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Review

Forest Therapy Trails: A Conceptual Framework and Scoping Review of Research

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Abstract: While most definitions of forest therapy emphasize the role of multisensory, immersive experiences in nature to achieve human health and wellbeing outcomes, reviews of research on forest therapy to date have predominantly focused on outcomes and provide limited insight on the factors and conditions that give rise to nature experiences. In this scoping review we employ a conceptual framework developed in the context of landscape perception research to examine empirical studies of forest therapy in terms of how the fuller process of human, forest, interaction, and outcome components are conceptualized and measured. Our literature search identified 266 studies focused on forest therapy and related activities, which were coded on a number of variables related to each of the four components in our framework. While most studies reported positive mental and/or physiological health outcomes using a wide array of measures, the typical study used small, homogeneous samples of participants who engaged in limited interactions with a forest environment that was minimally described. However, our analysis also identified a wider range of findings with regard to human-forest interactions, which together provide important insights for guiding forest therapy research and the provision of forest therapy trails, settings, and programs.

Keywords: forest therapy; forest bathing; forest walks; forest trails; landscape perception; conceptual framework; scoping review; key characteristics; people-forest interactions; health and wellbeing outcomes

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1. Introduction

Forest therapy is an umbrella term used in this paper to encompass activities by individuals and groups in the mindful engagement of slow, multi-sensory, immersive experiences in forests and other natural and semi-natural environments to achieve mental and physical health along with other wellbeing outcomes [1–3]. Related terms include forest bathing (shinrin yoku), nature therapy, forest walks, and forest healing. Although forest therapy engagements can take place while stationary in a confined location, in non-forested settings such as designed gardens and urban greenspaces, or even remotely through a window or digitally, most engagements take place in the form of walks along a path within a forest to optimally experience the array of sights, sounds, smells, and other sensory phenomena afforded along the route [3,4]. This interaction between person and landscape, individually or mediated by a trained forest therapy guide and shared among a group of participants, has been linked to a range of positive health benefits, from psychological stress relief and improvements in mood to physiological improvements in blood pressure and increased immune response [5]. On a broader level, forest therapy as a practice can bring a fuller awareness and appreciation of our umwelt, the world as we perceptually experience it, and lead to a better understanding of what it is to be human and connected to other living things in the natural world [6].

Because of these and other promising outcomes, forest therapy is viewed by an increasing number of health professionals as an alternative or complementary treatment for individuals with an array of health issues and an enjoyable wellness practice for everyone [7,8]. From the initial formalization of shinrin yoku as a health-based activity in Japan in the early 1980s [9], a rapidly growing body of evidence-based research has motivated health professionals in many countries to develop forest and nature-based therapy programs, including advocacy initiatives for doctors to prescribe a "dose of nature" to their patients [10,11]. However, while forestry agencies in a few countries such as Japan and South Korea have responded to this demand by developing networks of forest therapy bases and trails [12,13], in most places the selection of settings is left to the individual or forest therapy guide, without clear criteria for what features or conditions help facilitate desired health and wellness outcomes.

For these reasons, we established the Forest Therapy Trails project to examine the literature and conduct original research with the goal of developing guidelines for trail design, planning, and management [14]. In this initial effort, we review the forest therapy research literature to better understand the nature of people-forest interactions that give rise to health and wellbeing outcomes. With a few notable exceptions [15–17], most reviews of research on forest therapy and related concepts to date have focused principally on health outcomes. On one hand this is unsurprising, for many reviews adhere to standardized guidelines and procedures developed for medical research, which emphasize outcome effect measures (e.g., direction, magnitude, heterogeneity) and data quality (confidence, biases) [18–23]. On the other hand, however, the medical science orientation of many research reviews and the individual studies they select for inclusion often pay little attention to broader study details such as the nature of the forest setting in which health interventions take place or how participants interact with those settings in order to realize beneficial health outcomes [24]. Paradoxically, despite the focus of forest therapy on forests as a source of health outcomes, relatively little summary evidence has been brought to light about the multisensory, immersive experiences that underlie forest therapy engagements.

A Conceptual Framework for Understanding Forest Therapy Engagements

In this scoping review [25] we depart from the health outcomes paradigm to examine forest therapy research in terms of the fuller process of how human, environment, interaction, and outcome components are conceptualized and measured. To guide our work, our review builds upon a conceptual framework developed by Zube et al. [26] for the analysis of research in landscape perception, a multi-disciplinary field of inquiry concerned with understanding and assessing human responses to large-scale physical environments. While similar, more recent frameworks have been proposed, e.g., [27], the Zube et al. [26] framework is well-grounded in theory [28,29], enjoys continued use and citation [30,31], and is conceptually clear for guiding a review of research.

The framework, which we have adapted here to the specific context of research on forest therapy (Figure 1), views human health and wellbeing as outcomes that result from the interactions between humans and the forest environment. Although forest therapy engagements can be quite varied, they can be usefully examined in terms of each of the four human, forest, interaction, and outcome components in the framework. For the human component, we were interested in who is being studied and how the study samples reflect the broader population that might participate in or could benefit from forest therapy. We were also interested in whether particular individuals or groups varied in their experiences or outcomes from forest therapy engagements [32,33]. For the forest component, our primary interest was in identifying important features and qualities of the forest environment that give rise to, or are thought to give rise to, therapeutic forest experiences. As with the human component, we also wanted to know if particular forest types or features were more or less effective at producing beneficial outcomes [34,35]. For the interaction component, we sought information on the structural nature of forest therapy engagements in terms of what types of activities participants engaged in and the

duration of engagements. Additionally, important to us was the social nature of interactions, including the size of groups that participated in an engagement and whether and how guided forest therapy engagements differed from unguided ones [36,37]. Additionally, for the outcome component, similar to more standard reviews of the forest therapy literature, we wanted to identify the types of outcome measures being studied and the success of forest therapy engagements in achieving desired psychological, physiological, and other health and wellbeing outcomes [20–22].

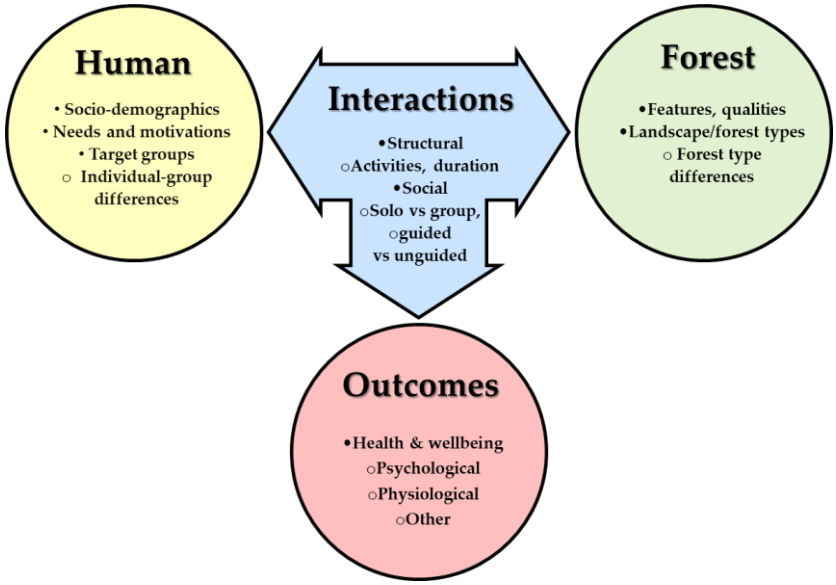

Figure 1. Forest therapy interaction process.

In line with the purposes of scoping reviews [25], in the following sections we apply this conceptual framework to a set of research articles from a broadly defined search of the literature to identify key concepts and themes as well as patterns of central tendency and variability among a range of key variables. While we acknowledge that published research on forest therapy may describe a more limited subset of factors and conditions than might occur in actual forest therapy engagements, identification of what is being researched and reported can be a useful first step in understanding the current state of knowledge and future research needs, leading to improved settings and programs.

2. Materials and Methods

2.1. Article Search and Screening Procedures

To help identify an appropriate set of search terms, we examined previous reviews of the forest therapy literature [15,16,38–40]. With our project emphasis on forest therapy trails, we were particularly interested in research that focused on forests and trails, but recognizing that forest therapy engagements can take on a wide range of settings and activities, we did not limit our search to these terms.

We conducted our search using the following search string: "forest therapy" OR "nature therapy" OR "forest bathing" OR "shinrin yoku" OR "forest medicine" OR "nature-assisted therapy" OR "nature-based therapy" OR "park therapy" OR "forest walks" OR "forest walking" OR "nature walks" OR "nature walking" OR "healing forest". A 9 March 2022 search in Scopus identified 512 articles. Using this same search string, the Scopus search identified 19% more articles than Web of Science, while a Dimensions search identified 30% more articles than Scopus and 54% more than Web of Science. Because Scopus provided a more robust selection than Web of Science and because we lacked institutional access to the analytical version of Dimensions, we used Scopus to build our database of articles.

From the downloaded .csv file of article information, we first screened the set to identify empirical research articles, eliminating full books and book reviews (n = 7); conceptual, editorial, and perspective essays (n = 66); errata (n = 1); and review papers (n = 79). From the remaining set of empirical articles (n = 359), we deleted duplicate listings (n =13) and reviewed the abstracts to eliminate those that were off-topic (n = 46). This left us with a targeted set of 300 articles, 25 of which were not retrievable via download or by contacting the corresponding author and another 9 that were not in English and not translatable, for a final sample of 266 articles for coding and analysis.

2.2. Concept Coding and Analysis

Except for one analysis described below where we employed a text mining approach, our coding procedures used the article as the unit of analysis (n = 266). To help characterize the article sample, we coded basic study information including date of publication, country location where the study focused, author disciplinary affiliations, and the type of research design and forest therapy research activity (e.g., forest bathing, forest therapy program) identified by the authors.

Using our conceptual framework (Figure 1) to guide the analysis, we then coded available study information for each of its four components. For the outcome component, as previously mentioned, the aim of our work was not to repeat previous reviews that evaluate the significance of study effects or quality of the research. Rather, in addressing the outcomes component in our framework, we sought to identify the types of measures being used and how they might vary by the type of research design employed. We also broadly coded the extent to which significant positive outcomes of the intervention were reported in the study.

For the human component, we coded sample size, demographic information (average age, percent female (only a few studies included nonbinary gender categories)), target population(s) studied, and whether the study design included any between-subject comparisons. While coding for most of these variables was straightforward and taken directly from the article abstract or full text, information about studies' target populations required some thematic categorization to a smaller number of logical groupings. In this case, and for similar variables for the other framework components below, grouping was done by the lead author with consultation and review by the project team (co-authors).

For the forest component, we coded landscape type, forest type, urban-rural study location, and whether the study took place at a designated forest therapy or bathing site. Because the characteristics of forest sites and settings were of primary interest to our Forest Therapy Trails project, we coded an array of summary and detailed information for this component. To help characterize quantitative site parameters, we coded articles for available information on trail length, site size, and number of sites included in the study. Studies that made within-forest comparisons were identified and grouped by the types of comparisons made. Forest setting descriptions were excerpted from each article and coded in two ways to try and extract the maximum amount of information about the features and qualities of the sites studied. The first was a by-article coding where each forest setting description was reviewed and coded for word count as an overall measure of descriptive richness and thematically coded for specific notable features that were mentioned [41,42]. The second employed a text-mining approach inspired by Grilli and Sacchelli's [24] review of the forest therapy literature, where the text corpus of title-keyword-abstract information was subjected to lexicometric analysis to identify and spatially map thematic groupings of key study concepts. We attempted a similar concept mapping of forest setting descriptions using VOSviewer [43], but the resulting clusters did not yield a meaningful interpretation so we manually grouped key concepts as identified by a frequency analysis of terms [42]. Finally, we sought to identify if the study design made any between-site comparisons of forests with other site types or control conditions, or within-forest comparisons by forest type or other conditions, and whether such comparisons resulted in significant differences in the outcome effects that were being assessed.

For the interaction component, we coded the type(s) of activities, duration, and number of sessions that participants engaged in as part of the study. In addition to these structural dimensions of the interaction, we also coded the social dimensions of maximum group size of the engagement and whether it was guided or unguided. Because these social-structural aspects of human-forest interactions might vary by the type of program, we also cross-coded studies by the type of forest therapy research activity as it was talked about in the article and identified by our keyword search string.

Additionally, as previously mentioned, the aim of our scoping review was to identify key concepts and themes and to describe patterns of central tendency and variability among variables of the four components [25]. To address this aim, our analytical procedures relied mainly upon reporting frequency of themes and categories along with mean/median scores and related statistics for key quantitative variables. Crosstabulations were also employed to help understand relationships between key variables, particularly as they related to study outcomes.

3. Results

3.1. Study Sample Characteristics

Table A1 in Appendix A provides a listing of sample characteristics for each of the 266 articles included in our review. Representative examples of studies corresponding to particular study variables are cited in the text of this and other subsections below. In terms of research type, forest therapy research is heavily oriented toward experimental work (n = 199, 74.8%), with most studies of this type following a pre/post research design where indicators of participants' health and wellbeing are assessed before and after engagement in a forest or other natural environment [44,45]. The other research types were much less represented in the sample and in some cases we grouped together a number of similar approaches. Qualitative studies (n = 34, 12.8%) included in-depth interviews, participant observation, and focus groups with forest therapy participants [46,47], interviews with forest therapy providers and other professionals [48,49], mixed-methods post-occupancy evaluations [50,51], and clinical case studies [52,53]. Survey research (n = 15, 5.6%) included both large-scale general population surveys [54] and targeted onsite intercept surveys of forest visitors engaged or interested in forest therapy experiences [55,56]. Research types used in less than 10 articles included expert assessments such as suitability analyses [57,58] and site inventories [59], image analysis of virtual landscape representations [60] and social media selfie posts [61], and epidemiological studies [62].

We also categorized articles by how authors described the main activity they studied under the umbrella term that we have been referring to in this paper as forest therapy. We identified three main research activity types and three lesser activity types. The three main activity types included forest-, nature-, or park therapy (n = 101, 41.0%), often with an emphasis on multi-activity programs made up of a series of sessions over time [34,63]; forest bathing or shinrin yoku (n = 76, 28.6%), which were more often operationalized by a single walking or stationary activity of limited duration [64,65]; and forest, nature, or park walks (n = 53, 19.9%), which were often described in similar ways to forest bathing but did not use that term [66,67]. The three lesser activity types were forest experiences (n = 5, 1.9%) which mainly derived from tourism research [68,69]; virtual-based studies (n = 17, 6.4%) or "digital shinrin yoku," which emphasized the use of digital representations of nature as an alternative or proxy to actual forest experience, sometimes in response to nature access constraints caused by the COVID-19 pandemic [70,71]; and forest air studies (n = 6, 2.3%), where the focus was on immunity or other health and wellbeing properties of the physical forest environment studied in the context of forest therapy [72,73].

Given the geographic origin of shinrin yoku, it was not surprising to find Japan to be the earliest and foremost location of forest therapy research, with 72 articles (27.6% of the entire sample) dating back to 1998. Of the 31 countries listed as the locations of forest therapy research in our sample, Japan and five other countries accounted for two-thirds of published articles to date (Figure 2). As the Figure 2 shows, research in Japan has steadily

increased over 2006–2021, while studies in South Korea (n = 43) and China (n = 29) have increased greatly in recent years. Europe as a whole has also seen a big increase in recent years, from only 1 between 2006–2013 to 15 in 2014–2017 and 37 in 2018–2021.

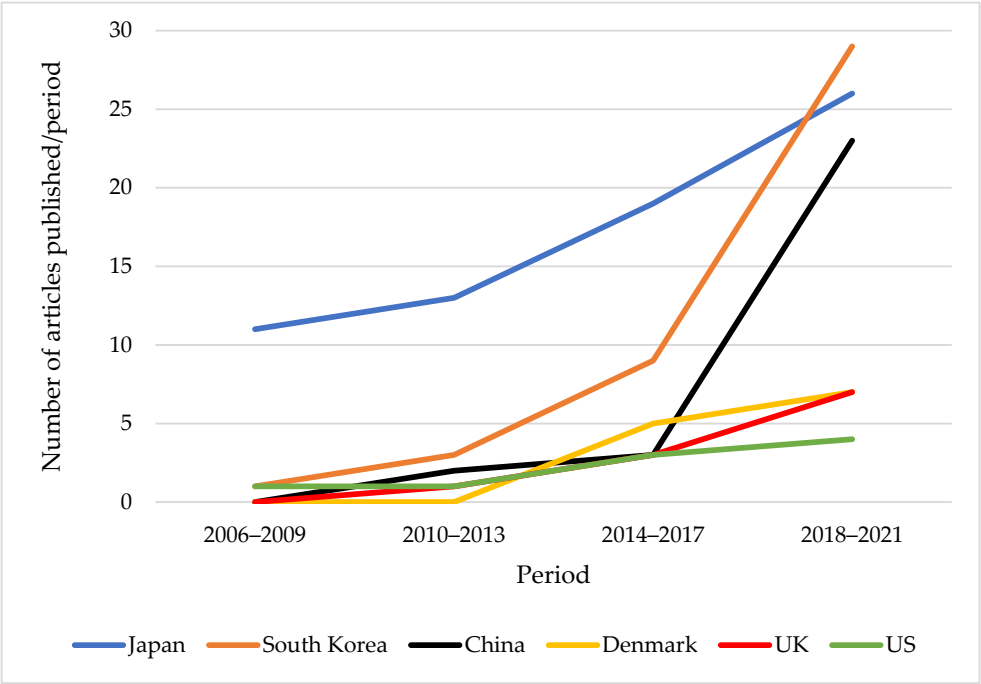

Figure 2. Forest therapy publication trends 2006–2021, top 6 countries (67% all articles).

Experimental studies accounted for at least two-thirds of articles in each of these top six countries, and while small cells sizes make it difficult to establish statistical significance for two-way tables, there did appear to be a larger proportion of qualitative studies based in Denmark (n = 4, 33%) and the UK (n = 3, 27.3%), more image analysis work coming from China (n = 6, 20.7%), and more studies employing surveys from Japan (n = 9, 12.5%). Additionally, of potential significance, studies from Japan tended to more often be described as forest bathing/shinrin yoku (n = 38, 52.8%), studies from South Korea (n = 33, 76.7%) and Denmark (n = 11, 91.7%) more often used the term forest therapy, and studies from the US (n = 9, 100%) and UK (n = 5, 45.5%) tended to use forest or nature walks.

As for author disciplinary affiliations, the natural resource professions (forestry, landscape architecture, recreation-tourism) were represented in the largest number of articles (n = 159, 59.8%), followed by the fields of medicine and health (n = 121, 45.5%), the social sciences (n = 69, 25.9%), environmental science and STEM fields (n = 26, 9.8%) and the arts and humanities (n = 2, 0.8%). Slightly more than half of the papers (n = 142, 55.3%) were authored by individuals within a single one of these affiliation groups, while the remainder were comprised of two (n = 97, 37.7%) or more (n = 18, 7.0%) affiliation groups, most often representing both the natural resource and medical-health fields.

Finally, we attempted to discern whether author disciplinary affiliations were associated with the type of research approach used in studies, using the subsample of papers where authors all came from a single field (n = 142). As might be expected, if authors were all from within the medical-health sciences, a high proportion of studies (n = 34, 87.2%) used experimental designs. Experimental designs also dominated the other disciplinary fields, though authors from the social sciences tended to employ qualitative approaches more often (n = 9, 33.3%) and authors from the natural resource professions appeared to employ a wider diversity of research types including qualitative (n = 8, 12.3%), survey (n = 7, 10.8%), and expert assessments (n = 4, 6.2%).

3.2. Outcome Component

3.2.1. Outcome Measures Studied

A large majority of studies (n = 219, 85.5%) employed psychological measures to assess health and wellbeing outcomes from forest therapy engagements, while about half (n = 135, 50.8%) employed physiological measures (including physical and psychophysiological). About 40 percent of studies (n = 101, 39.5%) employed both types of measures, while the others used only psychological (n = 121, 47.3%) or physiological measures (n = 34, 13.3%). The average study that included psychological measures employed 2.7 different measures, while the average study that included physiological measures employed 2.4 different measures, though the number of measures used ranged considerably, from 1 to 27 different psychological measures to 1 to 13 different physiological measures.

We tallied 246 different psychological measures used to assess health and wellbeing outcomes. These ranged from single-item measures such as willingness to visit or revisit [57,74] and sets of single-items such as a landscape feature checklist [75] used to assess environmental preferences, to previously developed and validated multi-item scales designed to assess various psychological states. The five most commonly used psychological scales were the Profile of Mood States (POMS) (n = 75, 34.2%), the Positive and Negative Affect Schedule (PANAS) (n = 34, 15.5%), the State-Trait Anxiety Inventory (STAI) (n = 21, 9.6%), the Semantic Differential (SD) (n = 22, 10.0%), and the Restorative Outcome Scale (ROS) (n = 17, 7.8%).

While there was some overlap between higher-order concepts for which these and other psychological measures were designed and employed, in Table 1 we attempted to classify measures used in the studies into broader psychological categories. As the table indicates, the studies in our sample sought to assess a wide variety of concepts related to psychological health and wellbeing, from commonly used concepts such as mood-emotion [76,77] and depression-anxiety-stress [67,78] to less-common concepts such as nature connectedness [79,80], self-esteem [81,82], mindfulness [83,84], and environmental learning [85,86]. While some of the qualitative studies tapped into similar concepts through the use of unstructured and semi-structured techniques, they also uncovered unique outcomes including an understanding of the "lived experience" of forest therapy including activity preferences and favorite places [87], improvements in the "capacitative body" of knowledge, skills, and motor-sensory capabilities [88], and "embodied spirituality" in experiencing the immensity and interconnectedness of nature [89].

We also tallied 81 different physiological measures, most of which assessed one or more aspects of heart rate (heart rate variability, RR interval) (n = 63, 46.7%) and blood pressure (systolic/diastolic) (n = 48, 35.6%) and tied to broader health concepts of stress-arousal and relaxation [90,91] (Table 1). Less-often studied measures include indicators of immune response and inflammation such as natural killer (NK) cell activity and inflammatory cytokines [64,92], physical health and mobility measures such as the Brief Physical Activity Assessment and Neck Disability Index [93,94], and cognitive function such as EEG [95,96].

3.2.2. Outcome Effects

Finally, we attempted to summarize the effects of forest therapy engagements on health and wellbeing outcomes. With many studies employing multiple outcome measures and complex research designs this was not always easy to do, but using the study abstracts and discussion/conclusion summaries as guidance to how authors characterized their principal findings, we grouped effects into four broad categories. For the 219 studies that employed psychological measures, 151 (68.9%) reported significant positive outcomes, 22 (10.0%) non-significant or mixed outcomes, no studies reported negative outcomes, and 46 studies (21.0%) reported outcomes that were too complex to be easily classified. For the 135 studies that employed physiological measures, 83 (61.5%) reported significant positive outcomes, 28 (20.7%) non-significant or mixed outcomes, 1 (0.7%) negative outcome (where the forest therapy engagement unexpectedly increased heart rate/arousal, [93]), and 23 (17.0%) whose outcomes were too complex to be easily summarized.

Table 1. Concepts measured by psychological and physiological indicators in the article set.

Concepts	*n* Articles	Percent
Psychological Concepts (*n* = 219 Articles)		
Mood-emotion	104	47.5
Depression-anxiety-stress	79	36.1
General well-being	39	17.8
Perceived restoration	32	14.6
Environmental perception-preference	25	11.4
Qualitative (e.g., open-ended)	23	10.5
Cognitive function	21	9.6
General health/lifestyle	17	7.8
Nature connectedness	14	6.4
Fatigue-insomnia	11	5.0
Self-esteem	10	4.6
Physical activity (self-report)	9	4.1
Social connectedness	7	3.2
Mindfulness	6	2.7
Pain	4	1.8
Miscellaneous	19	8.7
Physiological Concepts (*n* = 135 articles)		
Stress-arousal/relaxation	97	71.9
Immunity/inflammation	21	15.6
Physical health and mobility	12	8.9
Cognitive function	10	7.4
Diabetes	8	5.9
Miscellaneous other	21	15.6

3.3. Human Component

3.3.1. Human Characteristics Studied

Table 2 provides participant sample statistics across the entire set of articles. Because of the wide range of sample variability across the articles, the median statistic is a more representative indication of participant sample size (*Mdn* = 38.5) and average age (*Mdn* = 35), though it is noteworthy that a considerable number of studies were based on groups of 20 or less (*n* = 71, 28.1%), under 25 years of age (*n* = 93, 36.9%), and made up of either all male or all female participants (*n* = 69, 27.4%).

Table 2. Statistical summary of participant sample characteristics (*n* = 252 articles reporting).

Sample Population Statistics	*M*	*Mdn*	Mode	*SD*	Skewness	Min	Max
Number of participants	259.3	38.5	12	918.012	6.16	1	8792
Percent female	0.51	0.53	0	0.323	−0.211	0	1.00
Average age	36.7	35	22	17.806	0.434	5	83

We categorized study samples used in the articles by the populations from which they were drawn, the two largest of which were young adults and university students (*n* = 85, 33.7%) [63,97] and broadly defined samples of adults or mixed adult and student samples (*n* = 76, 30.2%) [98,99]. In contrast to these general samples, smaller sets of articles targeted specific populations of interest, including middle-aged and older adults (*n* = 27, 10.8%) [76,100], youth and families (*n* = 19, 7.6%) [101,102], forest visitors (*n* = 19, 7.5%) [55,103], forest therapy and healthcare providers (*n* = 14, 5.6%) [50,69], and healthcare recipients (*n* = 10, 4.0%) [46,104].

A few of these targeted populations matched with particular health or wellbeing concerns that were the focus of a subset of studies (*n* = 76). We categorized this smaller set of studies into five areas of concern: mental health issues (*n* = 28, 36.9%) such as severe stress/exhaustion [105,106] and trauma/PTSD [34,87]; chronic diseases (*n* = 24, 31.4%) such

as hypertension [65,72] and cancer [47,107]; youth issues (n = 10, 13.0%) such as youth who are placed at-risk [82,108] and those with learning difficulties [109,110]; individuals dealing with chronic pain or fatigue (n = 8, 10.4%) [111,112]; and those dealing with addictions (n = 4, 5.2%) [113,114].

Beyond these basic demographic and health-related characteristics, a few studies employing survey methods asked current and potential participants questions about their needs, motivations, and experience preferences with respect to forest therapy programs. Lee et al. [107] and Park [115] both conducted analyses of individuals challenged with disease about the types of programs that would best suit their needs with respect to activities, costs, and other factors. Choi [116] asked university students about their motivations and Kil et al. [55] asked onsite visitors about their recreation experience preferences for forest therapy engagements. In each of these cases the investigators aimed to better understand how programs and opportunities could be better geared to particular needs and preferences to achieve desired outcomes.

3.3.2. Human-Outcome Effects

The prevalence of articles in our full set with small, homogeneous samples is likely due to the fact that many experimental studies (the largest proportion of articles in our review set) can be labor intensive, especially when complex physiological data are collected, and by drawing from a homogeneous pool of participants in a within-subjects research design, often only small samples are needed to demonstrate statistical significance of a given outcome [117]. The disadvantage of such designs, however, is that they limit the ability to identify differences among subgroups of individuals that might respond differently to forest therapy engagements. Across all articles, we identified only 41 (16.1%) that examined differences between subgroups.

Most often these between-subject comparisons were across demographic variables in experimental studies and survey research with relatively large, broadly drawn participant samples. For example, in a large-scale population survey of Japanese residents, Morita et al. [118] found that male and older residents engaged in forest walking more frequently than female and younger residents. Additionally, in Japan, an onsite survey by Zhang et al. [56] found that female and older visitors to a National Recreational Forest placed higher emphasis on pavement conditions and degree of difficulty in selecting a trail for forest bathing than male and younger visitors. Additionally, in the UK, Marselle et al. [67] reported that frequent participants in the national Walking for Health program tended to be older, female, married, and living in the more affluent areas of the UK. While these observed differences relate to issues of site preference and use, for studies looking at other outcome variables, differences between demographic groups were not significant. For example, Kil et al. [55] found for forest bathers at South Korean forests that neither age, gender, education, nor income were significant predictors of place attachment, and in an image analysis of facial expressions of visitors to urban greenspaces in China, Liu et al. [119] found that happiness scores showed no differences by age or gender.

Beyond demographic differences, other studies have investigated and identified significant subgroup differences in outcomes as a function of A-B personality type [120], high-normal-low trait anxiety levels [121], and for those who lived and worked in forests versus urban settings [73]. A few studies in our sample examined forest therapy sites in multiple countries [103,122], but any differences were attributable more to site characteristics than the cross-national or cultural differences of participants. In contrast, while no cultural differences were explicitly compared in a survey of Malaysian students about forest therapy programs by Rajoo et al. [123], nearly 20% of the sample stated they were not interested in participating because the "animistic" association of forest bathing was against their religious beliefs and would create a negative social stigma in their conservative society.

3.4. Forest Component

3.4.1. Overall Forest Characteristics Studied

To address the forest component of our framework, we first examined the overall nature of the setting used as the basis of forest therapy engagements. In terms of landscape type, the large majority of studies were logically set in forest landscapes (n = 185, 73.7%), with successively fewer studies set in gardens (n = 29, 11.6%), including forest therapy gardens [87,124], botanic gardens [110,125], and arboreta [44,126]; mixed landscape types (n = 16, 6.4%) that often included forest areas along with non-forested landscapes such as meadows or agricultural land [127,128]; urban park and greenspace (n = 10, 4.0%) [129,130]; and other landscape types (n = 11, 4.4%) including deserts and wetlands [93,131]. Of the subset of studies set in forest environments (n = 185), forest types were broadly classified as dominantly coniferous (n = 23, 12.4%) [132,133], deciduous (n = 21, 11.4%) [134,135], mixed coniferous-deciduous (n = 53, 28.6%) [136,137], bamboo (n = 7, 3.8%) [63,138], or were unspecified (n = 81, 43.8%). Additionally, with respect to location, studies were set in rural (n = 105, 45.1%) [83,139], urban (n = 89, 38.2%) [84,140], mixed rural-urban (n = 25, 10.7%) [141,142], or were virtual studies without a specified location (n = 14, 6.0%) [143,144]. Along with these broad categorizations, the settings of 54 studies were identified as designated forest bathing or forest therapy sites, mainly in Japan [145,146], South Korea [108,111], and China [63,147].

We also sought to understand the quantitative dimensions of sites and trails used in forest therapy engagements for articles that reported them. As with the participant sample statistics reported earlier (Table 2), there was a wide variation in site characteristics and so we report median values here and refer readers to Table 3 for the full statistical summary. Most studies focused on a single site, and for the studies that reported their size (n = 67) the median size of smallest and largest sites ranged from 222–325 ha. Many studies included sites with multiple trails, although it was not always clear how many of the trails in the network at a site or across multiple sites were studied in the research. For the studies that reported trail lengths (n = 56), the median length of shortest and longest trails ranged from 2.0–2.9 km.

Table 3. Statistical summary of site and trail characteristics for the article set.

Characteristics *	*M*	*Mdn*	Mode	*SD*	Skewness	Min	Max
Site Characteristics							
Number of Sites	3.4	1	1	8.58	5	1	57
Smallest site (ha)	2907	222	1.4	9490	5.22	0.25	65,650
Largest site (ha)	4851	325	1.4	16,924	4.96	0.25	103,848
Trail Characteristics							
Shortest trail (km)	2.5	2	1	1.63	0.82	0.2	7
Longest trail (km)	3.9	2.9	2	3.63	3.31	0.6	23
Average trail (km)	3	2.5	2	1.92	1.48	0.6	11

* n = 219 articles reporting number of sites, n = 67 reporting site size, n = 57 articles reporting trail characteristics.

3.4.2. Key Forest Features and Qualities

A key aim of our Forest Therapy Trails project is to better understand the physical features and qualities of forest settings that facilitate multisensory, immersive experiences, and text analysis of forest setting descriptions in our article set provided further insights into the kinds of places that are being studied and used for forest therapy. As an indicator of descriptive detail, the word count of forest setting descriptions excerpted from the text of articles varied widely, with a median length of 30 words (M = 62.7, SD = 91.9) and with 42 articles (16.8%) offering no description outside of the mention of the name and/or location of the site. Another 68 articles (27.2%) offered only brief descriptions of 1–20 words conveying a few basic facts about the site such as forest type or location characteristics such as geographic coordinates and elevation. 84 articles (33.6%) offered what might be

considered ample descriptions of 21–100 words that included information seen in brief descriptions plus details on characteristic tree species, average tree age/size, key site features, and/or trail characteristics. At the upper end, 56 articles (22.4%) offered extensive descriptions of 202–897 words that usually included all of the previously described information plus special or unique features, historical information, and/or detailed descriptions of multiple sites.

It was primarily from the more detailed descriptions (n = 134 articles, 53.2%) that we compiled a list of notable features mentioned by authors about the sites used they for forest therapy research (Table 4). The top five most frequently mentioned features included water (e.g., waterfalls, streams with drinkable waters, therapeutic mineral springs), vegetation diversity (e.g., diverse vegetation communities, high species richness and abundance, 350 species of native and exotic trees and shrubs), designated or protected status (e.g., AAAA-level scenic area, first national healing forest in the country, forest therapy base, national park), naturalness (e.g., native forest, outstanding natural location, wild forest garden), and large trees (e.g., semi-ancient woodland, trees up to 180 years old, 300 year-old trees). Other types of attributes ranged from physical features such as terrain and fauna, to access and support facilities, to visual and extra-visual qualities.

Table 4. Notable features mentioned in forest setting descriptions in the article set (n = 134 articles reporting).

Feature	*n*	Percent	Example Citations
Water features	37	27.6	[148–150]
Rich, diverse tree/plant species	34	25.4	[131,151,152]
Designated, protected area	27	20.1	[12,82,153]
Wild, natural, unmanaged	25	18.7	[84,154,155]
Large, old growth trees	19	14.2	[80,104,156]
Accessibility	18	13.4	[56,81,157]
Scenic, special views	17	12.7	[111,130,153]
Extravisual sounds, smells, atmospheric (e.g., VOCs)	16	11.9	[35,143,151]
Diverse trail opportunities	16	11.9	[123,158,159]
Tended, garden	10	7.5	[34,81,98]
Built support features	10	7.5	[58,160,161]
Terrain	9	6.7	[137,162,163]
Unique features	8	6.0	[110,164,165]
Fauna	6	4.5	[166–168]

Building upon this by-article analysis, we used a frequency listing of terms extracted from a lexicometric analysis of forest setting descriptions to manually group terms into logical themes, four of which related to key features and characteristics of the forest setting: natural landscape, cultural landscape, evaluative, and viewscape (Table 5). Additional identified themes (landscape types, forest vegetation species, measurement units, places, weather, and activities) were less central to our purpose or were duplicative of other analyses and are not presented here.

The natural landscape theme (n = 62 terms, 771 total occurrences) included terms that were used to describe key features of the natural landscape of forest settings. Subthemes included vegetation (e.g., trees, plants, groundcover), water (e.g., waterfall, stream, lake), landform (e.g., level, slope, mountain), rock (rock, outcrop, karst), and wildlife (animals, habitat). The cultural landscape theme (56 terms, 414 occurrences) included terms relating to built and cultural features or elements of the forest setting. Subthemes included trails (e.g., trail, route, path), support facilities (e.g., shelter, bridges, stairs), people (e.g., people, visitors, tourists), interpretation (e.g., signs, interpretive, educational), and cultural/heritage (e.g., cultural, heritage, birthplace). The evaluative theme (60 terms, 575 occurrences) grouped together terms used to describe characteristics of setting quality. Subthemes included size/age (e.g., old, large, small), natural (e.g., natural, undisturbed, wild), dominance (e.g., dominated, dense, sparse), variety (e.g., varied, diverse, differ-

ent), superlative (e.g., best, famous, excellent), beauty (e.g., beautiful, scenic, pleasant), condition (e.g., suitable, good, dead), and uniqueness (e.g., special, unique, common). Additionally, the viewscape theme (36 terms, 290 occurrences) included terms used to describe spatial and sensory characteristics of the landscape. Subthemes included spatial (e.g., surrounded, open, canopied), visual (e.g., views, light, scenes), and extra-visual (e.g., sensory, sounds, aromatic).

Table 5. Relevant themes and subthemes of key features and characteristics extracted from a lexicometric analysis of forest setting descriptions in the article set.

Themes and Subthemes	*n* Terms	Total Occurrences	Percent of Occurrences
Natural landscape features and characteristics (62 terms, 771 total occurrences)			
Vegetation	28	447	58.0
Waterform	12	144	18.7
Landform	16	144	18.7
Rockform	4	30	3.9
Wildlife	2	6	0.8
Cultural landscape features and characteristics (56 terms, 414 occurrences)			
Trails	16	191	46.1
Support facilities	11	63	15.2
People	7	60	14.5
Interpretive	4	31	7.5
Cultural/heritage	4	13	3.1
Misc. other development	14	56	13.5
Evaluative characteristics and qualities (60 terms, 575 occurrences)			
Size/age	14	167	29.0
Natural	5	117	20.3
Dominance	11	107	18.6
Variety	6	61	10.6
Superlative	8	41	7.1
Beauty	5	31	5.4
Condition	6	28	4.9
Uniqueness	5	23	4.0
Viewscape characteristics (36 terms, 290 occurrences)			
Spatial	22	213	73.4
Visual	10	62	21.4
Extra-visual	4	15	5.2

3.4.3. Forest-Outcome Effects

We were especially interested in understanding how particular forest setting characteristics and features related to the outcomes of forest therapy engagements. However, only a relatively small proportion of studies (n = 50, 19.1%) examined how variations within some aspect of the forest setting influenced health and wellbeing outcomes (Table 6). For this subset, the characteristics of forest settings that were examined included variations by forest stand [164,169] and landscape type [133,170]; comparisons between different spatial and structural characteristics of forest settings [58,171]; and gradient effects including level of management [74,149], degree of naturalness [122,142], and seasonality [72,134].

Table 6. Forest outcome comparisons made by studies in the article set.

Comparison Subcategories	*n* Articles	Percent of All Studies *	Percent of Subcategory Comparisons		
			Significant Differences	Non-Significant or Mixed Differences	Results Too Complex to Code
No comparisons	100	38.3	NA	NA	NA
Forest vs. urban	77	29.5	88.0	12.0	0.0
Forest vs. control	31	11.9	74.0	26.0	0.0
Within-forest comparisons	50	19.2	48.0	40.0	12.0
Virtual comparisons	19	7.3	68.4	26.3	5.3

* Percentages do not sum to zero because some studies made multiple comparisons (e.g., forest vs. urban and within-forest comparisons).

More often, the forest setting was considered in its totality, with health or wellbeing outcomes assessed without reference to variations within any setting characteristics (n = 100, 38.3%), usually before and after a forest therapy engagement. Other studies compared a generically described forest to an equally generic urban setting (n = 64, 24.5%) such as a busy street [102,129] or campus hardscape devoid of vegetation [172,173], or to a control condition (n = 29, 11.1%) such as pursuing normal daily activities [174] or attending an indoor program [113,152] in order to compare outcomes. Yet, another category of studies used some form of virtual media (n = 19, 7.3%) to compare forest representations with virtual urban [71,175] or control conditions [98,144] or with actual forest settings [176,177].

While the majority of studies that compared generic forest settings with urban or control settings found significant differences favoring positive outcomes in forest settings, those studies that examined variations within forest settings reported fewer significant positive and more non-significant or mixed outcomes (Table 6). For example, with respect to forest stand type, Guan et al. [164] found that forest bathers in an urban park in Northeast China experienced reduced anxiety after visiting stands dominated by either birch, maple, or oak, though stand-specific anxiety reduction varied inconsistently depending on the nature of the stressor (e.g., employment worries, university assignments). Similarly, Liu et al. [178] found that participants who walked in a National Forest Park near Beijing, China, experienced greater psychological restoration and mood improvement in a coniferous forest stand compared with deciduous or mixed forest types, while reductions in blood pressure and heart rate were greater in mixed forests. Looking at the effects of management, Arnberger et al. [74] found that visitors to alpine meadows in Austria and Switzerland exhibited no differences in physiological (blood pressure) and psychological (attention restoration, stress reduction, wellbeing) outcomes between managed and unmanaged sites. In contrast, Lee et al. [149] found South Korean women with metabolic syndrome who participated in a half-day forest healing program at a wild Recreational Forest showed significantly better biophysical and psychological improvements than those who attended the same program in a tended urban forest in Seoul. With respect to landscape type, Marselle et al. [170] found that individuals from across the UK who took frequent group walks in natural environments reported similar positive outcomes with respect to psychological measures of wellbeing, depression, perceived stress, and moods across six different landscape types (natural and semi-natural places, green corridors, farmland, urban green space, coastal, urban public space, and mixed-use landscapes). Additionally, while Sonntag-Öström et al. [105,133] similarly found that participants in a forest therapy program at a boreal forest in northern Sweden experienced mood improvement irrespective of the type of landscape they chose to spend time in (forest/lake, pine forest, rock outcrop, mixed forest, spruce forest, forest/stream), there were definite preferences for certain types over others.

These examples illustrate the range of positive and mixed or non-significant outcomes found in studies where within-forest setting comparisons were made. While the small number of studies and wide range of forest, human, interaction, and outcome measures

studied prevent a more systematic analysis, one informal observation is that studies examining outcomes such as site suitability and preference were more likely to distinguish differences between forest settings than studies employing standardized psychological and physiological measures. This is not surprising, as expert-based suitability analyses [58,59] and participant-based preference assessments [75,179] are usually designed to discriminate between settings. Thus for helping to identify important features and qualities of forest settings, these types of outcome measures may display greater sensitivity than standardized psychological scales and physiological measures.

3.5. Interaction Component

3.5.1. Interaction Characteristics Studied

Consistent with our article search criteria and the objectives of our Forest Therapy Trails project, about three-quarters of the articles we reviewed focused on walking as a means of interacting with the forest setting (Table 7). In about a third of studies, participants sat or stood stationary to view the forest, while close to half included other activities besides walking or stationary viewing. Percentages in the table indicate that about half of the studies employed more than one of these major categories of forest engagement.

Table 7. Major engagement activity and other specific activities engaged in by forest therapy participants (n = 230 articles reporting).

Engagement Activity	*n* Articles	Percent	Example Citations
Basic Activities			
Walking	172	74.8	[126,180,181]
Stationary viewing	75	32.6	[182–184]
Other activities	104	45.2	[76,77,80]
Specific Other Activities			
Relaxation and relaxation/non-aerobic exercises	54	23.5	[90,91,152]
Five sense exercises, "invitations,", etc.	48	20.9	[80,174,185]
Meditation, sitting-contemplating	41	17.8	[78,108,186]
Conversation, group time, sharing, etc.	30	13.0	[34,187,188]
Purposeful hands-on engagement with nature	21	9.1	[12,68,189]
Arts and crafts activities, photography	21	9.1	[190–192]
Aerobic exercises, e.g., calisthenics, folk dancing	17	7.4	[36,82,100]
Games, forest orienteering, geocaching	16	7.0	[101,149,174]
Eating and drinking, incl forest products	16	7.0	[48,167,189]
General counseling, psychotherapy, CBT	12	5.2	[106,159,193]
Free time, unstructured time	12	5.2	[34,46,194]
Mindfulness info, forest therapy lectures	10	4.3	[125,190,195]
Environmental info about site or more general	9	3.9	[131,196,197]
Other outdoor recreational activities	9	3.9	[46,68,198]
Physical or general health info	8	3.5	[195,199,200]
Other, vague or unspecified	5	2.2	[73,201,202]

Looking more closely at other activities besides walking and stationary viewing, we identified a wide range of ways in which researchers or facilitators engaged forest therapy participants with the forest setting for achieving health and wellbeing outcomes. Foremost were relaxation activities (e.g., lying in a hammock, listening to music in the forest, stretching, yoga); "five senses" exercises to facilitate the multi-sensory, immersive experience (e.g., barefoot walking, aromatherapy, sitting by a waterfall); meditation or seated contemplation; group conversation and sharing (e.g., sitting around a campfire, sharing what one noticed or felt after a walk); purposeful hands-on engagement with nature (e.g., harvesting vegetables, wood splitting, tree planting); and nature-based arts and crafts activities (e.g., photography, making a mandala with leaves, self-expression using natural materials).

The number of "other" activities engaged in varied substantially by the main research activity type described in articles, as did other structural dimensions of the engagement as shown in Table 8 (forest experiences (n = 5) and forest air (n = 5) data not reported). For example, referring to the median values in the table, forest bathing engagements usually involved a single session of walking and or sitting for less than an hour with no other activities, while forest therapy engagements involved a program of six, three-hour sessions that included three other activities. However, as the Table 8 shows, there was a wide variation both within and between the major research activity types.

Table 8. Summary characteristics of interactions for different research activity types.

Characteristics	*M*	*Mdn*	Mode	*SD*	Skewness	Min	Max
Forest bathing							
(n = 109 articles, n = 59–66 reporting)							
Length of intervention (h)	1.33	0.75	0.25	1.270	0.975	0.17	5
Number of sessions	1.44	1	1	2.028	6.662	1	16
Total length of intervention (h)	2.39	0.75	0.25	4.854	4.610	0.17	32
Maximum group size	8.73	6	1	9.419	1.561	1	44
Tl. "other" engagement activities	0.61	0	0	1.108	2.104	0	5
Forest/nature/park walks							
(n = 76 articles, n = 33–52 reporting)							
Length of intervention (h)	1.23	0.88	2	1.031	1.528	0.23	5
Number of sessions	2.61	1	1	2.737	1.378	1	10
Total length of intervention (h)	3.67	1.5	0.25	5.555	2.315	0.23	25
Maximum group size	5.88	2	1	6.309	1.360	1	26
Tl. "other" engagement activities	0.54	0	0	1.163	2.317	0	5
Forest/nature/park therapy							
(n = 109, n = 71–89 reporting)							
Length of intervention (h)	2.82	3	2	1.922	0.267	0.02	6
Number of sessions	9.60	6	1	12.727	2.831	1	80
Total length of intervention (h)	29.03	12	12	54.490	5.538	0.02	440
Maximum group size	11.83	9	1	9.387	0.628	1	33
Tl. "other" engagement activities	2.80	3	0	2.079	−0.073	0	7
Virtual studies							
(n = 17, n = 16–17 reporting)							
Length of intervention (h)	0.10	0.08	0.03	0.089	1.466	0.02	0.33
Number of sessions	1.25	1	1	1.000	4.000	1	5
Total length of intervention (h)	0.12	0.09	0.03	0.119	1.449	0.02	0.42
Maximum group size	1.24	1	1	0.970	4.123	1	5
Tl. "other" engagement activities	0.00	0	0	0.000	-	0	0
All research activity types							
(n = 266, n = 183–230 reporting)							
Length of intervention (h)	1.86	1.50	0.25	1.759	0.919	0.02	6
Number of sessions	5.02	1	1	9.137	4.287	1	80
Total length of intervention (h)	13.46	2	0.25	37.191	8.045	0.02	440
Maximum group size	8.68	6	1	8.949	1.245	1	44
Tl. "other" engagement activities	1.43	0	0	1.913	1.034	0	7

As for the social dimensions of engagements, those studies reporting group sizes (n = 183) ranged from a median of one for virtual studies and two for forest walks to six for forest bathing and nine for forest therapy engagements. On the lower end, group sizes for some activity types such as forest walks and virtual studies seemed in large part to be an artifact of the research protocols employed in many experimental studies to ensure

independent assessments of outcomes [181,203] and/or because of complex equipment needs and measurements taken before, during, and/or after the engagement [204,205]. This included a number of studies where participants walked in or viewed the forest as a group but were instructed to keep their distance from each other and avoid interaction, for which we coded a group size of one [97,206]. On the upper end, larger group sizes tended to be from studies of forest therapy where social interaction among group participants was an explicit part of the program in helping realize health and wellbeing outcomes [123,140]. Few of these studies offered explanations for their choice of group size; the most frequent set of reasons of those that did was to reduce risk and crowding and/or to ensure a quality experience for participants (n = 10 [80]; n = 12 [137]; n = 16 [207]). In other cases, we informally observed that there were somewhat smaller group sizes for programs aimed at special populations such as youth placed at-risk (n = 8 [196]) and adults being treated with severe stress-related illnesses (n = 6 [155,179]).

Another social dimension of interest was whether forest engagements were facilitated by a forest therapy guide or other health or environmental professional. Looking across the major activity types, the highest proportion of studies where guides were part of the engagement was for forest therapy programs (n = 86, 68.6%), followed by forest experiences (n = 2, 50.0%), forest walks (n = 51, 35.3%), forest bathing (n = 65, 24.6%) and virtual studies (n = 17, 0.0%). Similar to the statistics for forest therapy programs reported in Table 8, studies that made use of a guide (n = 94) tended to include a number of longer sessions that engaged participants in multiple activities, whereas unguided engagements (n = 127) tended to be short, one-time affairs limited to walking or stationary viewing.

3.5.2. Interaction-Outcome Effects

As was the case with human and forest components, relatively few studies examined how differences between interaction variables affected health and wellbeing outcomes. The most frequent comparison was made among different forest engagement activities, especially forest walking and forest viewing. Unfortunately, the majority of studies that examined both walking and viewing focused instead on reporting forest versus urban differences and did not report statistical comparisons between the two forest-based activities [135,208,209], but those that did showed mixed effects on outcomes. In studying the psychological outcomes of forest engagements, Kobayashi et al. [210] found that participants who walked for 15 min along a 1 km forest trail in one of five different forest areas in Japan reported feeling higher vigor and lower fatigue and confusion as assessed by POMS scores than when they sat and viewed the same landscape for an equivalent time. However, no differences were found between the two engagement activities on POMS scores for tension-anxiety, depression-dejection, or anger-hostility. In contrast, Lyu et al. [166] found no differences in any of the POMS dimensions between participants who walked or viewed bamboo forest sites in China. In studying physiological outcomes, earlier studies by Kobayashi and colleagues using a similar research design and locations found that participant data on heart rate variability indicated significantly greater relaxation after viewing forests than after walking in them [211] but that levels of salivary cortisol indicated stress did not differ significantly between the two engagement types [212]. Additionally, Zeng et al. [153] concluded that viewing bamboo forests in China resulted in better physiological outcomes than walking in them, but study data showed only limited evidence of this difference for increased oxygen saturation in one of three forest sites studied and no differences between engagement type for blood pressure (SBP and DBP) or heart rate.

Beyond these focused comparisons of walking and viewing, there were a few studies that compared other forest therapy activities with similar non-forest-therapy activities also conducted within forest settings, such as green exercise [78], traditional qigong [100], and compassionate mind training [80]. Findings here were also mixed but tended to show that forest therapy and alternative therapies both led to similar, positive psychological and physiological outcomes. Additionally, in a unique study comparing a range of different forest bathing activities, Fu et al. [213] used wearable sensors to collect continuous physiological

data from participants as they were guided in a 2 h forest bathing experience at a forest in Canada, with activities and locations along the route each designed to stimulate the five senses. The investigators found many similar, positive effects and also some significant differences in physiological measures between several activity-location segments, notably the lowest skin temperature (increased focus and attention) and highest electrodermal activity (increased arousal) during the barefoot walking segment of the engagement.

In addition to forest engagement activities, a few studies compared the effect of guides and related informational interventions on forest outcomes, again with no definitive findings on the superiority of one type of engagement over the other. Igawahara et al. [214] examined psychological and physiological effects of guided versus solo forest walks in Japan. The authors found greater stress reduction from the guided walk as measured by salivary cortisol levels along with more positive emotional improvements along some POMS and semantic differential (SD) subscales, though differences along other subscales were not significant. Lim et al. [160] found no significant differences in quantitative measures of nature connectedness, mood, or heart rate between participants of guided versus unguided forest therapy walks in Singapore. However, qualitative responses from guided participants more often described their experience as refreshing, meaningful, and unique, while unguided participants more often described it as positive, mindfulness of wildlife and nature, and alert/refreshed. Kim and Shin [36] compared themes coded from essays of participants in guided forest therapy groups in South Korea with those of self-guided individuals and found that more essays from solo participants mentioned auditory elements, although other sensory perceptions did not differ. Self-guided therapy led to greater introspection while guided therapy programs yielded greater positive emotion and social interaction, though other health benefits showed no differences due to the type of forest therapy. Additionally, Korcz et al. [215] compared the responses of participants who engaged in a 10 min forest walk through a managed urban forest in Poland either alone, with a forest educator as interpretive guide, or with the aid of educational boards posted along the route describing management activities. The authors reported improved wellbeing and psychological restoration for all participant groups, with little difference found on account of educational treatment.

As a final note on interaction outcomes, while no formal comparisons were made in the studies we reviewed, we did identify several studies that sought to measure outcome effects beyond typical pre/post assessments. These tended to be multi-session forest therapy programs that extended over several weeks in length, though a few were single-session forest bathing studies. For the 21 studies we identified that measured follow-up outcomes, engagements ranged in duration from a single 2 h session to daily and weekly hours-long programs up to 16 weeks in length, and with follow-up outcomes measured from 1 week up to 5 years after the completion of the engagement. Two short-term follow-ups examined physiological outcomes. Wang et al. [216] found that individuals who took a 2 h forest walk had significantly lower levels in a urinary biomarker of stress one day after the walk that remained low one week later. Kim et al. [194] found that women with breast cancer who participated in a daily forest therapy program for 2 weeks while living in the forest showed a significant increase in immune-response NK cell activity at the end of the program. While NK activity dropped 1 week after participants returned to their home in the city, anti-cancer blood proteins produced by NK cells continued to increase. Most of the longer-term follow-ups looked at the psychological outcomes of extended forest therapy programs. For example, Korpela et al. [161] found that individuals coping with depression experienced reduced depression and improved well-being at the completion of an 8-week nature walking program, with positive impacts extending to their 3-month follow-up. Sahlin et al. [200] found that participants in a 12-week nature-based stress management course showed decreased stress, burnout, and long-term sick leave, and increased work ability; these patterns persisted 6 months after the program and for some measures further improved 12 months after. Additionally, Pálsdóttir et al. [217], in a longitudinal study of individuals experiencing stress-related mental disorders who participated in a 12-week

forest therapy program, found that nature smells had the effect of triggering sensory awareness and positive memories aiding in mental health recovery that in some cases persisted over the five-year follow-up period. Because of the small number of studies that examined these longer-term outcomes and the wide range of outcomes measured we were not able to quantify the relationship between the duration of engagements with the lasting effects of outcomes, but one study illustrates the potential limits of short-duration engagements. McEwan et al. [80] found that individuals who participated in a 2 h forest bathing experience showed improvements in positive emotions, mood, rumination, nature connection, and compassion immediately after the engagements. However, a 3-month follow-up showed that fears of compassion and rumination had increased and nature connection had decreased, with the authors concluding that regular practice is needed to maintain positive health and wellbeing outcomes.

4. Discussion

In this initial effort of our Forest Therapy Trails project, we adapted a framework from research in landscape perception [26] (Figure 1) to review empirical studies on forest therapy in relation to how human, forest, and interaction components are conceived and measured in the context of human health and wellbeing outcomes. While the 266 articles we identified were heavily dominated by experimental research designs and focused on outcomes, variations in these and other research approaches, the types of forest therapy activities studied, and other study details provided important insights into how human, forest, and interaction components have been investigated to date. In the following sections we reflect on the findings for each of these components and identify gaps and opportunities for future research.

4.1. Outcome Component

While our review identified a plethora of psychological and physiological measures used to assess the health and wellbeing outcomes of forest therapy engagements, most were aimed at a few broad concepts relating to mood-emotion and stress-arousal/relaxation. Specific psychological scales such as POMS and PANAS and physiological measures of blood pressure and salivary cortisol are long-established and validated, relatively easily to apply and interpret, and their wide use facilitates comparison of results across studies. For broadly drawn experimental designs such as pre-post assessments and comparisons between forest and urban settings, they also reliably yield positive results in support of forest therapy as a useful intervention for achieving health and wellbeing outcomes. While publication bias likely plays some role in the reporting of significant, positive results [218,219], one meta-analysis in the related area of garden therapy that corrected for underreporting of non-significant results concluded that it had little effect on the overall pattern of positive outcomes [220].

This consistency of findings across dozens of similar study replications in our review set leads us to conclude that further scholarly publication of basic, outcomes-focused assessments will be of diminishing utility unless studies speak to a fuller suite of outcome, human, forest, and interaction components described by our framework. Future work relating outcomes to the other framework components are discussed below but in considering outcomes alone, further work is needed in explicating less-studied outcomes directly and indirectly related to human health and wellbeing. For example, forest therapy engagements may lead to greater appreciation of the natural world, inspiring people to develop their environmental knowledge, outdoor skills, and become active in environmental protection activities [221–223], and studies exploring these outcomes and relationships could be fruitful not only in improving outcomes for the individuals involved but also for the natural world. Additionally, previous studies of people's aesthetic, transcendent, and spiritual experiences in forests and other natural environments have many close parallels to the multi-sensory immersive experiences that define forest therapy engagements [224–226], and further qualitative research exploring these relationships could help expand the theo-

retical grounding for forest therapy. Finally, a few studies in our review set examined how forest therapy can be used in conjunction with mindfulness practice [80,227], and given the growing interest in each of these approaches in managing stress and becoming more fully present in an increasingly distracting world, further studies integrating these approaches would be useful [228,229].

4.2. Human Component

Consistent with the preponderance of experimental research designs, a large number of forest therapy studies in our review set were based on small samples of homogeneous participants, frequently university undergraduates. The use of pre/post, within-subject designs can be an efficient strategy for assessing the outcomes of an intervention, particularly in cases where complex physiological measures are taken. However, such studies provide little insight into broader questions of who participates in forest bathing and forest therapy programs, and, importantly, who currently does not. To the contrary, the few larger-scale experimental studies and surveys in the review set show that individuals who frequently participate in forest therapy, including forest bathing, forest walks, and other related activities, tend to be older adults [56,118], and in one UK study, came from more affluent areas [67]. Such findings, while in need of further validation, raise important issues with respect to access, not only to help ensure that trails and related support facilities are designed so that they are physically accessible for older adults [56], but to also ensure that forest therapy opportunities are economically accessible for all individuals who might benefit from healthful engagements in nature [128]. Forest therapy research could benefit from additional larger-scale studies to examine between-subject differences in needs, preferences, and outcomes as a function of other social, demographic, and stakeholder groups.

The wide international scope of forest therapy is testament to the power and potential that mindful, multi-sensory engagements in forests and other natural settings can have for individuals throughout the world who are dealing with the stressful realities of modern civilization. The global community of forest therapy researchers and practitioners have much to learn from countries like Japan and South Korea, which have not only mounted strong research programs to document the benefits of forest therapy but have developed networks of forest therapy bases to accommodate and encourage participation [12,230]. At the same time, there are likely important cultural differences in how forest therapy engagements are perceived and experienced, including hesitation by some individuals in conservative societies that certain activities may go against religious or societal norms [123]. An important next step in advancing forest therapy research would be to conduct cross-cultural investigations to understand to what extent there are differences in people's nature experiences so that programs and opportunities can be designed to best meet the needs of particular cultural groups [231,232].

A strength of the studies we reviewed is the attention paid to particular groups of individuals with major health and wellbeing challenges, with more than a quarter of articles in our set focusing on some targeted population, ranging from older people living with chronic diseases [111,230], to veterans suffering post-traumatic stress [87,124], to youth who are placed at-risk [82,108]. Although the findings from these targeted investigations are highly encouraging in demonstrating the positive outcomes of forest therapy engagements, there is also a need to identify and begin to distinguish the characteristics of programs and facilities that are effective for groups facing different challenges. While programs can be flexibly adapted to meet the needs of special groups, facility design is somewhat less flexible, particularly for public facilities that must accommodate a wide variety of needs and preferences. In many cases, minimum standards for physical accessibility can help ensure that a trail can serve all individuals regardless of mobility issues [233]. However, it is also important for managers to think about going beyond minimum standards, to enhance experience of key features and qualities of the forest setting for groups such as individuals with sensory impairments, young children, and those with dementia. Whether they are general use or special use facilities, specific design considerations can aid in delivering

desired health and wellbeing outcomes [234,235]. The need for program and design diversity also applies to individuals without major health challenges, where particular motivations and experience preferences point to the need for a spectrum of forest therapy opportunities [55].

4.3. Forest Component

The identification of key features and qualities of the forest setting is a primary goal of our Forest Therapy Trails project, and while the articles in our review set often provided only meager descriptions of the settings that were studied, our text analysis yielded a ranked list of notable features such as water, diverse vegetation, and big trees along with key themes relating to natural and cultural landscape features, evaluative dimensions, and viewscape qualities. Few studies attempted to relate specific features of forest settings to health and well-being outcomes, though nearly a third of studies compared forest therapy engagements with similar visits to urban settings, with the latter frequently portrayed as stark environments lacking natural features. A high proportion of these comparisons showed significant differences in health and wellbeing outcomes, with forest engagements improving psychological and physiological indicators and urban engagements resulting in no change or a worsening of outcomes. While such comparisons set a rather low bar for measuring the success of forest therapy interventions, it is also an unfortunate and increasingly common reality that many people live their daily lives in nature-impoverished urban hardscapes. Thus the findings of these studies make a strong case for increasing access to parks, greenspace and natural areas near people's homes [236].

In contrast to these basic forest-urban comparisons, about 20% of the articles in our review set made within-forest comparisons of forest/landscape type, spatial-structure properties, level of management, and other characteristics. For these comparisons there was a much lower proportion of studies that found differences in outcomes between the conditions tested. One interpretation of these findings is that healthful engagements can be achieved in a wide range of forest settings and that their particular physical characteristics are less important than just being in green nature [170]. A parallel interpretation is that it is what you do in the forest setting that matters, and that with the proper frame of mind and/or facilitation by a forest therapy guide nearly any forest setting can provide sufficient stimulus for a healthful experience [1]. While both of these explanations can be true, it is also the case that certain characteristics of forest settings such as big trees and waterfalls are consistently associated with people's landscape preferences and are reported to produce "peak" aesthetic and other highly valued experiences for people [226,237]. In our review we identified a small number of studies that looked at preference and suitability as outcome measures, which seemed better able to discriminate between forest setting characteristics than standardized psychological and physiological indicators [57,60,156]. However, there is also an extensive research literature on landscape perception and preference [30,238], that except for selected studies [75,239] has not been linked to forest therapy research to date. While a large proportion of landscape perception work is focused on the visual quality of landscapes and addresses a scale larger than the site-based features and multisensory qualities that we identified in our text analysis, a priority next step in our Forest Therapy Trails project is to sort through this literature for findings that have relevance to forest therapy site- and trail-based engagements.

By the same token, the articles in our review set provided little information in identifying other criteria important for forest therapy site selection and for trail design and construction. For example, environmental noise and other distractions were addressed as peripheral issues in a few studies [74,240], and it would be useful to examine relevant research on such topics as noise and tranquility mapping [241], solitude and privacy [242,243] and other factors that can facilitate peaceful engagements in forest settings. Access is another key issue: site selection factors such as proximity and cost can affect people's ability to get to and use forest therapy sites [244,245], while design factors such as trail grade and surfacing can make sites accessible for users including older individuals and those

with mobility impairments [246]. Again, such considerations were examined in only a few articles in our review set [40,115] and review of other work relating to trail choice preferences and design and construction standards could provide useful guidance for the siting and design of forest therapy trails.

In terms of future research relating to the forest component in our framework, studies in our article set that yielded the most useful information about salient features and qualities tended not to be experimental research but rather employed surveys with questions relating to site feature preferences [86,156], image analysis including feature identification and eye-tracking [204,247], expert assessments such as site inventories of key site attributes [59], and qualitative techniques such as content analysis of participants' sketches [248] and observation of where participants spent time within a forest therapy site [249]. While this work constituted only a small fraction of the article set, the techniques employed are well-suited to identifying key features and qualities and further work of this type should be encouraged. Choice modeling is another tool that is especially well-suited to questions in this realm, and has been successfully used to identify key attributes of sites and trails in other recreational contexts [250].

4.4. Interaction Component

Our analysis found that forest therapy interactions varied widely in terms of activity types and number of activities engaged in, duration, group size, and guide facilitation, with notable differences in these structural and social dimensions as a function of whether investigators characterized the engagements they studied as forest bathing, a forest therapy program, or another major activity type. We were somewhat surprised by the limited nature of forest bathing interactions reported, with modal values reflecting more than 40% of the 59 studies in its activity type (Table 8) showing forest bathing as an unguided solo engagement of walking in or stationary viewing of forests for 15 min. In contrast, forest therapy studies tended to be longer duration, multi-activity group programs involving multiple sessions guided by a forest therapy expert. While the table statistics show variation both within and between these and other activity types, one observation between forest bathing and forest therapy studies is that the former tended to be set up as research experiments with the structural dimensions defined by the researcher while the latter were often established or pilot programs with the research serving more as a program evaluation. In the case of experimental studies of forest bathing, it is encouraging to see that even brief nature encounters appear to reliably produce a positive impact on people's health and wellbeing, but for forest therapy practitioners it is important to note that the structural and social dimensions of interactions we reported may in part be an experimental artifact and may not be indicative of typical forest bathing. While there are good examples of actual programs examined in each of the major research activity types in our review set, further work on forest bathing and forest walks might fruitfully examine situations where engagements can be studied as natural experiments so that their findings are more translatable into practice [27].

While there were few studies in our review set that examined how differences in the ways people interact with forest settings affected health and wellbeing outcomes, those that did raise important questions for further research. In terms of person-forest interactions, work by Kobayashi et al. [210–212] and Zeng et al. [153] yielded somewhat ambiguous findings but seemed to indicate that stationary viewing activities may provide participants with a more relaxing experience while walks may increase vigor and lower fatigue. This sounds logical, but both walking and viewing are operationalized in many of the experimental studies as rather passive ways of person-forest interaction and may not invoke the fuller range of emotional, cognitive, and behavioral responses possible through more active interactions with forest settings [251]. For example, activities employed in some of the forest therapy programs we reviewed such as five-senses exercises [77,209], hands-on nature-based arts and crafts [252,253], and purposeful activities like picking vegetables and planting trees [34,254] invite actions that put participants in direct, intimate contact

with nature. Such activities may extend the benefits of forest therapy engagements beyond typical psychological and physiological health benefits into other areas of wellbeing such as environmental learning and stewardship [255,256] and building reciprocal relationships between people and nature [257]. In our review set the study by Fu et al. [213] suggests one way in which research can begin to investigate how different types of interactions can affect people's response to forests, and further exploration using a full range of quantitative and qualitative approaches is warranted.

People's interactions with forests also take place in a social context, and studies in our set provided information regarding group size and guided versus unguided forest therapy engagements. Data from our analysis showed that median groups sizes varied by major activity type and tended to be highest for forest therapy programs, with explanations by investigators for limiting sizes to reduce risk and crowding and to maintain a quality experience. The research designs of many studies restricted engagements to one person at a time to maintain independence in the measurement of outcomes, and while this may tend to deflate group size estimates, the few studies that did explicitly compare guided group versus unguided solo engagements showed that each type of interaction can yield unique and beneficial outcomes [36,160,214]. One idea for improving knowledge about preferred types of social interactions and other aspects of forest engagements would be to include a few debriefing questions at the end of more formal outcomes assessments asking participants about their satisfaction with the experience and what might be done to improve it.

5. Conclusions

In this scoping review of empirical research in forest therapy we adapted a framework developed by Zube et al. [26] in the context of landscape perception research to better understand the human-forest interactions that lead to health and wellbeing outcomes. Based on their review, Zube et al. [26] proposed a set of considerations or principles that they concluded should drive further study in landscape perception. Building on their work, we summarize our own findings and recommendations in the following set of principles for helping guide forest therapy research and programs:

(1) Forest therapy settings are multimodal, surrounding, information-rich environments. They invite movement and exploration and engage the participant. A goal for forest therapy research is to understand the full range of sensory information and experiences that forest settings can provide. A related goal of forest therapy programs is to facilitate the expansion of people's umwelt through the provision of high-quality settings and interpretive information.

(2) Forest therapy settings provide central and peripheral information. Information is received through direct attention to environmental stimuli as well as peripherally from outside the focus of attention, some of which can be distracting and interfere with desired forest therapy experiences and outcomes. A goal for forest therapy research and programs is to understand the factors that contribute to pleasing and healthful engagements while minimizing or avoiding negative factors.

(3) People's access to forest therapy settings and opportunities is varied. Access is influenced by physical factors such as proximity, individual abilities and comfort, and facility design; and by social factors such as cost, socio-demographic, and cultural differences. A goal of forest therapy research and programs is to work toward equity and inclusion for all who desire and can benefit from forest therapy engagements.

(4) Forest therapy interactions have an ambience. Interactions arise in relation to aesthetic and systemic qualities of the setting and are mediated through various structural and social factors such as activity and whether one is alone and unguided or with a guided group. The goal of forest therapy research and programs is to better understand the ambient qualities of interactions and how they can best meet the preferences and constraints of individuals.

(5) Meaningful forest therapy interactions can be highly variable. They can range from brief, passive, encounters while sitting or walking or can involve extended, multi-activity programs designed to actively engage individuals and groups to attain specific health and wellbeing outcomes. A goal of forest therapy research is to understand the unique and shared benefits of various interactions. A related goal of forest therapy practice is to provide programs and opportunities that serve people's needs, including frequent short-term restoration and longer-term physical, emotional, and behavioral change.

(6) Forest therapy engagements result in a range of health and wellbeing outcomes. Outcomes range from perceptual expressions of preference and choice; to psychological and physiological improvements in emotions, stress, and relaxation; to cognitive and behavioral changes that improve people as individuals and their relationships with the human and nonhuman world. A goal of forest therapy research and programs is to explicate and manifest the full range of outcomes.

In closing, we note some important limitations in our review. Our search strategy and coding procedures were largely confined to articles in English, which limited information that could be access and retrieved from studies reported in other languages, particularly pioneering work in forest therapy by Japanese and South Korean scholars. Additionally, while our coding strategy necessarily grouped some items within the human, landscape, interaction, and outcome categories into a manageable number of themes and subthemes, in doing so we acknowledge losing some important specificity that could help better understand the nature of forest therapy engagements. Additionally, while some coding categories we used represent discrete, independent concepts, we acknowledge that some measures used in forest therapy research tap multiple, interdependent dimensions of forest landscapes and people's responses to them.

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Conflicts of Interest: The authors declare no conflict of interest.

Appendix A

Table A1. Summary characteristics of all articles in review (n = 266).

Reference Number	Citation	Research Type	Main Activity	Country	Landscape Type	Urban-Rural	Affiliation
[179]	Adevi et al., 2018	qualitative	forest therapy	Sweden	garden	urban	For-Soc
[143]	Alyan et al., 2021	experimental	virtual	NA	forest	virtual	EnvSci
[201]	An et al., 2019	experimental	forest experience	China	forest	urban	Forestry
[74]	Arnberger et al., 2018	experimental	forest therapy	Europe	mixed	rural	missing
[258]	Bach et al., 2021	experimental	forest walks	Spain	forest	rural	Mod-Soc-Env
[259]	Bang et al., 2016	experimental	forest walks	S. Korea	forest	missing	Medical
[199]	Bang et al., 2017	experimental	forest walks	S. Korea	forest	urban	Medical
[260]	Bang et al., 2018	experimental	forest therapy	S. Korea	forest	urban	Medical

Table A1. *Cont.*

Reference Number	Citation	Research Type	Main Activity	Country	Landscape Type	Urban-Rural	Affiliation
[168]	Baroqah et al., 2021	experimental	forest therapy	Indonesia	forest	rural	Forestry
[261]	Berger 2006	qualitative	forest therapy	Israel	greenspace	urban	Forestry
[109]	Berger 2008	qualitative	forest therapy	Israel	greenspace	urban	Forestry
[187]	Berger & Lahad 2010	qualitative	forest therapy	Israel	greenspace	urban	Forestry
[44]	Berman et al., 2012	experimental	forest walks	US	garden	urban	SocSci
[134]	Bielinis et al., 2018a	experimental	forest bathing	Poland	forest	urban	Forestry
[97]	Bielinis et al., 2018b	experimental	forest bathing	Poland	forest	urban	Forestry
[262]	Bielinis et al., 2019a	experimental	forest therapy	Poland	forest	urban	For-Soc-Env
[263]	Bielinis et al., 2019b	experimental	forest bathing	Poland	forest	urban	Forestry
[104]	Bielinis et al., 2020a	experimental	forest bathing	Poland	forest	urban	For-Soc
[175]	Bielinis et al., 2020b	experimental	virtual	Finland	forest	virtual	Forestry
[172]	Bielinis et al., 2021	experimental	forest bathing	Finland	forest	urban	Forestry
[129]	Bratman et al., 2015	experimental	forest walks	US	park	urban	Soc-Env
[176]	Calogiuri et al., 2018	experimental	virtual	Norway	trail	urban	Med-Forest
[57]	Capecchi et al., 2021	expert assessment	forest therapy	Italy	forest	rural	For-Soc
[83]	Cervinka et al., 2020	experimental	forest walks	Austria	forest	rural	Med-Soc
[264]	Cha & Kim 2009	qualitative	forest experience	S. Korea	forest	NS	Medical
[79]	Chan et al., 2021	experimental	virtual	Singapore	forest	virtual	SocSci
[207]	Chen et al., 2018	experimental	forest therapy	Taiwan	forest	rural	Forestry
[116]	Choi 2018	survey	forest therapy	S. Korea	missing	missing	missing
[11]	Chou et al., 2021	experimental	forest walks	Taiwan	forest	rural	Forestry
[227]	Clarke et al., 2021	qualitative	forest bathing	UK	missing	missing	Med-Forest
[167]	Conti 2019	qualitative	forest experience	missing	missing	missing	missing
[155]	Corazon et al., 2018a	experimental	forest therapy	Denmark	garden	urban	Forestry
[113]	Corazon et al., 2018b	experimental	forest therapy	Denmark	garden	urban	Med-Forest
[144]	Crossan & Salmoni 2021	experimental	virtual	Canada	forest	virtual	Forestry
[127]	Dahlan et al., 2021	expert assessment	forest bathing	Indonesia	mixed	rural	Forestry
[265]	Davydenko & Peetz 2017	experimental	forest walks	Canada	trail	urban	SocSci
[58]	Dodev et al., 2021	expert assessment	forest therapy	Bulgaria	forest	rural	Forestry
[266]	Dolling et al., 2017	experimental	forest therapy	Sweden	forest	urban	Forestry
[139]	Droli et al., 2021	expert assessment	forest therapy	Italy	forest	rural	missing
[46]	Dybvik et al., 2018	qualitative	forest therapy	Norway	garden	rural	missing
[52]	Edwards & Woods 2018	qualitative	forest therapy	Canada	forest	rural	Med-Soc
[184]	Elsadek et al., 2021	experimental	virtual	China	forest	NS	Forestry
[69]	Farkić et al., 2020	qualitative	forest experience	UK	water	rural	Forestry
[48]	Farkić et al., 2021	qualitative	forest bathing	Serbia	forest	rural	For-Soc
[213]	Fu et al., 2022	experimental	forest bathing	Canada	forest	rural	Medical
[145]	Furuyashik et al., 2019	experimental	forest bathing	Japan	forest	rural	Medical
[204]	Gao et al., 2021a	experimental	virtual	China	forest	virtual	Forestry
[156]	Gao et al., 2021b	survey	forest walks	Japan	forest	rural	Forestry
[164]	Guan et al., 2017	experimental	forest bathing	China	forest	urban	Forestry
[88]	Guyon F. 2020	qualitative	forest bathing	France	forest	rural	missing
[111]	Han et al., 2016	experimental	forest therapy	S. Korea	forest	rural	Medical
[47]	Harmon 2019	qualitative	forest therapy	missing	forest	NS	missing
[192]	Hohashi & Kobayashi 2013	experimental	forest bathing	Japan	garden	urban	Medical
[101]	Hong et al., 2021	experimental	forest therapy	S. Korea	forest	rural	Forestry
[267]	Horiuchi et al., 2015	experimental	forest walks	Japan	forest	rural	Medical
[150]	Huber et al., 2019	experimental	forest therapy	Austria	water	rural	Medical
[214]	Igawahara et al., 2007	experimental	forest bathing	Japan	forest	rural	missing
[268]	Ikei et al., 2014	experimental	forest therapy	Japan	forest	rural	Medical
[269]	Ikei et al., 2015	experimental	forest therapy	Japan	forest	rural	Medical
[98]	Iwata et al., 2016	experimental	forest walks	Ireland	various	rural	Med-Forest
[126]	Izenstark et al., 2021	experimental	forest walks	US	garden	missing	SocSci
[180]	Janeczko et al., 2020	experimental	forest bathing	Poland	forest	urban	Medical
[270]	Jeon et al., 2018	experimental	forest therapy	S. Korea	forest	urban	Forestry
[108]	Jeon et al., 2021	experimental	forest therapy	S. Korea	forest	rural	Med-Forest
[271]	Jia et al., 2016	experimental	forest bathing	China	forest	rural	Medical
[120]	Jo et al., 2020	experimental	forest therapy	Japan	forest	rural	Med-Forest
[183]	Joung et al., 2015	experimental	forest therapy	S. Korea	forest	missing	Med-For-Soc
[158]	Joung et al., 2020	experimental	forest bathing	S. Korea	forest	rural	For-Soc
[272]	Joye et al., 2020	experimental	virtual	Europe	forest	virtual	SocSci
[186]	Jung et al., 2015	experimental	forest therapy	S. Korea	forest	rural	Medical
[273]	Kamitsis & Simmonds 2017	qualitative	forest therapy	various	missing	missing	SocSci
[94]	Kang B et al., 2015	experimental	forest bathing	S. Korea	forest	missing	Medical
[191]	Kang B.-H. & Shin 2020	experimental	forest therapy	S. Korea	mixed	urban	Forestry
[99]	Kang H. & Chae 2021	experimental	forest therapy	S. Korea	missing	missing	Medical

Table A1. *Cont.*

Reference Number	Citation	Research Type	Main Activity	Country	Landscape Type	Urban-Rural	Affiliation
[274]	Kang H.W. & Lee 2021	qualitative	forest therapy	S. Korea	forest	missing	Medical
[81]	Kang S.-J. et al., 2021	experimental	forest therapy	S. Korea	forest	rural	Medical
[275]	Keenan et al., 2021	experimental	forest walks	Ireland	various	rural	SocSci
[55]	Kil et al., 2021	survey	forest bathing	S. Korea	forest	various	Forestry
[194]	Kim B.J. et al., 2015	experimental	forest therapy	S. Korea	forest	rural	Med-Forest
[276]	Kim G. et al., 2020	expert assessment	forest air	S. Korea	forest	rural	Med-Forest
[154]	Kim H. et al., 2019	experimental	forest therapy	S. Korea	forest	rural	Medical
[185]	Kim H. et al., 2020	experimental	forest therapy	S. Korea	forest	rural	Med-Soc
[82]	Kim I.-O. et al., 2020	experimental	forest therapy	S. Korea	forest	rural	Forestry
[277]	Kim J.-C. et al., 2019	experimental	forest air	S. Korea	missing	missing	EnvSci
[36]	Kim J.-G. & Shin 2021	experimental	forest therapy	S. Korea	forest	urban	Forestry
[174]	Kim J.-G. et al., 2020	experimental	forest therapy	S. Korea	forest	urban	Forestry
[278]	Kim J.-G. et al., 2021	experimental	forest therapy	S. Korea	forest	urban	Forestry
[279]	Kiper et al., 2016	expert assessment	forest walks	Turkey	mixed	rural	Forestry
[141]	Kobayashi et al., 2015	experimental	forest therapy	Japan	forest	various	Med-Forest
[211]	Kobayashi et al., 2018	experimental	forest walks	Japan	forest	various	Med-Forest
[212]	Kobayashi et al., 2019	experimental	forest walks	Japan	forest	various	Med-Forest
[210]	Kobayashi et al., 2021	experimental	forest walks	Japan	forest	various	Med-Forest
[68]	Komppula et al., 2017	qualitative	forest experience	Finland	missing	missing	missing
[215]	Korcz et al., 2021	experimental	forest bathing	Poland	forest	urban	Forestry
[161]	Korpela et al., 2016	experimental	forest walks	Finland	various	urban	SocSci
[103]	Korpela et al., 2017	experimental	forest walks	Europe	forest	rural	For-Soc
[181]	Koselka et al., 2019	experimental	forest walks	US	forest	urban	Med-Soc
[198]	Kotera & Fido 2021	experimental	forest bathing	Japan	forest	rural	SocSci
[140]	Lee H.J. et al., 2019	qualitative	forest therapy	S. Korea	forest	urban	Forestry
[280]	Lee J. et al., 2011a	experimental	forest therapy	Japan	forest	urban	Med-Forest
[45]	Lee J. et al., 2011b	experimental	forest bathing	Japan	forest	rural	Med-Forest
[281]	Lee J. et al., 2014	experimental	forest walks	Japan	forest	rural	Medical
[188]	Lee J.-H. et al., 2020	experimental	forest therapy	S. Korea	forest	urban	Forestry
[282]	Lee J.-Y. et al., 2014	experimental	forest walks	S. Korea	forest	urban	Medical
[149]	Lee K.J. et al., 2018	experimental	forest therapy	S. Korea	forest	various	Medical
[107]	Lee M.-M. et al., 2020	survey	forest therapy	S. Korea	missing	missing	Forestry
[197]	Li C. et al., 2020	experimental	virtual	China	forest	virtual	For-Soc
[283]	Li Q. et al., 2007	experimental	forest bathing	Japan	forest	rural	Med-Forest
[284]	Li Q. et al., 2008a	experimental	forest bathing	Japan	forest	rural	Med-Forest
[285]	Li Q. et al., 2008b	experimental	forest bathing	Japan	forest	rural	Med-Forest
[286]	Li Q. et al., 2011	experimental	forest walks	Japan	forest	urban	Forestry
[287]	Li Q. et al., 2016	experimental	forest bathing	Japan	forest	rural	Med-Forest
[160]	Lim P.Y. et al., 2020	experimental	forest therapy	Singapore	garden	urban	SocSci
[95]	Lim Y.-S. et al., 2021	experimental	forest therapy	S. Korea	forest	urban	Med-Forest
[147]	Lin W et al., 2022	experimental	forest walks	China	forest	urban	Forestry
[288]	Liu P. et al., 2021a	image analysis	forest therapy	China	forest	urban	Forestry
[119]	Liu P. et al., 2021b	image analysis	forest bathing	China	park	urban	Forestry
[169]	Liu Q. et al., 2021a	experimental	forest therapy	China	forest	urban	For-Env
[178]	Liu Q. et al., 2021b	experimental	forest therapy	China	forest	urban	For-Env
[50]	Lygum et al., 2019	qualitative	forest therapy	Denmark	garden	urban	Forestry
[166]	Lyu et al., 2019a	experimental	forest therapy	China	forest	various	Forestry
[63]	Lyu et al., 2019b	experimental	forest therapy	China	forest	various	Forestry
[196]	Macháčková et al., 2021	experimental	forest bathing	Czech Rep.	forest	NS	Forestry
[289]	Mao G.-X. et al., 2012a	experimental	forest bathing	China	forest	rural	Med-Forest
[290]	Mao G.-X. et al., 2012b	experimental	forest bathing	China	forest	urban	Med-Forest
[92]	Mao G.-X. et al., 2017	experimental	forest bathing	China	forest	rural	Med-Forest
[233]	Mao G.-X. et al., 2018	experimental	forest bathing	China	forest	rural	Med-Forest
[291]	Markwell & Gladwin 2020	experimental	forest bathing	UK	forest	NS	SocSci
[67]	Marselle et al., 2013	experimental	forest walks	UK	various	various	Med-Forest
[292]	Marselle et al., 2014	experimental	forest walks	UK	various	various	Many
[170]	Marselle et al., 2015	experimental	forest walks	UK	various	various	Many
[142]	Marselle et al., 2016	experimental	forest walks	UK	various	various	Med-Soc
[293]	Marselle et al., 2019	experimental	forest walks	UK	various	various	Med-Env
[131]	Maund et al., 2019	experimental	forest therapy	UK	water	rural	For-Soc-Env
[177]	Mayer et al., 2009	experimental	forest walks	US	forest	urban	SocSci
[85]	McClain & Zimmerman 2014	qualitative	forest walks	US	forest	urban	SocSci
[80]	McEwan et al., 2021	experimental	forest bathing	UK	forest	rural	For-Soc
[122]	Mena-García et al., 2020	experimental	forest walks	Europe	various	various	SocSci
[294]	Meneguzzo et al., 2019	expert assessment	forest air	Italy	forest	rural	For-Soc

Table A1. *Cont.*

Reference Number	Citation	Research Type	Main Activity	Country	Landscape Type	Urban-Rural	Affiliation
[148]	Meneguzzo et al., 2021	experimental	forest therapy	Italy	forest	rural	Med-For-Soc
[60]	Menser et al., 2021	image analysis	forest therapy	missing	missing	missing	Medical
[125]	Meore et al., 2021	experimental	forest walks	US	garden	urban	Med-Forest
[138]	Mihardja et al., 2021	qualitative	forest bathing	Indonesia	forest	rural	SocSci
[295]	Morita et al., 2007	experimental	forest bathing	Japan	forest	rural	Med-For-Soc
[163]	Morita et al., 2009	survey	forest walks	Japan	forest	rural	Med-Env
[157]	Morita et al., 2011a	experimental	forest walks	Japan	forest	rural	Med-Soc
[296]	Morita et al., 2011b	survey	forest walks	Japan	forest	missing	Med-Soc
[118]	Morita et al., 2013	survey	forest walks	Japan	forest	various	Medical
[54]	Morita et al., 2019	survey	forest walks	Japan	forest	missing	Med-Forest
[84]	Muro et al., 2022	experimental	forest bathing	Spain	forest	urban	Med-For-Soc
[193]	Nakau et al., 2013	experimental	forest therapy	Japan	park	urban	Med-Forest
[89]	Naor & Mayseless 2020	qualitative	forest therapy	various	missing	missing	SocSci
[49]	Naor & Mayseless 2021a	qualitative	forest therapy	various	missing	missing	SocSci
[297]	Naor & Mayseless 2021b	qualitative	forest therapy	various	missing	missing	SocSci
[298]	Naor & Mayseless 2021c	qualitative	forest therapy	various	missing	missing	SocSci
[299]	Nisbet & Zelenski 2011	experimental	forest walks	Canada	trail	urban	SocSci
[76]	Ochiai et al., 2015a	experimental	forest therapy	Japan	forest	rural	Med-Forest
[300]	Ochiai et al., 2015b	experimental	forest therapy	Japan	forest	rural	Med-Forest
[114]	Ochiai et al., 2020	experimental	forest therapy	Japan	forest	rural	Med-Forest
[301]	Oh et al., 2020	qualitative	forest therapy	S. Korea	forest	various	Forestry
[12]	Ohe et al., 2017	experimental	forest therapy	Japan	forest	rural	For-Soc
[302]	Ohtsuka et al., 1998a	experimental	forest bathing	Japan	forest	missing	Medical
[303]	Ohtsuka et al., 1998b	experimental	forest bathing	Japan	forest	missing	Medical
[217]	Pálsdóttir et al., 2021	qualitative	forest therapy	Sweden	garden	urban	For-Env
[203]	Park B.-J. et al., 2007	experimental	forest bathing	Japan	forest	urban	For-Env
[136]	Park B.-J. et al., 2008	experimental	forest bathing	Japan	forest	rural	Med-Forest
[304]	Park B.-J. et al., 2009	experimental	forest bathing	Japan	forest	missing	Medical
[208]	Park B.-J. et al., 2011	experimental	forest bathing	Japan	forest	rural	Forestry
[305]	Park B.-J. et al., 2014	experimental	forest bathing	Japan	forest	missing	Med-Forest
[306]	Park B.-J. et al., 2020	experimental	forest therapy	S. Korea	forest	rural	For-Soc
[115]	Park K.-H. 2022	survey	forest therapy	S. Korea	missing	missing	Medical
[90]	Park S. et al., 2021b	experimental	forest therapy	S. Korea	forest	rural	Med-Forest
[307]	Pasanen et al., 2018	experimental	forest walks	Finland	garden	urban	For-Soc
[64]	Peterfalvi et al., 2021	experimental	forest bathing	Hungary	forest	rural	Medical
[34]	Poulsen et al., 2016	experimental	forest therapy	Denmark	garden	urban	missing
[124]	Poulsen et al., 2018	experimental	forest therapy	Denmark	garden	urban	Forestry
[165]	Pratiwi et al., 2019	experimental	forest therapy	Japan	forest	urban	For-Env
[308]	Pratiwi et al., 2020	experimental	forest therapy	Japan	forest	urban	Forestry
[123]	Rajoo et al., 2019	experimental	forest therapy	Malaysia	forest	urban	For-Env
[130]	Rajoo et al., 2020b	experimental	forest therapy	Malaysia	forest	urban	For-Env
[78]	Rajoo et al., 2021	experimental	forest therapy	Malaysia	park	urban	Forestry
[189]	Ramshini et al., 2018	experimental	forest therapy	Iran	greenspace	urban	SocSci
[70]	Reese et al., 2022	experimental	virtual	Germany	forest	urban	SocSci
[62]	Roviello & Roviello 2021a	epidemiological	forest bathing	Italy	various	various	EnvSci
[309]	Roviello & Roviello 2021b	epidemiological	forest bathing	Italy	various	various	EnvSci
[310]	Rozmi et al., 2020	qualitative	virtual	missing	forest	virtual	Soc-Env
[200]	Sahlin et al., 2014	experimental	forest therapy	Sweden	forest	rural	Med-Soc
[311]	Saito et al., 2019	experimental	forest bathing	Japan	forest	rural	Med-Env
[102]	Schutte et al., 2017	experimental	forest walks	US	trail	urban	SocSci
[93]	Scott et al., 2021	experimental	forest walks	US	desert	rural	For-Soc
[190]	Serrat et al., 2020	experimental	forest therapy	Spain	forest	NS	Med-For-Soc
[312]	Shin W.S. et al., 2012	experimental	forest therapy	S. Korea	forest	rural	Forestry
[66]	Shin Y.-K. et al., 2013	experimental	forest walks	S. Korea	forest	rural	Med-Soc
[173]	Shrestha et al., 2021	experimental	forest walks	Ireland	trail	urban	SocSci
[87]	Sidenius et al., 2017a	qualitative	forest therapy	Denmark	garden	urban	Med-For-Env
[51]	Sidenius et al., 2017b	qualitative	forest therapy	Denmark	garden	urban	For-Env
[313]	Sidenius et al., 2020	experimental	forest therapy	Denmark	garden	urban	Forestry
[314]	Song et al., 2013a	experimental	forest bathing	Japan	forest	various	Medical
[315]	Song et al., 2013b	experimental	forest walks	Japan	park	urban	Medical
[316]	Song et al., 2014	experimental	forest bathing	Japan	forest	various	Medical
[77]	Song et al., 2015	experimental	forest bathing	Japan	forest	rural	Med-Forest
[317]	Song et al., 2016	experimental	forest bathing	Japan	forest	various	Med-Forest
[65]	Song et al., 2017a	experimental	forest bathing	Japan	forest	rural	Med-Forest
[91]	Song et al., 2017b	experimental	forest therapy	Japan	forest	rural	Med-Forest
[318]	Song et al., 2018a	experimental	virtual	Japan	forest	virtual	Med-Forest
[121]	Song et al., 2018b	experimental	forest bathing	Japan	forest	various	Med-Forest

Table A1. *Cont.*

Reference Number	Citation	Research Type	Main Activity	Country	Landscape Type	Urban-Rural	Affiliation
[319]	Song et al., 2019a	experimental	forest bathing	Japan	forest	rural	Med-Forest
[320]	Song et al., 2019b	experimental	forest bathing	Japan	forest	rural	Med-Forest
[321]	Song et al., 2019c	experimental	virtual	Japan	forest	virtual	Med-Forest
[182]	Song et al., 2020a	experimental	forest bathing	Japan	forest	rural	Med-Forest
[206]	Song et al., 2020b	experimental	forest bathing	Japan	forest	various	Med-Forest
[205]	Song et al., 2021	experimental	virtual	Japan	forest	virtual	Med-Forest
[133]	Sonntag-Öström et al., 2011	experimental	forest therapy	Sweden	forest	urban	Medical
[322]	Sonntag-Öström et al., 2014	experimental	forest therapy	Sweden	forest	urban	Med-For-Soc
[323]	Sonntag-Öström et al., 2015a	experimental	forest therapy	Sweden	forest	urban	Med-For-Env
[105]	Sonntag-Öström et al., 2015b	experimental	forest therapy	Sweden	forest	urban	Med-For-Soc
[53]	Spurio 2021	qualitative	forest bathing	Italy	forest	urban	SocSci
[247]	Stevenson et al., 2019	experimental	forest walks	Norway	mixed	rural	Med-Forest
[110]	Stevenson et al., 2021	experimental	forest walks	New Zealand	garden	urban	Medical
[151]	Stigsdotter et al., 2017	experimental	forest walks	Denmark	garden	urban	For-Soc
[106]	Stigsdotter et al., 2018	experimental	forest therapy	Denmark	garden	urban	Med-For-Soc
[86]	Suksri et al., 2021	survey	forest walks	Thailand	forest	rural	Forestry
[159]	Sung et al., 2012	experimental	forest therapy	S. Korea	forest	rural	Medical
[209]	Takayama et al., 2014	experimental	forest bathing	Japan	forest	rural	Med-Forest
[132]	Takayama et al., 2017a	experimental	forest bathing	Japan	forest	rural	For-Soc
[324]	Takayama et al., 2017b	experimental	forest bathing	Japan	forest	rural	Forestry
[325]	Takayama et al., 2019	experimental	forest bathing	Japan	forest	rural	Forestry
[326]	Takayama et al., 2022	experimental	virtual	Japan	forest	virtual	For-Env
[202]	Thomas et al., 2020	experimental	forest therapy	Australia	garden	rural	Medical
[73]	Tsao et al., 2018	experimental	forest air	Taiwan	forest	rural	Med-For-Env
[135]	Tsunetsugu et al., 2007	experimental	forest bathing	Japan	forest	rural	Forestry
[248]	Ueda & Takayama 2011	qualitative	forest bathing	Japan	forest	rural	Forestry
[327]	Varning Poulsen et al., 2021	qualitative	forest therapy	Denmark	garden	urban	SocSci
[152]	Vujcic et al., 2017	experimental	forest therapy	Serbia	garden	urban	For-Soc
[254]	Vujcic Trkulja et al., 2021	experimental	forest therapy	Serbia	garden	urban	For-Soc
[59]	Wajchman-Świtalska et al., 2021	expert assessment	forest therapy	Poland	garden	urban	Forestry
[328]	Wang C. et al., 2019	survey	forest therapy	China	missing	missing	SocSci
[239]	Wang D.-H. et al., 2018	experimental	forest walks	Japan	forest	rural	Medical
[216]	Wang X. et al., 2019	experimental	virtual	China	forest	virtual	Forestry
[128]	Ware 2022	qualitative	forest bathing	Canada	trail	rural	Arts
[329]	Wei et al., 2019	image analysis	forest bathing	China	forest	urban	EnvSci
[61]	Wei et al., 2020	image analysis	forest bathing	China	forest	urban	Forestry
[240]	Wei et al., 2021	image analysis	forest bathing	China	garden	urban	Med-For-Env
[330]	White et al., 2018	qualitative	forest therapy	UK	garden	urban	Med-Env
[195]	Willert et al., 2014	experimental	forest therapy	Denmark	garden	rural	Medical
[331]	Wu et al., 2019	experimental	forest therapy	China	forest	rural	Med-Forest
[146]	Yamada et al., 2020a	experimental	forest walks	Japan	forest	rural	Med-Soc
[332]	Yamada et al., 2020b	experimental	forest walks	Japan	forest	rural	Medical
[333]	Yamaguchi et al., 2006	experimental	forest bathing	Japan	forest	rural	Forestry
[96]	Yi et al., 2019	experimental	forest therapy	S. Korea	forest	missing	Med-Forest
[100]	Yi et al., 2021	experimental	forest therapy	S. Korea	forest	urban	Med-Forest
[253]	Yu C.-P. & Hsieh 2020	experimental	forest therapy	Taiwan	garden	urban	Med-Forest
[137]	Yu C.-P. et al., 2017	experimental	forest bathing	Taiwan	forest	rural	Med-Forest
[37]	Yu C.-P. et al., 2021	experimental	forest therapy	Taiwan	forest	rural	Med-Forest
[252]	Yu Y.-M. et al., 2016	experimental	forest therapy	S. Korea	forest	rural	Forestry
[71]	Zabini et al., 2020	experimental	virtual	Italy	forest	virtual	Med-For-Soc
[153]	Zeng et al., 2020	experimental	forest therapy	China	forest	various	Forestry
[171]	Zhang J. et al., 2021	image analysis	forest bathing	China	park	urban	Forestry
[249]	Zhang T. et al., 2013	survey	forest walks	Japan	forest	rural	missing
[35]	Zhang T. et al., 2015	survey	forest bathing	Japan	forest	rural	Forestry
[56]	Zhang T. et al., 2019	survey	forest bathing	Japan	forest	rural	Forestry
[75]	Zhang T. et al., 2020	survey	forest bathing	Japan	forest	rural	Forestry
[334]	Zhou C. et al., 2019	experimental	forest bathing	China	forest	various	Med-Forest
[72]	Zhou Q. et al., 2021	experimental	forest air	China	forest	urban	Forestry
[162]	Zhu S.-X. et al., 2021	expert assessment	forest air	China	forest	rural	Forestry
[112]	Zhu Z. et al., 2021	experimental	forest therapy	China	water	rural	Medical

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