

REVIEW

A Bibliometric and Visualization Analysis of Forest Therapy Research: Investigating the Impact of Forest Environments on Human Physiological and Psychological Well-Being

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ABSTRACT

Human interaction with natural environments is gaining increasing attention in environmental sciences as research consistently shows that access to green spaces, clean air, and biodiversity plays a crucial role in enhancing physical health, reducing stress, and improving overall well-being. This study conducts a bibliometric and visualization-based analysis of forest therapy research, emphasizing its physiological and psychological benefits. Using the Web of Science database, we identified and analyzed 414 studies from 1998 to 2023. Through CiteSpace and VOSviewer, we mapped these documents to examine research trends, publication networks, leading scholars and institutions, key journals, and thematic evolution. Findings indicate that forest therapy research is predominantly concentrated in East Asia, North America, Australia, and Europe, with strong collaborative networks among authors and institutions. The concentration of publications, research evolution, and keyword trends reflect the development of forest therapy research. The analysis further identifies sixteen research clusters and discusses two research themes: physiological and psychological effects. By analyzing how the

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ARTICLE INFO

Received: 7 March 2025 | Revised: 27 March 2025 | Accepted: 2 April 2025 | Published Online: 13 May 2025

DOI: <https://doi.org/10.30564/jees.v7i5.8996>

CITATION

Hong, W., Zhu, S., Lu, D., et al., 2025. A Bibliometric and Visualization Analysis of Forest Therapy Research: Investigating the Impact of Forest Environments on Human Physiological and Psychological Well-Being. *Journal of Environmental & Earth Sciences*. 7(5): 434–452. DOI: <https://doi.org/10.30564/jees.v7i5.8996>

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natural environment contributes to human well-being, we provide a comprehensive and visually structured understanding of forest therapy as an intersection of environmental science, public health and well-being, and ecosystem conservation. Our findings offer a new perspective for future interdisciplinary research, emphasizing the need for well-designed clinical trials to substantiate forest therapy's diverse health effects and its role in promoting sustainable interactions between human societies and natural environments.

Keywords: Forest Therapy; CiteSpace; VOSviewer; Environment Science

1. Introduction

Cities attract people with better job opportunities, higher salaries, quality education, and improved healthcare, driving rural-to-urban migration^[1]. However, as cities grow larger, environmental conditions have worsened, especially air quality, making urbanization a pressing public health concern^[2]. These changes affect both the mental and physical well-being of city residents^[3]. Environmental factors such as air and noise pollution, water contamination, waste accumulation, and workplace stress are prompting people to seek healthier lifestyles^[4–6]. Recent research increasingly highlights the benefits of natural environments, such as green space and forests, in reducing stress and improving overall health^[7]. As a result, nature-based therapies, such as forest therapy, are becoming more popular among urban dwellers^[8, 9].

Forest therapy, often referred to as 'forest bathing' or 'shinrin-yoku' in Japanese, is a wellness practice that immerses individuals in a natural forest or urban green space to improve health and well-being^[10, 11]. In forest therapy, individuals step away from their usual environments to participate in guided therapeutic programs within forest settings, which not only support their health but also fulfill a desire for meaningful, experiential tourism^[9]. Guided by a trained practitioner, participants engage all their senses in a structured experience aimed at fostering a deep connection with nature. This immersion has been shown to reduce stress, elevate mood, and support physical health^[12], helping people improve both their physical and psychological conditions^[13–15]. In addition, as a nature-based intervention, it offers a unique opportunity to connect human health with a natural environment, aligning closely with ecological studies that examine the interdependence between humans and the external environment^[16]. Therefore, immersion in a forest environment not only provides physiological and psycho-

logical benefits but also underscores the critical ecosystem services that forests offer, such as carbon sequestration, water regulation, and biodiversity conservation—key components of ecological resilience and sustainability^[17]. By promoting the therapeutic effects of forests, forest therapy programs can enhance public awareness of ecological integrity, fostering a deeper appreciation for biodiversity and the need for responsible environmental stewardship^[18].

The bibliometric and visualization method is a quantitative technique for analyzing books, articles, and other scholarly documents, and it has recently gained popularity in academic studies for visualizing the intellectual structure, emerging trends, and research directions within scholarly fields^[19]. For novice scholars in a particular study area, bibliometric analysis serves as a valuable tool for understanding cumulative scientific knowledge, as it helps organize large volumes of unstructured data in a structured and rigorous manner^[20]. Given the substantial volume of research on forest therapy conducted in recent years, bibliometric analysis is thought to be a well-suited method to explore this broad topic because it also provides vivid insights into the performance of articles and authors through visualization^[19, 20].

Previous review studies have primarily focused on organizing, synthesizing, and analyzing research on the effects and implementations of forest and nature-based therapies^[9–12, 15, 21–30]. However, a comprehensive analysis of the connections among these studies is lacking, which may leave researchers feeling disoriented in the study of forest therapy. Moreover, systematic literature reviews on forest therapy tend to limit the number of articles examined^[11], while meta-analyses focus specifically on synthesizing results across studies^[10, 11, 22, 29]. This creates a research gap for a bibliometric analysis to thoroughly explore numerous studies on forest therapy comprehensively, helping researchers understand connections between studies, contributors, and research institutions.

Considering this research background, we aim to address the following questions: (1) *What are the current research trends and citation patterns in forest therapy studies?* (2) *Who are the leading contributors in this field, and what do their collaboration networks look like?* (3) *How has research in forest therapy evolved over time?* Additionally, (4) *what are the main keyword distributions and research clusters identified within these studies?* We apply bibliometric and visualization methods using CiteSpace and VOSviewer to answer these questions and map the literature landscape. Through our research cluster analysis, we identify two research themes in forest therapy studies: namely, physiological and psychological benefits. Further, this paper asks: (5) *What are the main physiological and psychological benefits of forest therapy?*

The structure of this paper is organized as follows. First, we outline the literature search strategy and describe our research method. Next, we analyze research trends, including publications, citations, key publishers and journals, key contributors, collaborative networks, research evolution, and clusters within forest therapy studies. We then discuss two primary research themes, namely physiological and psychological effects. Finally, we conclude by addressing the research questions, summarizing findings, acknowledging limitations, and proposing a research agenda.

Our research offers a clear, vivid, and historically grounded presentation of the hot topics and emerging trends in forest therapy. This research identifies key researchers, maps their connections, and highlights relationships among publications—providing a more comprehensive overview compared to previous literature review papers. This may help scholars quickly gain a broad understanding of the field. In addition to discussing the primary effects of forest therapy, our study proposes a forward-looking and insightful research agenda for future study. By aligning these directions with established research themes, this paper supports the development of new research ideas, particularly in the areas of physiological and psychological effects. Overall, our goal is to deliver a holistic and in-depth bibliometric analysis of forest therapy, offering a broader perspective than earlier reviews and pointing to new possibilities for future research.

2. Literature Search Strategy

In the beginning, our study categorized forest therapy as a specific branch of forest tourism and compiled relevant literature on both topics from the Web of Science Core Collection. After collecting the initial body of research, the focus shifted to forest therapy, where all relevant studies were identified and subsequently analyzed. After reviewing the literature, this study identified key concepts at both macro and micro levels, as shown in **Table 1**. Forest recreation is included because its connection to forest therapy remains underexplored. Analyzing these terms separately, we used bibliometric analysis to identify the links between them. To broaden the search, the initial stage results were consolidated and refined through a de-weighting process along with inclusion and exclusion criteria, resulting in the dataset (**Table 1**). The search was conducted in January 2024 using the CiteSpace program (version 5.6.R5) and covered studies published between 1998 and 2023. The first-stage search yielded 895 initial results, which were filtered by document type—retaining articles, review articles, proceedings papers, book chapters, and early access papers—resulting in a total of 850 records.

In the second stage, the research focused specifically on forest therapy. As shown in **Table 1**, key search terms included “forest therapy*,” “forest bath*,” and “shinrin-yoku.” To include variations in search terms and broaden the search scope, this study employed wildcard symbols and avoided quotation marks that might restrict results. For example, “forest bath*” was used to capture results for both “forest bathing” and “forest bath.” Similarly, recognizing that some studies use “therapeutic forest” instead of “forest therapy,” this term was also included in the search process.

To ensure precision, each term was enclosed in double quotation marks to ensure it was treated as an exact phrase. This method helped avoid unintended word separation, reduced the retrieval of irrelevant results, and maintained consistency throughout the search process. Search Stage 2 yielded 451 results, which were further filtered by document type and thematic relevance (**Table 2**). Therefore, our final dataset consisted of 416 documents.

Among the 416 documents, the most frequent document type was journal articles ($n = 327$), accounting for 78.6% of the total. This was followed by review articles ($n = 78$, 18.7%) and proceedings papers ($n = 11$). A total of 15

Table 1. Search Strategy, Results, and Inclusion/Exclusion Criteria.

Activity	Details
Search Stage 1	Keywords: “forest tourism” (Topic) OR “forest recreation” (Topic) OR “forest health tourism” (Topic) OR “forest therapy*” (Topic) OR “forest bath*” (Topic) OR “shinrin-yoku” (Topic) OR “forest-based well-being” (Topic) OR “forest-based tourism” (Topic) OR “forest medicine” (Topic) OR “forest medical tourism” (Topic) Results: 895 initial hits; 850 after refining by document type
Search Stage 2	Keywords: “forest therapy*” (Topic) OR “forest bath*” (Topic) OR “shinrin-yoku*” (Topic) Results: 451 initial hits; 416 after refining by document type
Inclusion Criteria	Publications from 1998 to 2023; English language only; Document types: journal articles, review articles, proceeding papers Relevant to forest therapy and related concepts Indexed in CiteSpace-compatible databases (e.g., Web of Science Core Collection)
Exclusion Criteria	Duplicate records; Non-English publications; Non-academic sources (e.g., news, editorials, commentaries); Book chapters; Irrelevant topics (minimal focus on forest therapy, e.g., forest tourism); and Grey literature (e.g., theses, dissertations, unpublished reports).

Table 2. Types of Retrieved Documents.

Type of Document	Record Count	Proportion
Article	327	78.606%
Review Article	78	18.75%
Proceedings Paper	11	2.644%
Book Chapters	7 (Removed)	-
Early Access	7 (Removed)	-
Editorial Material	1 (Removed)	-
Total	416	100%

documents were excluded from the final analysis (**Table 2**).

Nonetheless, the two-stage search and refinement process enhance the transparency, reliability, and replicability of this bibliometric study.

3. Findings and Analyses from Literature Studies

3.1. Research Trends, Publications, and Citations

The number of publications per year reflects the academic output trend of forest therapy studies while the number of citations per year indicates its influence and significance.

Figure 1 illustrates the increase of both the number of publications and citations related to forest therapy research. The

citation data begins in 2006. The possible explanation is that articles are retrieved from the Web of Science Core Collection, and many journals have been indexed in databases of the Core Collection since that year.

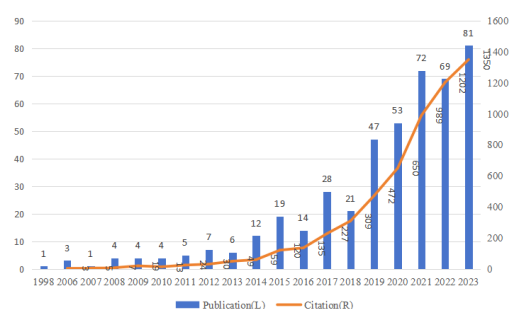


Figure 1. Increase of Both the Number of Publications and Citations Related to Forest Therapy Research (1998–2023).

As illustrated in **Figure 1**, the development of forest

therapy research can be categorized into three distinct phases: the emergent phase, the steady growth phase, and the rapid growth phase. The emergent phase (1998–2013) marks the beginning of this field, with fewer than ten publications per year. This was followed by the steady growth phase (2014–2018), during which the number of publications increased steadily. In the rapid growth phase (2019–2023), the number of publications exceeded 50 per year, reflecting a surge in academic interest and a widespread scholarly discussion.

3.2. Distribution of Published Journals in Forest Therapy

Figure 2 illustrates the distribution of papers published in SCI journals, highlighting the concentration of forest therapy-related studies. *The International Journal of Environmental Research and Public Health* ranks first, with over 100 published articles on the topic. It is followed by *Forests* (41 articles), *Urban Forestry & Urban Greening* (31), and *Sustainability* (12). Other journals have published fewer articles related to forest therapy. Collectively, the top ten journals account for approximately 55% of indexed articles, demonstrating a significant concentration of forest therapy research within a small group of publications.

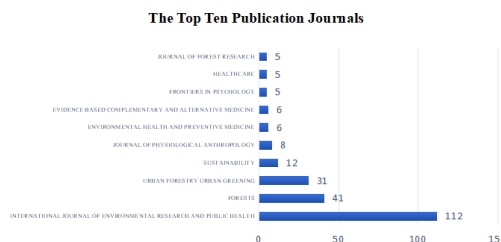


Figure 2. The Top Ten Journals with Forest Therapy-Related Publications (by 2023).

3.3. Contributors to Forest Therapy Research

Table 3 highlights the top 15 researchers, institutes, and countries or regions in forest therapy research. Researchers from the Forestry and Forest Products Research Institute and Chiba University in Japan, including Yoshifumi Miyazaki and Takahide Kagawa, have made significant contributions to the clinical understanding of forest therapy's physiological and psychological effects^[13, 25, 31, 32]. As shown in **Table 3**, researchers from Japanese institutions represented 5 of the 15 top contributing authors.

In South Korea, researchers from Chungbuk National University, such as Dr. Chorong Song, have explored the therapeutic potential of forests. Dr. Chorong Song has made notable contributions by studying psychological well-being and stress reduction linked to forest experiences^[13, 31–34]. Dr. Ju-hyoung Lee has focused on the intersection of nature and mental health, with her research emphasizing how natural environments, including forests, alleviate stress and improve mood^[17]. Their collective work often delves into the psychological benefits of forest therapy and the enhancement of well-being through nature exposure^[17]. Researchers from Seoul National University, including Dr. Qing Li, have investigated the cognitive and emotional benefits of forest experiences. Dr. Qing Li, born in 1964, is an important researcher in forest medicine, with extensive research on the immune-boosting effects of forest therapy^[35–38].

Chinese Academy of Sciences is the sole Chinese institution represented in the top 15 (**Table 3**). Through partnerships with various institutions, their researchers have contributed to understanding the effectiveness of forest therapy in Chinese contexts^[3, 6, 39].

In European countries, scholars have contributed to the global discourse on forest therapy, often exploring the relationship between forest environments and human well-being with a focus on socio-cultural dimensions, such as Mazzoleni et al. from the National Research Council of Italy^[40]. Mazzoleni et al. examine 26 studies involving 2,775 participants across nine European countries to assess the effects of forest therapy^[40]. Most studies measured psychological outcomes—such as mood, well-being, and attention—while some assessed physiological effects such as cortisol levels, vital signs, and immune response^[40, 41]. Forest therapy consistently showed benefits for mental health and some physical conditions, notably asthma^[40, 41]. However, Mazzoleni, Donelli et al. found that clinical studies varied in quality and design, revealing the need for standardized methodologies and further research^[40] and they emphasize the potential of forest therapy as a holistic health intervention in Europe and highlights opportunities for integration into public health and environmental sustainability efforts.

In North America, scholars have paid attention to the value of nature experiences for mental health^[42]. Scholars such as Berman et al. underscore the importance of natural features contributing to human health^[43, 44]. R. Kaplan and

Table 3. Contributors to Forest Therapy Research (by 2023).

No.	Author Ranking	N/C of Authors	Perspective of Forest Therapy Study	Institution of the Country Ranking	N/C of Institutions	Country Ranking	N/C of Countries
1	Yoshifumi Miyazaki	53/2765	Advancing the recognition of nature's therapeutic effects	Forestry & Forest Products Research Institute, Japan	53/3650	Japan	95/5277
2	Chorong Song	36/1753	Psychological well-being and stress reduction	Chiba University, Japan	51/3472	China	88/1920
3	Harumi Ikei	35/1669	Physiological impacts of forest therapy	Chungbuk National University, South Korea	17/162	S. Korea	85/2536
4	Takahide Kagawa	28/2283	Medical aspects of forest therapy	Nippon Medical School, Japan	17/843	USA	50/2837
5	Bum-Jin Park	24/1343	Connecting forest therapy to the broader field of ecotherapy	Chungnam National University, South Korea	16/1009	UK	26/641
6	Insook Lee	19/776	Intersection of nature and mental health	Korea Forest Research Institute, South Korea	12/486	Italy	25/442
7	Li Qing	17/947	Cognitive and emotional benefits	National Institute of Forest Science, Japan	12/43	Canada	18/273
8	Norimasa Takayama	16/890	Quality of life	Seoul National University, South Korea	11/227	Poland	18/399
9	Sujin Park	14/62	Cultural and environmental factors	Academy of Sciences, China	10/241	Spain	14/370
10	Soojin Kim	13/23	Cognitive and emotional benefits	National Research Council, Italy	10/79	Australia	13/264
11	Won-Sop Shin	13/47	Psychological and emotional benefits	University of Warmia and Mazury, Poland	10/348	Germany	13/193
12	Ernest Bielinis	11/372	Global discourse on forest therapy	Kongju National University, South Korea	9/74	Finland	12/1061
13	Geonwoo Kim	10/83	Physiological and psychological effects	National Taiwan University	9/361	Austria	7/199
14	Michiko Imai	9/478	Cognitive and emotional benefits	University Of Derby, UK	9/146	Denmark	6/226
15	Yuko Tsunetsugu	9/1344	Physiological and psychological effects	University Of Tokyo, Japan	9/562	Malaysia	6/95

Note: N/C=numbers of documents/citation times.

S. Kaplan from the USA identified four essential qualities of environments that support mental restoration^[45]:

- Being away – a psychological or physical break from one's usual routines and mental tasks;
- Fascination – gentle, effortless attention drawn by the environment's features, such as patterns of light, bird songs, or flowing water;
- Extent – a sense of scope and coherence that allows for immersive experiences;
- Compatibility – the environment aligns with the person's goals, needs, or preferences^[45].

This framework is known as Attention Restoration Theory (ART), which has been widely applied in forest therapy studies^[46, 47].

In summary, worldwide researchers have collaboratively advanced the understanding of how forests promote human health and well-being, fostering a deeper integration of forest therapy into healthcare practices and environmental policies.

3.4. Analysis of Collaborative Networks

Figure 3 illustrates the forest therapy collaborative networks among authors, institutions, countries, and regions. The size of the bubbles reflects publication numbers by country. The thread connections represent the frequency of co-authorship between different entities. Japan, South Korea, Poland, Finland, Italy, England, Spain, the USA, Canada, and China are shown to actively collaborate in advancing forest therapy research, highlighting a strong international network.

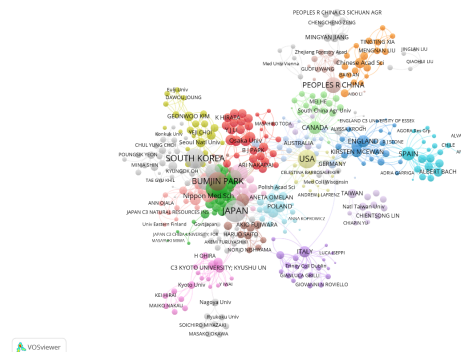


Figure 3. Collaborative Networks of Authors, Institutions, and Countries/Regions (by 2023).

3.5. Forest Therapy Research Evolution

Figure 4, generated by VOSviewer, presents an overlay visualization of the evolution of forest therapy research. The nodes with deeper hues represent earlier research topics, while lighter shades signify more recent developments. Initially, the conversation was dominated by the deep green node for “forest recreation,” with much of the early research focusing on its benefits. The node most closely associated with “benefit” is “health,” indicating that health is a primary advantage of forest exposure. To validate these health benefits, researchers conducted empirical studies using forest therapy experiments, represented by the green node for “Shinrin-yoku”. Around 2020, yellow nodes labeled “forest therapy” and “forest bathing” appeared, representing the largest bubbles of that year. By 2022, more research had shifted its focus to COVID-19 and related forest therapy activities.

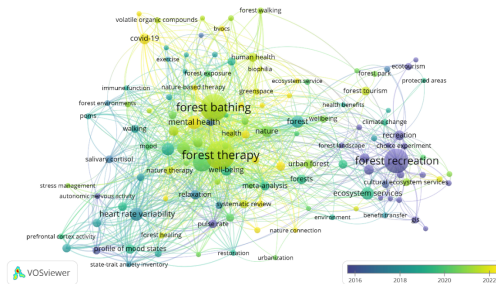


Figure 4. Keyword Co-occurrence Network of Forest Therapy Publications (2016–2022).

3.6. Research Keyword Analysis

We analyzed the keyword distribution of forest therapy using a co-occurrence network image, a keyword ranking table, and a density visualization map. **Figure 5** illustrates the strength of links between keywords and the connections among research terms such as forest therapy, forest bathing, shinrin-yoku, heart rate variability (HRV), blood pressure, stress, mental health, well-being, COVID-19, and nature.

Table 4 lists the top ten keywords in terms of frequency and link strength. **Figure 6** illustrates the frequency of keywords while the color of the node is contingent on the density of items at that node. Red indicates a high frequency, while green represents a lower frequency. **Table 4** and **Figure 6** highlight the focus of researchers on terms such as “forest therapy”, “forest bathing”, “blood pressure”, “stress”, and “mental health”.

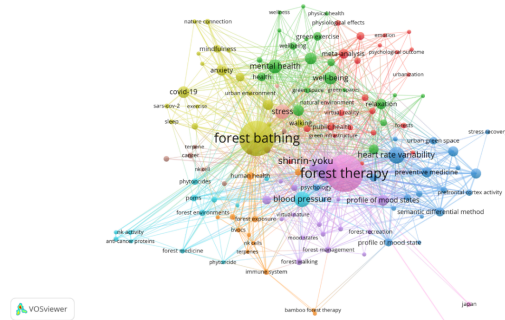


Figure 5. Keyword Co-occurrence Network of Forest Therapy Studies (by 2023).

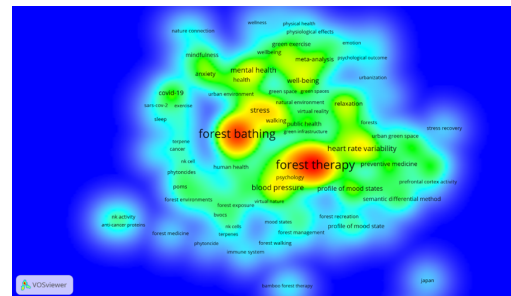


Figure 6. Keyword Density Visualization Map of Forest Therapy Studies (by 2023).

3.7. Research Cluster Analysis

3.7.1. Describing Cluster Analysis

Cluster analysis was performed using CiteSpace 5.65 software package on Web of Science Core Collection with peer-to-peer reviewed articles and reviews. Clusters were derived via MI (Mutual Information) and labeled by keywords. The cluster map identifies 16 research clusters, illustrating the evolution of forest therapy research themes from 1998 to 2023. **Figure 7** shows these clusters. At first glance, two primary research themes emerge: physiological and psychological effects.

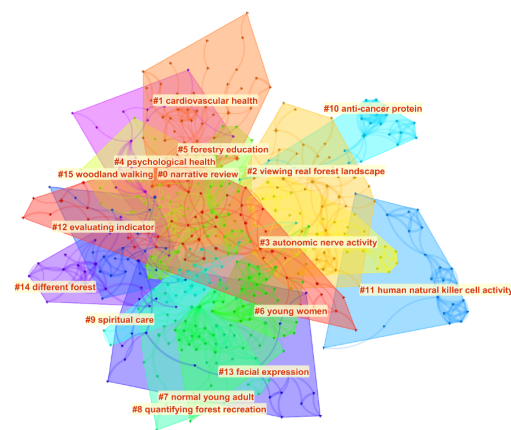


Figure 7. Cluster Analysis of Terms Co-occurrence (1998–2023).

Table 4. The Top Ten Keywords of Forest Therapy Studies (by 2023).

Rank	Keyword	Occurrences	Total Link Strength
1	forest therapy	114	275
2	forest bathing	102	281
3	shinrin-yoku	48	185
4	heart rate variability	29	108
5	blood pressure	26	96
6	stress	24	68
7	mental health	22	71
8	well-being	19	59
9	COVID-19	16	34
10	nature	16	42

Physiological effects are reflected in clusters such as cardiovascular health (#1), autonomic nerve activity (#3), human natural anti-cancer proteins (#10), evaluating indicators (#12) such as systolic blood pressure and diastolic blood pressure^[3, 10], and killer cell activity (#11). Psychological effects are represented by clusters including psychological health (#4), spiritual care (#9), evaluating indicators (#12) such as anxiety and positive emotions^[22], and facial expression (#13).

Beyond these two main themes, other clusters reflect the broader research aims of forest therapy studies. Demographic-focused analyses, such as those on young women (#6) and healthy young adults (#7), highlight interest in specific populations. Additional study types and applications include narrative reviews (#0), viewing real forest landscapes (#2), forestry education (#5), quantifying forest recreation (#8), comparisons among different forests (#14), and woodland walking (#15). These clusters underscore the diverse dimensions of forest therapy research.

Overall, **Figure 7** illustrates the methodologies, subjects, and contexts that define forest therapy research clusters. Sections 3.7 and 4 provide a detailed discussion of these clusters.

3.7.2. Review Research Study Cluster

The cluster #0 narrative review is on comprehensive analyses of multiple clinical studies or other conceptual works. Systematic reviews and meta-analyses provide a broader perspective on the literature surrounding forest therapy (cluster #0) and these papers synthesize findings from studies to assess the overall effectiveness of forest therapy interventions. For instance, Yeon et al. used a meta-analysis and summarized the positive effects of forest therapy on

anxiety, depression, and mental well-being through recent randomized controlled trials (RCTs)^[29], and another review found that forest-based interventions significantly improved mental health outcomes^[22]. In line with this perspective, it was found that there were significant improvements in psychological symptoms such as anxiety, depression, anger, fatigue, confusion, and vigor in forest-exposed groups compared to non-exposed groups^[15]. Yau and Loke reviewed previous studies and concluded that physiological and psychological benefits of forest therapy exist, specifically for adults suffering from pre-hypertension or hypertension^[28]. By systematically analyzing articles, Piva et al. contended that forest walking, along with other activities, is the most effective intervention for generating positive measures^[39]. Similarly, Park et al. reached a consistent conclusion, showing that forest walking leads to consistent positive effects after reviewing 32 RCTs^[23]. Kotera et al. studied 497 articles and found that forest therapy can be effective in reducing mental health symptoms in the short term^[11]. Consistently, systematic literature reviews argued that forest therapy is effective in reducing adults' depression levels^[12]. Responding to COVID-19, researchers reviewed previous forest therapy studies and contended that many exercises performed in the forest may promote immunostimulatory effects, which help restore the immune system against COVID-19 infection^[48]. Some scoping reviews provided a general map of existing research on forest therapy^[26, 40, 49, 50].

3.7.3. Demographic Research Cluster Analysis

Compared with literature reviews, clinical studies typically involve controlled experiments or participant-involved trials that assess the impact of forest exposure on various health outcomes. These studies often include comparison

groups, using a variety of measures, such as stress levels, mood, and physiological indicators, to evaluate performance. However, the quality of these studies varies due to limitations such as small, homogeneous sample sizes and insufficient descriptions of the forest environments in which they are conducted^[14, 25, 33, 51].

Regarding research subjects, forest therapy has been studied across various age groups and demographics, as indicated by clusters such as young women (#6) and healthy young adults (#7). Forest therapy research targets individuals with distinct characteristics and needs. For instance, young adults (#6 or #7) often face significant stress as they transition from education to employment or navigate the early stages of their careers. Forest therapy has been shown to reduce stress in young people, offering a valuable tool for managing these pressures. Studies suggest that forest therapy can promote both physiological and psychological relaxation in young women^[13]. This is especially critical since young women may experience unique stressors and mental health challenges.

For elderly populations, forest therapy can enhance health and well-being in their later life, and forest walking, either alone or combined with other activities, improves physical health by lowering blood pressure and heart rate (HR) and improving cardiopulmonary and neurochemical markers^[49]. Additionally, studies on children explore how early exposure to nature influences development and well-being. For example, Bielinis et al. reported that nature-based therapy improves skills and knowledge in young adults^[41]. Forest therapy has also been examined in specific patient populations, including those with chronic illnesses, mental health disorders, and other conditions, to assess its potential in disease management and quality of life enhancement.

3.7.4. Research Contexts Research Cluster Analysis

From the research contexts or settings perspective, representations by cluster labels include viewing real forest landscapes (#2), quantifying forest recreation (#8), and woodland walking (#15). Forest therapy clinical studies have been conducted in diverse contexts, reflecting the wide range of environments where forest therapy can be performed. Studies on viewing real forest landscapes (#2) have shown that immersion in natural forest environments significantly reduces oxyhemoglobin concentration in the right prefrontal cortex,

which is associated with physiological relaxation^[37]. Forest therapy also provides recreational experiences for participants^[8, 16], which alleviates negative symptoms of stress^[41]. Research on Central European urban forests highlights the importance of accessible green spaces within cities, which play a key role in enhancing both mental and physical health among urban residents^[52].

Different forests (#14), along with woodland walking (#15), also influence the therapeutic effects of forest therapy, owing to the varying sensory experiences they provide. Studies focus on the use of specific plants in treatment, such as forest plant healing therapy, which has been shown to positively impact the emotions of college students^[53]. Other research investigates forest therapy trails, examining the characteristics of trails and forest settings that facilitate optimal experiences for visitors^[9]. Additionally, comparisons have been made between urban and rural settings to evaluate the differing effects of forest therapy in these contrasting environments^[54].

3.7.5. Education Value Research Cluster Analysis

The educational value of forest therapy has been widely discussed, as cluster forestry education (#5). Forest therapy serves as an effective educational tool, promoting a deeper understanding and appreciation of nature among participants^[18]. It provides experiential learning opportunities that foster a strong connection with the natural world. Additionally, forest therapy programs often integrate elements of environmental education, enabling participants to learn about local flora, fauna, ecosystems, and the importance of conservation. Different forests (#14), whether urban green spaces or remote woodlands, can influence the outcomes of forest therapy^[44]. Forest therapy, as an educational tool, not only promotes natural appreciation but also enhances participants' understanding of ecological systems^[18].

3.7.6. Other Value Research Cluster Analysis

Forest therapy also brings notable economic benefits^[7, 54, 55]. For example, forest-related activities have contributed to the circular economy and industrial development in Japan, resulting in significant savings for healthcare and welfare systems and productivity gains. In Europe, sustainable urbanization, including the addition of green spaces, can stimulate economic growth and protect individuals from dis-

eases caused by harmful environmental exposures^[21]. In the United States, the economic value of protected areas has been emphasized^[56], highlighting the potential economic benefits of forest therapy. Furthermore, forests have become popular tourist attractions, drawing visitors worldwide and boosting local economies^[53]. Developing urban forest therapy through urban green space planning adds another dimension to economic development.

Additional values of forest therapy include opportunities for self-reflection and the promotion of social bonds through interactions with others^[26, 34, 57], which are beneficial for human health. Research also highlights the emotional benefits of forest therapy, such as eliciting positive reactions and enhancing the level of sensory connection^[58].

In conclusion, the multi-faceted benefits and effects of forest therapy are reflected in research clusters spanning environmental and economic domains.

4. Discussion on Psychological and Physiological Effects

The previous section explored various connections among researchers, research keywords, research evolution, and institutions. In addition, we discussed research clusters such as normative reviews, young women, and young adults. We noted that psychological and physiological effects are two primary themes that require further elaboration. In the Discussion section, we emphasize the physiological and psychological effects of forest therapy, aligning our findings with established research themes and other studies^[13–15, 33].

4.1. Physiological Effects of Undertaking Forest Therapy

Key physiological effects include improvements in blood pressure, cardiovascular health, immune function, respiratory system performance, and sleep quality (various indicators #12). These physiological benefits highlight the vital role of natural environments in promoting human health, emphasizing the need for environmental conservation and sustainable practices.

4.1.1. Regulating Blood Pressure

Can forest therapy regulate blood pressure? Systolic

blood pressure (SBP) and diastolic blood pressure (DBP) are negatively correlated with walking in the forest environment^[3]. Ideno et al. systematically examined the effects of forest therapy on blood pressure and mental stress in urban residents, and the study found that forest therapy significantly reduces both SBP and DBP compared to urban control groups (#12)^[10]. Yau and Loke found that forest therapy interventions effectively reduce blood pressure, lower pulse rates, increase HRV, and improve cardiopulmonary and metabolic functions^[28]. These findings suggest that forest therapy can serve as a useful intervention for managing high blood pressure. However, its effectiveness can vary based on factors such as population characteristics and the environmental setting. While forest therapy shows promise as a non-pharmacological approach to managing high blood pressure, more research is needed to investigate its full physiological benefits and optimize its application for individuals with hypertension.

4.1.2. Improving Cardiovascular System

Can forest therapy improve the cardiovascular system? An et al. verified that participants who engaged in forest therapy experienced reductions in HR and HRV compared to those in an urban setting, suggesting that forest therapy can enhance cardiovascular health and resilience (#1)^[3]. Forest therapy has been linked to improved HRV, which reflects the heart's ability to adapt to stress^[50]. Higher HRV is associated with better cardiovascular health and greater resilience to stress, further emphasizing forest therapy's role in promoting overall physiological well-being. Chun et al. found that forest therapy interventions are effective in reducing blood pressure, lowering pulse rates, increasing HRV, and improving cardiac-pulmonary and metabolic functions^[59]. It has been concluded that forest therapy leads to improvements in pulse rates, HRV, and cardiopulmonary and metabolic functions^[28]. Since high blood pressure is a significant risk factor for stroke, these findings suggest that forest therapy can be a valuable intervention for managing high blood pressure and supporting heart health. In summary, stable blood pressure and effective stress relief through forest therapy are powerful interventions to improve HRV, contributing to better cardiovascular health and reducing the risk of conditions such as stroke.

4.1.3. Enhancing Immune Function

Can forest therapy enhance immune function? Forest therapy enhances immune function through a combination of biological, environmental, and psychological factors^[35, 52, 53, 60]. One of the key factors contributing to people's immune function is the biological chemistry generated by forest therapy. Phytoncides, the organic compounds released by trees, are among these elements that serve as a defense mechanism against microbes and insects^[36]. Phytoncides have been shown to stimulate the immune system, particularly by increasing natural killer (NK) cell activity, which plays a crucial role in combating pathogens and even cancerous cells (see research clusters #11, #12). Studies have demonstrated that after just two days of forest immersion, NK cell activity significantly increases, with effects lasting up to a month^[61]. Forest therapy also creates an environment where children are exposed to specific allergens and bacteria, which decreases the likelihood of wheezing and allergic sensitization, thereby improving their immune system^[7]. The cleaner atmosphere within forest therapy empowers the immune system to function more efficiently, further supporting the body's resilience.

Forest therapy has also been associated with reduced levels of pro-inflammatory cytokines, which play a role in the severity of infections such as COVID-19. For example, research by Roviello et al. shows that spending time in forests may lower cytokines, supporting immune function in the context of viral infections^[49]. The potential benefits of forest therapy extend to cancer prevention as well. NK cells, which have anti-tumor properties, are stimulated by forest immersion. Nakau et al. suggest that regular exposure to forest environments may reduce cancer risk, though more long-term studies are needed to confirm this link (#10)^[62].

The mental benefits of forest therapy, including stress reduction and improved mood, indirectly boost the human immune system^[60]. Reduced anxiety and low stress levels have been linked to increased HRV, which positively correlates with the immune system^[39]. Exposure to natural calming sounds and sights helps alleviate stress—an essential factor, as chronic stress can suppress immune function, while relaxation and positive emotions strengthen it^[60].

Additionally, gentle physical exercises, including walking in nature, improve circulation and immune response^[50]. By reducing stress and promoting a calm mental state, forest

therapy creates an optimal environment for immunity development and sustainability. The mental-immune connection underscores how forest therapy fosters a holistic boost to both mental and physical well-being, reinforcing the body's ability to resist diseases^[27]. Furthermore, compared to the urban environment, the forest setting is likely to stimulate the benefits of automatic nerve activities (#3)^[63?].

Taken together, forest therapy enhances immunity through a combination of direct effects—such as increased NK cell activity and reduced inflammation—and indirect benefits, including stress reduction, which creates an optimal environment for overall health improvement. For a more detailed analysis, a systematic review by Chae, Lee et al. comprehensively summarizes the effects of forest therapy on immune function^[60].

4.1.4. Boosting Respiratory

Can forest therapy boost respiratory health? Current research suggests that forest therapy may play a critical role in restoring various health conditions, including those affecting the respiratory system^[8, 9, 30]. For respiratory diseases, forest therapy has been associated with improvements in key respiratory function parameters, such as forced expiratory volume (FEV), peak expiratory flow (PEF), and forced vital capacity (FVC)^[28, 30]. These improvements have been observed in both healthy individuals and patients, as well as among young and elderly participants with respiratory conditions. This suggests that forest therapy can enhance respiratory function across diverse populations^[30]. However, it is important to acknowledge certain limitations. The available scientific evidence is restricted, as only five clinical studies have been included in the current analysis. Additionally, some plant-derived compounds may interact with air pollutants, potentially exacerbating respiratory conditions rather than alleviating them^[30].

4.1.5. Improving Sleep Quality

Can forest therapy improve sleep quality? Though studies that directly associate forest therapy with sleep disorders are limited, its stress-relieving benefits may contribute to better sleep quality and prolonged sleeping hours^[9, 36, 57, 65]. Sleep is essential for overall health, and forest interventions that improve sleep quality are highly valuable. Morita et al. tested 71 healthy adult participants and found that two hours of forest walking can improve actual sleeping hours,

depth of sleep, and quality of sleep as measured by a self-administered questionnaire^[66]. Similarly, a clinical study by Li et al. examined the effects of forest therapy on subjective sleep quality in middle-aged males^[37]. Their findings showed significant improvements in sleep outcomes, including better sleepiness upon waking and a greater sense of refreshment (fatigue recovery).

4.2. Psychological Effects of Undertaking Forest Therapy

Psychological benefits are another key focus for forest therapy studies (#4, #12), encompassing inspiration, a sense of meaningfulness in life, and a deeper connection with nature^[62]. Shim et al. explored psychological effects of forest therapy by analyzing 17 studies with 1,418 participants and they found significant reductions in anxiety, depression, anger, fatigue, and confusion alongside improved vigor^[15]. In this section, we discuss forest therapy psychological effects such as stress, depression, cognitive function (here as a psychological aspect), and creativity.

4.2.1. Reducing Stress

Can forest therapy reduce participants' stress? Stress reduction is widely recognized as a key outcome for forest therapy participants^[3, 27, 38, 51, 59, 63]. Previous clinical research has found that forest therapy lowers cortisol levels—a hormone linked to the body's stress response—thereby offering protection against the negative effects of chronic stress^[59, 63]. In addition to hormonal regulation, forest therapy is associated with cardiovascular benefits, such as reduced blood pressure and HR and increased HRV, which reflects the heart's ability to adapt to stress^[3, 58].

Recent studies have also explored the neurophysiological effects of forest therapy, showing that it may directly influence brain activity. A functional magnetic resonance imaging (fMRI) study has demonstrated decreased activity in the prefrontal cortex—a brain region involved in stress and negative emotions—during forest therapy^[32], which suggests that forest therapy fosters a calmer, more relaxed internal state. Forest therapy can play a significant role in building the body's resilience to disease, lowering stress levels, and improving immune function, which is linked to increased NK cell activity^[47].

Criticism of forest therapy's effectiveness in address-

ing stress perception suggests that its stress-reducing effects may stem from a combination of factors beyond simply being in nature. These factors include gentle physical activity, sensory stimulation from natural sounds, and opportunities for mindful reflection^[27, 38]. Environmental setting and individual differences may influence how people experience and benefit from forest therapy, highlighting the need for further research^[27, 63, 67]. Therefore, though forest therapy positively affects hormonal regulation, cardiovascular health, immune function, and brain activity, more research is needed to fully understand the mechanisms behind these benefits and to optimize forest therapy for stress management.

4.2.2. Managing Depression

Can forest therapy reduce the likelihood of depression? Research suggests that prolonged stress can predict depression^[68]. The accumulation of stressful events over time, regardless of their specific nature, can generate a persistent pattern of negative and undesirable experiences. This cumulative stress can contribute to emotional overwhelm, increasing the likelihood of developing depression^[68]. A growing body of research suggests that forest therapy may offer potential relief for those struggling with depression^[12, 64, 67, 69]. The calming and therapeutic effects of the forest environment appear to address the emotional difficulties of depression directly. In a systematic literature review, Lee et al. observed significant reductions in depressive symptoms after individuals spent time in forests compared to urban settings^[12]. Similarly, Li et al. reported decreases in both depression scores and feelings of hopelessness following forest therapy sessions, suggesting that nature's exposure possesses an inherent ability to lift mood and dispel the dark fog of depression^[37].

Similar to stress reduction, forest therapy may help reduce the likelihood of depression due to various reasons. One explanation for nature's therapeutic touch may lie in its ability to quiet the orchestra of stress hormones. Toda et al., via a clinical study, found a significant decrease in salivary cortisol, the stress hormone, after just two days of woodland walking compared to an urban control group and the reduction in cortisol likely translates to emotional relief, calming the inner turmoil often associated with depression^[67]. Beyond hormonal changes, forest therapy also appears to affect brain activity in ways that are beneficial for depression. Yeon et al. used fMRI scans to observe decreased activity in the

prefrontal cortex—a region of the brain associated with negative emotions and rumination—among individuals engaged in urban forest therapy^[69]. Their findings suggest that immersing oneself in nature significantly alleviates depression symptoms.

In addition to the solitary comfort provided by nature, forest therapy offers the potential for social connection, which plays a crucial role in combatting depression. Spending time in nature with others can foster a sense of belonging and community, helping to alleviate the feelings of isolation that often accompany depression. Hong et al. found that urban green spaces promote social interaction and community engagement, both of which are vital for emotional well-being^[70]. Moreover, the gentle exercise of walking through a forest adds another layer to the therapeutic effects. Meneguzzo et al. observed improvements in mood and reductions in depression symptoms after forest walks^[55]. These benefits are likely due to the combined effects of physical activity and exposure to nature.

4.2.3. Improving Cognitive Functioning

Can forest therapy improve participants' cognitive functioning? The relationship between immersion in natural environments and enhanced cognitive function has become a focal point of recent research^[71, 72]. A growing body of evidence supports a strong, multi-faceted relationship between immersion in natural environments and improved cognitive function. Several theoretical frameworks and clinical studies indicate that natural exposure may enhance attention, memory, executive function, and creativity^[65, 71, 72]. In essence, it is suggested that spending time in natural environments clears the mind while optimizing cognitive processes is crucial for success in modern life^[38]. Several studies support the idea that cognitive function is significantly boosted by exposure to nature. For instance, forest therapy has shown promising results in improving cognitive abilities^[71]. Engaging in physical activity within natural settings, often referred to as green exercise, also appears to benefit cognitive function. Specifically, forest therapy has been found to improve working memory and attention compared to walking in non-forested environments^[66]. This statement underscores the potential of natural environments to enhance cognitive function by offering measurable benefits beyond relaxation.

4.2.4. Exploring Creativity

Regarding exploring creativity, Khalil et al. argued that a creative mind acts as a gateway to achieving significant success across personal, professional, and social domains^[73]. Their review emphasized the importance of understanding the neural mechanisms that drive creativity, offering an integrative view of how neural systems support creative cognition and motivation. Yu and Hsieh found that green exercise enhances attention, memory of individuals, and their executive function is more effective than exercise performed in built environments^[72]. In practice, it is found that four days of immersion in nature, combined with disconnection from multimedia and technology, led to a remarkable 50% improvement in creativity and problem-solving performance among a group of inexperienced hikers^[74]. Overall, these studies suggest that immersion in natural settings provides a distinct cognitive advantage, enhancing both creativity and problem-solving abilities.

4.3. Ethical Considerations in Forest Therapy Studies

Ethical considerations play a critical role in forest therapy research, given its interplay with participants, natural environments, and sometimes involving vulnerable populations, e.g., senior citizens^[48] and young people^[13, 14]. As forest therapy often involves direct engagement with participants in outdoor, often semi-controlled environments, researchers must navigate both biomedical and environmental ethical frameworks to ensure the integrity and responsibility of their studies. However, in previous studies it is reported that less than half of studies follow the ethical protocol such as Institutional Review Board while some studies do not report their ethical procedures at all^[12, 50]. Some researchers reported that their studies have obtained approvals from the Ethic committee of their institutions^[3, 31, 62, 65, 71], while others reported that their research ethical approval is in accordance with authorities such as Polish Committee of Ethics in Science and with the 1964 Helsinki Declaration and Regional Research Ethics Committee of the Medical Centre, Pécs, Hungary^[52]. These protocols have provided solid and specific requirements for obtaining participants' consent and other necessary data protection. In future studies, it is suggested that researchers should at least provide

ethical statements, such as IRB approval, in their study, to standardize procedures of forest therapy studies.

5. Conclusion and Research Implications

Regarding the first research question (*What are the current research trends and citation patterns in forest therapy studies?*), our study found that forest therapy research in SCI journals began in the late 20th century and has continued to grow in recent years. The increasing number of publications and citations highlights the rising significance of this field^[9–12, 15, 21, 23, 26, 28–30, 49, 54–56]. We argue that forest therapy has gained substantial traction among scholars^[28] and interest in exploring its benefits has steadily increased^[54].

Regarding the second research question (*Who are the leading contributors in this field, and what do their collaboration networks look like?*), we found that scholars from Japan, South Korea, China, European countries, the United States, and Canada contribute the most to forest therapy publications, with influential institutions from these countries reflecting their active involvement (**Table 3** and **Figure 4**). This aligns our observations from previous review studies^[9–12, 15, 21, 23, 26, 28–30, 44–49, 49–56]. The concentration of forest therapy studies in certain journals further reflects the current landscape of scholarly publications in this field (**Figure 2**).

We contend that there are connections among some researchers and institutions, and we observed strong collaborations among scholars domestically. Furthermore, considering the third research question (*How has research in forest therapy evolved over time?*), by tracking the evolution of forest therapy research, we observed a shift in focus—from forest recreation in 2014 to forest therapy by 2020 (**Figure 4**). Notably, researchers in the 2020s placed emphasis on health-related aspects of forest therapy^[8, 11, 22, 30, 54, 60], such as COVID-19-related studies^[49].

Regarding the fourth research question (*What are the main keyword distributions and research clusters identified within these studies?*), we found that scholars primarily focus on the various benefits of forest therapy, as we identified 16 research clusters to explore publication patterns (**Figure 7**). This finding is consistent with previous literature reviews^[13–15, 33]. Upon further examination of these clusters,

we identified two primary research themes^[13–15, 33]: physiological effects and psychological effects.

Concerning the fifth research question (*What are the main physiological and psychological benefits of forest therapy?*), we examined two primary research themes and discussed a range of effects, including the regulation of blood pressure, improvement of cardiovascular and immune functions, enhancement of the respiratory system, better sleep quality, stress reduction, depression management, improved cognitive functioning, and increased creativity. These physiological and psychological effects are consistent with findings from previous literature review studies^[11, 26, 28–30, 56].

5.1. Research Agenda

In the context of forest therapy, we identified two key research themes that offer unique insights into its health-related benefits, contributing to a broader understanding of its role in promoting overall well-being. Future research is needed to explore the effects of forest therapy across a wider variety of environments, including urban settings, rural areas, and other ecological contexts. Comparing these environmental scenarios could make forest therapy studies more compelling and persuasive.

Respecting the demographic distribution of participants, we observed that while diverse groups provide valuable insights into the broad health benefits of forest therapy^[13, 31, 54], additional research is necessary to fully understand its effects across various demographic groups and patient populations, particularly considering cultural and individual differences. Furthermore, existing clinical studies highlight the need for more geographically diverse applications^[29].

Despite strong domestic collaborations, we observed that international and cross-national studies remain limited. Greater global networking is needed to facilitate simultaneous clinical research and to validate the effects of forest therapy across diverse ecological systems. When combined with different environmental settings, multi-sited clinical research may help verify the effectiveness and efficiency while comparative studies possibly contribute to a more comprehensive understanding of forest therapy's global applicability.

As a holistic approach to health and well-being, forest therapy offers benefits that support both physical and mental health. It can serve as a valuable complement to tra-

ditional medical interventions, promoting overall wellness and a higher quality of life. Nevertheless, it is important to acknowledge that participants' experiences may vary, and forest therapy should be viewed as a supplementary practice rather than a replacement for conventional treatments. Taken together, while forest therapy shows promising in addressing various health conditions, further research is essential to completely examine its therapeutic effects—particularly in areas such as sleep, neurological conditions, and chronic diseases.

5.2. Research Limitations

The present study acknowledges several limitations in the collection and analysis of data. First, non-English publications were excluded, which may have led to the omission of valuable research—particularly in languages such as Japanese, Korean, and Chinese, where significant contributions to forest therapy studies are likely. Nonetheless, we believe the English-language articles selected and analyzed represent the most recent and critical advancements in forest therapy research, because English dominates high-impact academic publishing, making it a practical and representative basis for literature reviews^[75].

Second, given the rapidly increasing volume of research on forest therapy in recent years, this study focuses exclusively on literature published in journals indexed by the SCI. Other articles, book chapters and grey literature, which may offer substantial insights, were not considered because they are not peer-reviewed publications. Our selective approach was adopted to ensure academic rigor while effectively managing the scope of the review. By narrowing the source pool, the study aims to analyze published trends and trace the evolution of forest therapy research within mainstream academic discourse. SCI-indexed journals were prioritized for their peer-reviewed standards, high impact, and scholarly recognition, allowing for a focused and credible understanding of how the field has developed over time.

Third, the interpretation of results generated by CiteSpace and VOSviewer may be subject to human bias, potentially affecting the accuracy of our conclusions when compared to the software-generated data. Simultaneously, as CiteSpace techniques and algorithms continue to evolve, the increasing number of publications may pose additional challenges to our findings. Nevertheless, we believe that

the publications from 1998 to 2023 sufficiently capture the trends, evolution, and other key metrics in forest therapy research.

Fourth, due to the large number of articles retrieved, this study does not include a critical assessment of the quality of the included research. It is important to note that bibliometric and visualization studies differ from systematic literature reviews, as our study places greater emphasis on identifying research trends and developments rather than critically appraising individual studies. Therefore, it is acknowledged that an in-depth analysis of the 416 papers is lacking.

5.3. Summary

Forest therapy is closely linked to environmental science, emphasizing the relationship between natural ecosystems and human health. Our research highlights the growing recognition the effectiveness of forest therapy—particularly in areas such as cardiovascular health, cognitive function, and stress reduction. This connection underscores the importance of conservation efforts aimed at maintaining and restoring forests to ensure their health benefits remain accessible. As interest in forest therapy continues to grow, environmental science plays a vital role in understanding how nature supports well-being, reinforcing the need for sustainable forest management to preserve these natural healing environments for future generations.

Author Contributions

Conceptualization, W.H. and S.Z.; methodology, W.H.; software, D.L.; validation, W.H., S.Z. and D.L.; formal analysis, W.H.; investigation, W.H.; resources, W.H.; data curation, D.L.; writing—original draft preparation, W.H.; writing—review and editing, W.H.; visualization, W.H.; supervision, C.I.; project administration, C.I.; funding acquisition, C.I. All authors have read and agreed to the published version of the manuscript.

Funding

This research received no external funding.

Institutional Review Board Statement

Not applicable.

Informed Consent Statement

Not applicable.

Data Availability Statement

The data is available at request.

Acknowledgments

The authors would like to express their sincere gratitude to Professor Wunhong Su from Hangzhou Dianzi University for his generous help; to the editors for their careful editing and very nice communication; and to the reviewers for their contributions to improvement and thoughtful comments.

Conflicts of Interest

The authors declare that they have no known conflicts of interest.

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