta-analysis. *Int J Ment Health Addict* **2022**, *20*, 337-361. https://doi.org/10.1007/s11469-020-00363-4

[11] Coventry, P.A.; Brown, J.E.; Pervin, J.; et al. Nature-based outdoor activities for mental and physical health: systematic review and meta-analysis. *SSM Popul Health* **2021**, *16*, 100934. https://doi.org/10.1016/j.ssmph.2021.100934

[12] Kaleta, B.; Campbell, S.; O'Keeffe, J.; Burke, J. Nature-based interventions: a systematic review of reviews. *Front Psychol* **2025**, *16*, 1625294. https://doi.org/10.3389/fpsyg.2025.1625294

[13] Heinen-Stach, D.; Herbold, E.; Hendricks, C.L.; et al. The effectiveness of nature-based interventions on mental health: a systematic review. *Appl Psychol Health Well Being* **2026**, *18*, e70164. https://doi.org/10.1111/aphw.70164

[14] Keniger, L.E.; Gaston, K.J.; Irvine, K.N.; Fuller, R.A. What are the benefits of interacting with nature? *Int J Environ Res Public Health* **2013**, *10*, 913-935. https://doi.org/10.3390/ijerph10030913

[15] Shanahan, D.F.; Astell-Burt, T.; Barber, E.A.; et al. Nature-based interventions for improving health and wellbeing: the purpose, the people and the outcomes. *Sports* **2019**, *7*, 141. https://doi.org/10.3390/sports7060141

[16] Arksey, H.; O'Malley, L. Scoping studies: towards a methodological framework. *Int J Soc Res Methodol* **2005**, *8*, 19-32. https://doi.org/10.1080/1364557032000119616

[17] Peters, M.D.J.; Marnie, C.; Tricco, A.C.; et al. Updated methodological guidance for the conduct of scoping reviews. *JBI Evid Synth* **2020**, *18*, 2119-2126. https://doi.org/10.11124/JBIES-20-00167

[18] Levac, D.; Colquhoun, H.; O'Brien, K.K. Scoping studies: advancing the methodology. *Implement Sci* **2010**, *5*, 69. https://doi.org/10.1186/1748-5908-5-69

[19] Tricco, A.C.; Lillie, E.; Zarin, W.; et al. PRISMA extension for scoping reviews (PRISMA-ScR): checklist and explanation. *Ann Intern Med* **2018**, *169*, 467-473. https://doi.org/10.7326/M18-0850

[20] McHugh, M.L. Interrater reliability: the kappa statistic. *Biochem Med (Zagreb)* **2012**, *22*, 276-282. https://doi.org/10.11613/BM.2012.031

[21] Feinstein, A.R.; Cicchetti, D.V. High agreement but low kappa: I. The problems of two paradoxes. *J Clin Epidemiol* **1990**, *43*, 543-549. https://doi.org/10.1016/0895-4356(90)90158-L

[22] Byrt, T.; Bishop, J.; Carlin, J.B. Bias, prevalence and kappa. *J Clin Epidemiol* **1993**, *46*, 423-429. https://doi.org/10.1016/0895-4356(93)90018-V

[23] Gwet, K.L. Computing inter-rater reliability and its variance in the presence of high agreement. *Br J Math Stat Psychol* **2008**, *61*, 29-48. https://doi.org/10.1348/000711006X126600

[24] Lim, A.J.; Colarelli, S.M.; Li, N.P.; et al. Nature versus non-natural environments: effects on stress and creativity. *J Environ Psychol* **2026**, *110*, 102929. https://doi.org/10.1016/j.jenvp.2026.102929

[25] Flecke, S.L.; Huber, J.; Kirchler, M.; Schwaiger, R. Nature experiences and pro-environmental behavior: evidence from a randomized controlled trial. *J Environ Psychol* **2024**, *99*, 102383. https://doi.org/10.1016/j.jenvp.2024.102383

[26] Davydenko, M.; Peetz, J. Time grows on trees: the effect of nature settings on time perception. *J Environ Psychol* **2017**, *54*, 20-26. https://doi.org/10.1016/j.jenvp.2017.09.003

[27] Guo, D.; Xu, T.; Luo, J.; et al. The evidence for stress recovery in forest therapy programs: investigating whether forest walking and guided forest therapy activities have the same potential? *J For Res* **2025**, *36*, 15. https://doi.org/10.1007/s11676-024-01812-9

[28] Rozario, K.; Oh, R.R.Y.; Marselle, M.; et al. The more the merrier? Perceived forest biodiversity promotes short-term mental health and well-being: a multicentre study. *People Nat* **2024**, *6*, 180-201. https://doi.org/10.1002/pan3.10564

[29] Chen, R.; Weng, P.Y.; Miao, L.; Lin, Z.; Zhao, X. Restorative effects of urban biodiversity: a study based on age differences using multigroup structural equation modeling. *Front Psychol* **2026**, *17*, 1907289. https://doi.org/10.3389/fpsyg.2026.1907289

[30] Turner, T.L.; Stevinson, C. Affective outcomes during and after high-intensity exercise in outdoor green and indoor gym settings. *Int J Environ Health Res* **2017**, *27*, 106-116. https://doi.org/10.1080/09603123.2017.1282605

[31] Flowers, E.P.; Turner, A.I.; Abbott, G.; Timperio, A.; Salmon, J.; Veitch, J. People with the least positive attitudes to green exercise derive most anxiolytic benefit from walking in green space. *Urban For Urban Green* **2022**, *72*, 127587. https://doi.org/10.1016/j.ufug.2022.127587

[32] Ebrahimi, I.; Kazemi, F.; Agha Ebrahimi, M.A. Birdwatching vs. nature walks: a randomized trial to compare mental health outcomes in Iran. *Hum Dimens Wildl* **2026**, *31*, 599-614. https://doi.org/10.1080/10871209.2025.2589874

[33] Serantes, J.; Araña, J.E. Can traveling change your life? Testing claims of durable transformation with the T-Index. *J Travel Res* **2026**. https://doi.org/10.1177/00472875261485332

[34] Ojala, A.; Korpela, K.; Tyrväinen, L.; Tiittanen, P.; Lanki, T. Restorative effects of urban green environments and the role of urban-nature orientedness and noise sensitivity: a field experiment. *Health Place* **2019**, *55*, 59-70. https://doi.org/10.1016/j.healthplace.2018.11.004

[35] Triguero-Mas, M.; Gidlow, C.J.; Martínez, D.; et al. 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* **2017**, *12*, e0172200. https://doi.org/10.1371/journal.pone.0172200

[36] Ng, K.S.T.; Sia, A.; Ng, M.K.W.; et al. Effects of horticultural therapy on Asian older adults: a randomized controlled trial. *Int J Environ Res Public Health* **2018**, *15*, 1705. https://doi.org/10.3390/ijerph15081705

[37] Ng, T.K.S.; Gan, D.R.Y.; Mahendran, R.; Kua, E.H.; Ho, R.C.M. Social connectedness as a mediator for horticultural therapy's biological effect on community-dwelling older adults: secondary analyses of a randomized controlled trial. *Soc Sci Med* **2021**, *284*, 114191. https://doi.org/10.1016/j.socscimed.2021.114191

[38] Saadi, D.; Agay-Shay, K.; Tirosh, E.; Schnell, I. A comparison of the effects of selected mono-ethnic urban environments on the autonomic functions of Muslim and Jewish women in Israel. *Environ Monit Assess* **2018**, *190*, 627. https://doi.org/10.1007/s10661-018-7000-0

[39] Serrat, M.; Almirall, M.; Musté, M.; et al. Effectiveness of a multicomponent treatment for fibromyalgia based on pain neuroscience education, exercise therapy, psychological support, and nature exposure (NAT-FM): a pragmatic randomized controlled trial. *J Clin Med* **2020**, *9*, 3348. https://doi.org/10.3390/jcm9103348

[40] Colléony, A.; Levontin, L.; Shwartz, A. Promoting meaningful and positive nature interactions for visitors to green spaces. *Conserv Biol* **2020**, *34*, 1373-1382. https://doi.org/10.1111/cobi.13624

[41] Lopes, S.; Lima, M.; Silva, K. Nature can get it out of your mind: the rumination reducing effects of contact with nature and the mediating role of awe and mood. *J Environ Psychol* **2020**, *71*, 101489. https://doi.org/10.1016/j.jenvp.2020.101489

[42] Müller-Riemenschneider, F.; Petrunoff, N.; Yao, J.; et al. Effectiveness of prescribing physical activity in parks to improve health and wellbeing - the park prescription randomized controlled trial. *Int J Behav Nutr Phys Act* **2020**, *17*, 42. https://doi.org/10.1186/s12966-020-00941-8

[43] Petrunoff, N.; Yao, J.; Sia, A.; et al. Activity in nature mediates a park prescription intervention's effects on physical activity, park use and quality of life: a mixed-methods process evaluation. *BMC Public Health* **2021**, *21*, 204. https://doi.org/10.1186/s12889-021-10177-1

[44] Byrka, K.; Ryczko, N. Positive effects of dancing in natural versus indoor settings: the mediating role of engagement in physical activity. *J Environ Psychol* **2018**, *57*, 25-33. https://doi.org/10.1016/j.jenvp.2018.06.002

[45] Samus, A.; Freeman, C.; van Heezik, Y.; Krumme, K.; Dickinson, K.J.M. How do urban green spaces increase well-being? The role of perceived wildness and nature connectedness. *J Environ Psychol* **2022**, *82*, 101850. https://doi.org/10.1016/j.jenvp.2022.101850

[46] Hyvönen, K.; Salonen, K.; Paakkolanvaara, J.V.; Väkeväinen, P.; Korpela, K. Effects of nature-based intervention in the treatment of depression: a multi-center, randomized controlled trial. *J Environ Psychol* **2023**, *85*, 101950. https://doi.org/10.1016/j.jenvp.2022.101950

[47] Harris, J.M.; Vögele, C.; Öz, I.T.; Brevers, D. Walking in nature decreases state anxiety through pleasure. *Health Place* **2025**, *94*, 103498. https://doi.org/10.1016/j.healthplace.2025.103498

[48] Luo, M.K.; Zhang, W.Y. Fostering life hope in urban green spaces through brief online mindfulness: findings from four studies with park visitors. *Front Psychol* **2025**, *16*, 1642533. https://doi.org/10.3389/fpsyg.2025.1642533

[49] Meng, B.; Cao, J.; Wei, Y.; Rui, C.; Tan, F. The effects of mindfulness on psychological thriving among urban park visitors: evidence from three experimental studies. *Front Public Health* **2025**, *13*, 1638301. https://doi.org/10.3389/fpubh.2025.1638301

[50] Noushad, S.; Ahmed, S.; Saleem, Y.; Aziz, S.A. The effects of nature walk therapy on post-traumatic growth in breast cancer survivors: a comparative study. *Eur J Oncol Nurs* **2025**, *79*, 102994. https://doi.org/10.1016/j.ejon.2025.102994

[51] Wang, X.; Lymeus, F.; Yu, W.; Hartig, T. Nature-based interventions for stress and anxiety: two randomized trials with alternative setting-activity combinations. *J Environ Psychol* **2026**, *113*, 103116. https://doi.org/10.1016/j.jenvp.2026.103116

[52] Wang, X.; Lymeus, F.; Yu, W.; Hartig, T. Nature-based interventions for university student stress and anxiety: two randomized trials in urban campus settings. *Urban For Urban Green* **2026**, *124*, 129582. https://doi.org/10.1016/j.ufug.2026.129582

[53] Yan, S.; Liu, L.; Zhao, Z.; Li, Y. Psychophysiological restoration in nature: a randomized controlled trial investigating the cognitive, affective, and physiological benefits of green exercise. *Sci Rep* **2026**, *16*, 29620. https://doi.org/10.1038/s41598-026-60002-1