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**Austrian Journal of
Forest Science**

Centralblatt
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Forstwesen**Global Review of Literature on Forest Bathing****Globaler Überblick über die Literatur zum Waldbaden**A. Denche-Zamorano¹, Y. Rodríguez-Redondo^{2*}, J. Rojo-Ramos³, V. Miguel-Barrado⁴,
A. Sánchez-Leal³, E. Pérez-Calderon⁴**Keywords:** Green therapy, nature-based therapy, nature therapy, health-care, mental health, shirin-yoku**Schlüsselbegriffe:** Grüne Therapie, naturbasierte Therapie, Naturtherapie, Gesundheitswesen, psychische Gesundheit, shirin-yoku**Abstract**

Forest bathing, or shinrin-yoku, is a practice that involves immersion in forest environments to improve health and well-being, associated with stress reduction, immune system strengthening and mood enhancement. The aim of the present analysis is to quantify and evaluate scientific output, map collaboration among researchers, as well as identify prolific and prominent researchers, identify prolific journals, and analyze thematic trends. The set of 285 documents was extracted from the Web of Science, processed with Microsoft Excel and VOSviewer programs, and the analysis was performed following the traditional rules of bibliometrics. The number of publications show exponential growth, demonstrating the interest of the scientific community. The core of prolific journals is composed of only two journals, and the most prominent author is M. Yoshifumi from Chiba University (47 articles and 2208 citations). Japan and South Korea stand out as the most prolific countries. The researchers focus on the positive effects of forest bathing on mental health, especially in mitigating symptoms of depression, anxiety and stress.

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Zusammenfassung

Waldbaden oder Shinrin-yoku ist eine Praxis, die das Eintauchen in Waldumgebungen zur Verbesserung der Gesundheit und des Wohlbefindens beinhaltet und mit Stressabbau, Stärkung des Immunsystems und Verbesserung der Stimmung in Verbindung gebracht wird. Ziel der vorliegenden Analyse ist es, die verfügbare wissenschaftlichen Literatur zu erfassen und zu bewerten, die Zusammenarbeit zwischen Forschern darzustellen sowie zentrale Forschende zu identifizieren, wichtige Zeitschriften zu identifizieren und thematische Trends zu analysieren. Die 285 Dokumente wurden aus Web of Science extrahiert, mit Microsoft Excel und VOSviewer bearbeitet und die Analyse wurde nach den traditionellen Gesetzen der Bibliometrie durchgeführt. Die Anzahl der Dokumente weist ein exponentielles Wachstum auf, was das Interesse der wissenschaftlichen Gemeinschaft an diesem Thema deutlich macht. Im Zentrum der Publikation stehen nur zwei Journale und der prominenteste Autor ist M. Yoshifumi von der Universität Chiba (47 Artikel und 2208 Zitate). Japan und Südkorea sind die Länder mit der höchsten wissenschaftlichen Output. Die Forscher konzentrieren sich auf die positiven Auswirkungen des Waldbadens auf die psychische Gesundheit, insbesondere auf die Linderung der Symptome von Depression, Angst und Stress.

1 Introduction

Today, due to climate change, population growth and uncontrolled development of cities, decreasing biodiversity and forest degradation, which has been steadily depleting over the last decades, are real problems for our planet (Sandifer *et al.*, 2015). This situation is motivating many collectives and individuals, world organisations, governments, public administrations and associations, to increase their concern and appreciation for natural environments, forests and ecosystems, given the benefits that nature and biodiversity can offer to quality of life and the health of the population, and the potential negative consequences resulting from their degradation (Bermejo-Martins *et al.*, 2022; Honeyman, 1992; Kotera *et al.*, 2022; Sandifer *et al.*, 2015; Ulrich, 1984; Ulrich *et al.*, 1991). For decades, researchers have studied how the beneficial relationship with nature has influenced human evolution and people's state of health (Q. Li, 2022; Millward & Appleton, 1988; Orians & Heerwagen, 1992; Wilson, 1984).

In 1982, the Japanese Ministry of Agriculture, Forestry and Fisheries introduced the term "Shinrin-yoku", which means "forest bathing" in Japanese (B. J. Park *et al.*, 2008). Forest bathing is a natural therapeutic technique that involves spending time in a forest or natural environment. This therapy is believed to have numerous positive effects on people's mental and physical health, as evidenced by several studies that investigated the relationship between forest bathing and its potential health benefits, such as: reducing stress (Miyazaki *et al.*, 2014a; Stier-Jarmer *et al.*, 2021; Zhu *et al.*, 2021), improving cardiovascular function (J. Lee *et al.*, 2009; Ochiai *et al.*, 2015;

Stier-Jarmer *et al.*, 2021; Tsunetsugu *et al.*, 2007), strengthening the immune system (Q. Li *et al.*, 2007, 2008, 2010; Stier-Jarmer *et al.*, 2021) and alleviating symptoms of chronic diseases such as anxiety, depression and insomnia (Baek *et al.*, 2022; Kang *et al.*, 2022; H. Kim *et al.*, 2020; López-Pousa *et al.*, 2015; Qiu *et al.*, 2022; Stier-Jarmer *et al.*, 2021; Timko Olson *et al.*, 2020). We can establish some differences between forest bathing and forest therapy, both being nature-based practices aimed at promoting wellness, but differing in their approach and structure. Forest bathing, originating in Japan, involves immersing oneself in natural environments, mostly forests, to relax and connect with nature through sensory engagement and mindfulness. It emphasizes informal activities such as walking and meditation. Forest therapy, meanwhile, is a more structured approach, led by trained facilitators or therapists, that incorporates specific therapeutic techniques in the forest setting to address the physical, emotional and mental health needs of individuals. While both practices recognize the benefits of nature for personal wellness, forest therapy offers a more intentional and therapeutic framework for healing and support (Baek *et al.*, 2022; Kang *et al.*, 2022; H. Kim *et al.*, 2020; López-Pousa *et al.*, 2015; Qiu *et al.*, 2022; Stier-Jarmer *et al.*, 2021; Timko Olson *et al.*, 2020)..

Some authors suggest that by going into forests and surrounding oneself with trees and vegetation, the body and mind relax, benefiting from the healing effects of nature. This activity, such as forest bathing, could be done alone or in groups, including activities such as walking, meditation, yoga or just sitting and enjoying the environment (Yu *et al.*, 2021). Even in pure virtual reality forests can serve as relaxation environment (Hejtmánek *et al.*, 2022). In this regard, one of the main benefits of forest bathing is its ability to improve people's mental health, notably its ability to reduce stress (Miyazaki *et al.*, 2014b; Stier-Jarmer *et al.*, 2021; Zhu *et al.*, 2021), as well as being an effective treatment for depression and anxiety (H. Li *et al.*, 2022; Q. Li *et al.*, 2016; Muro *et al.*, 2021). Chronic stress is one of the leading causes of illness worldwide (Torrades, 2007) and spending time in nature has been shown to help lower cortisol levels (J. Lee *et al.*, 2011; B. J. Park *et al.*, 2008; Tsunetsugu *et al.*, 2007, 2010), a stress-related hormone, in the body (Torrades, 2007). In addition, being surrounded by trees and vegetation also increases serotonin levels, a brain chemical related to well-being and happiness (B. J. Park *et al.*, 2020; S. Park *et al.*, 2021), thus improving people's mood and having positive effects on anxiety and depression (Muro *et al.*, 2021).

Forest bathing also has benefits for cardiovascular health (J. Lee *et al.*, 2009; Ochiai *et al.*, 2015; Stier-Jarmer *et al.*, 2021; Tsunetsugu *et al.*, 2007). Spending time in nature has been linked to a reduction in blood pressure (J. Lee *et al.*, 2009; B. J. Park *et al.*, 2007, 2010) and improved cardiovascular system function (Jimenez *et al.*, 2021). In addition, walking in natural environments has positive effects on heart rate and respiration, which helps to strengthen the cardiovascular system (J. Lee *et al.*, 2009; B. J. Park *et al.*, 2008, 2010; Tsunetsugu *et al.*, 2007). Another important benefit of forest bathing is its ability to strengthen the immune system (Q. Li *et al.*, 2007, 2008, 2010), spending time in natural spaces has been found to be associated with an increase in

the number of immune cells in the body, which helps prevent disease and accelerates recovery from existing illnesses (Q. Li *et al.*, 2007, 2008, 2010).

On the other hand, it has also been shown that forest bathing can have benefits in improving insomnia (H. Kim *et al.*, 2020; López-Pousa *et al.*, 2015). Studies have found that spending time in nature has the potential to enhance the quality of sleep, shorten the time required to initiate sleep, and extend the overall duration of sleep (H. Kim *et al.*, 2020; López-Pousa *et al.*, 2015). In addition, walking in natural environments can help regulate circadian rhythms, which may be beneficial for people with sleep disorders (H. Kim *et al.*, 2020; López-Pousa *et al.*, 2015).

Moreover, forest bathing not only has a prominent role in improving people's health, but the practice can also be understood as an opportunity for the improvement of socio-economic development in rural areas (Ohe *et al.*, 2017). The evolution of society, new tourism trends or the consequences of the COVID-19 pandemic have boosted the practice of recreational activities carried out in nature (Peng *et al.*, 2023; Vada *et al.*, 2019; Wen *et al.*, 2020). Thus, the importance of tourism modalities related to the health and well-being of tourists (Dillette *et al.*, 2020; Heung & Kucukusta, 2013; Peng *et al.*, 2023), with forest immersion being an emerging tourism practice worldwide (Farkic *et al.*, 2021; Kil *et al.*, 2021; Ohe *et al.*, 2017), should now be highlighted.

Thus, in previous literature there are some studies that have highlighted the effects that this immersion in nature can have from the point of view of different dimensions, thus adopting a multidisciplinary character (Farkic *et al.*, 2021; Ohe *et al.*, 2017). This study's main objective was to analyse the scientific production published in the Web of Science (WoS) on forest baths, checking the trend followed by annual publications, identifying the prolific and prominent researchers, journals with the highest production and lines of research on forest baths.

2 Material and Methods

2.1 Design and data sources

This scientific mapping was a descriptive bibliometric study based on data extracted from the Web of Science (WoS) core collection, in the editions: Science Citation Index Expanded (SCI-Expanded) and Social Sciences Citation Index (SSCI). Web of Science is a popular database for bibliometric analysis due to its broad multidisciplinary coverage, high quality content, citation tracking capabilities and advanced functionalities that allow efficient and reliable searching, filtering and generation of impact metrics; these being tools that other databases lack. (Ding & Li, 2020; Lu *et al.*, 2019; Mulet-Forteza *et al.*, 2019; Y. Wang *et al.*, 2022). The data strategy followed included the search vector: "forest bathing" (Topic) or "shinrin yoku" (Topic) or "Shirin-yoku"

(Topic) or "forest therapy" (Topic) and Articles or Review articles (Documents types); without time or language restrictions.

2.2 Data analysis

The phase of scientific development of the object of study was studied, applying Price's Law of Exponential Growth of Science (Dobrov *et al.*, 1979; Price, 1976). The author data was cleaned, eliminating duplicate identities. The most relevant journals in the subject were identified, applying Bradford's Law of concentration of scientific production, calculating the Bradford zones and the adjustment of the dataset to this law (Desai *et al.*, 2018; Morse & Leimkuhler, 1979; Venable *et al.*, 2016). This law states that the scientific literature can be divided into a core and fringe, where a small number of journals contain most of the important articles (Desai *et al.*, 2018; Morse & Leimkuhler, 1979; Venable *et al.*, 2016). Each of these zones should accumulate approximately 33% of the total papers. Lotka's Law was used to identify the prolific co-authors (Coile, 1977; Vega-Muñoz *et al.*, 2022). Hirsch index (h-index) was used to identify the most cited articles, considering as these, the h articles with h or more citations (Hirsch, 2005). Matching prolific co-authors to co-authors of the most cited papers, prolific co-authors who submitted one or more articles among the most cited papers were considered prominent co-authors (Mendoza-Muñoz *et al.*, 2022). A descriptive analysis was carried out with the countries involved in the topic. The keywords most used by the authors were located, applying Zipf's Law (Bulick & Bulick, 1978; Valderrama-Zurián *et al.*, 2021). Data processing and visualisation was carried out with Microsoft Excel v.2204 and VOSviewer software. The network plots generated for co-authors and keywords represented a strength of association analysis. This is a measure that indicates the strength of the relationship between two terms or elements in a bibliographic dataset. This measure is based on the frequency with which two terms appear together in the documents analyzed.

3 Results

We found 285 articles (234 articles and 51 article reviews) indexed in WoS and published between 1998 and 2022, assigned to 63 WoS categories. The categories with the highest number of articles were: Environmental Sciences (121), Public Environmental Occupational Health (119), Forestry (65), Environmental Studies (49) and Urban Studies (32).

The topic of study was found to be in a phase of exponential growth between 2006 and 2021 (the years prior to 2006 were excluded as there was no continuity in the annual publications, as well as the year 2022, as there was not yet complete data on the publications for that year), with an adjustment of 94.3% (R^2) (Figure 1).

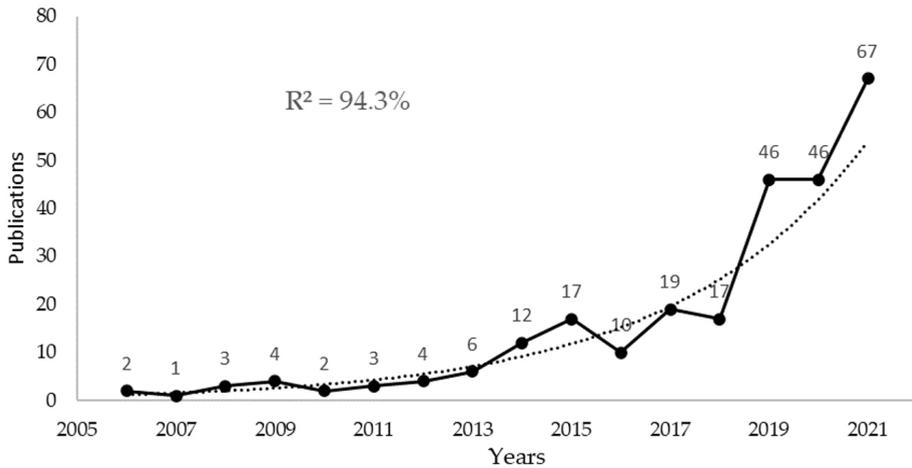


Figure 1: Exponential increase in yearly publications related to forest bathing.

Abbildung 1: Exponentieller Anstieg der Anzahl der Publikation zu Waldbaden.

The Bradford zones formed by the journals, according to the number of articles published, were adjusted, with a margin of error of 2%, to the estimates obtained by applying Bradford's law of dispersion of the scientific literature. The core group of journals with the most publications on the subject consisted of two journals that accounted for 43% of the articles: International Journal of Environmental Research and Public Health (94 articles) and Urban Forestry & Urban Greening (29 articles). Bradford's zone 1 was made up of 13 journals, accumulating 68% of the publications between the core journals and zone 1 (Table 1). In terms of the number of citations, the core was made up of three journals, which accounted for 37.9% of the citations: International Journal of Environmental Research and Public Health (2029 citations, 94 articles), Urban Forestry & Urban Greening (651 citations, 29 articles) and Ecosystem Services (486 citations, 1 article).

Table 1: Core and Zone 1 (Bradford's zone) of journals, according to number of articles published on forest bathing. JCR (Journal Citation Reports: Quartiles 1 to 4); Art. (Articles); % Art. (Percentage of total articles); % Acc. (Accumulated percentage of total number of articles); % O. A. (Percentage of articles of the journal in Open Access).

Tabelle 1: Kern und Zone 1 (Bradford's Zone) der Zeitschriften, hinsichtlich der Anzahl der Artikel publiziert zum Thema Waldbaden. JCR (Journal Citation Reports: Quartiles 1 bis 4); Art. (Artikel); % Art. (Anteil an Artikelgesamtanzahl); % Acc. (Kummulierter Anteil an Artikelgesamtanzahl); % O. A. (Anteil Artikel in Open Access Journalen).

Bradford's zones	Journals	Publishers	JCR	Art.	% Art.	% Acc.	Cites	%O.A.
Core	International Journal of Environmental Research and Public Health	MDPI	Q1	94	33%	33%	2029	99.8%
	Urban forestry & Urban Greening	Elsevier GMBH	Q1	29	10%	43%	651	5.4%
Zone 1	Forests	MDPI	Q1	19	7%	50%	232	99.8%
	Sustainability	MDPI	Q2	10	4%	53%	30	99.8%
	Journal of Physiological Anthropology	BMC	Q2.	8	3%	56%	249	100.0%
	Evidence-Based Complementary and Alternative Medicine	Hindawi LTD	Q2	6	2%	58%	246	98.1%
	Sante Publique	Soc Francaise Sante Publique	Q4	5	2%	60%	22	0.0%
	Environmental Health and Preventive Medicine	Springer	Q1	4	1%	61%	158	100.0%
	Frontiers in Psychology	Frontiers Media SA	Q2	4	1%	63%	53	99.7%
	Journal of Forest Research	Taylor & Francis LTD	Q3	4	1%	64%	46	2.3%
	Environmental Chemistry Letters	Springer	Q1	3	1%	65%	74	4.9%
	Healthcare	MDPI	Q2	3	1%	66%	4	99.9%
	International Journal of Environmental Health Research	Taylor & Francis LTD	Q2	3	1%	67%	18	2.0%
	Journal of Alternative and Complementary Medicine	Mary Ann Liebert INC	Q2	3	1%	68%	43	7.4%
	Landscape and Urban Planning	Elsevier	Q1	3	1%	69%	144	16.8%
	Scandinavian Journal of Forest Research	Taylor & Francis AS	Q2	3	1%	71%	275	17.9%

A total of 971 researchers were found with at least one article on the subject. With only one published article, 763 co-authors were found, with 122 researchers co-authoring only two articles, with the number of co-authors dropping to one researcher with 47 co-authored publications (Figure 2).

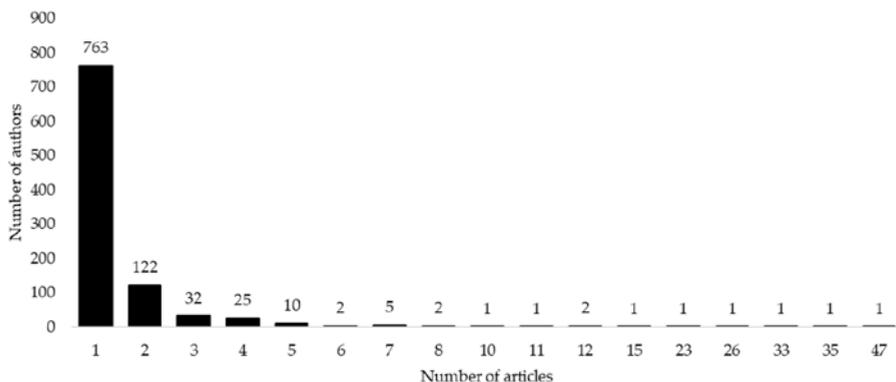


Figure 2: Histogram of publications per authors on forest bathing.

Abbildung 2: Histogramm der Anzahl Publikationen pro Autor zum Thema Waldbaden.

Applying Lotka's Law to the authors, it was estimated that the prolific authors should be the 31 authors with the highest number of publications. We found 54 co-authors with at least 4 articles, and 29 co-authors with 5 or more articles, so the latter were considered the prolific authors (Supplementary Material 1). A graph of the interrelationships of the 29 prolific co-authors was produced (Method: Fractionalization. Attraction: 6. Repulsion: -6). In this graph the colors represent groups of collaborating authors, the nodes are authors (their size indicates productivity/importance), and the lines indicate collaborations between them. Eight collaborative clusters were found. The main cluster was led by Yoshifumi Miyazaki, together with 14 other researchers (Figure 3).

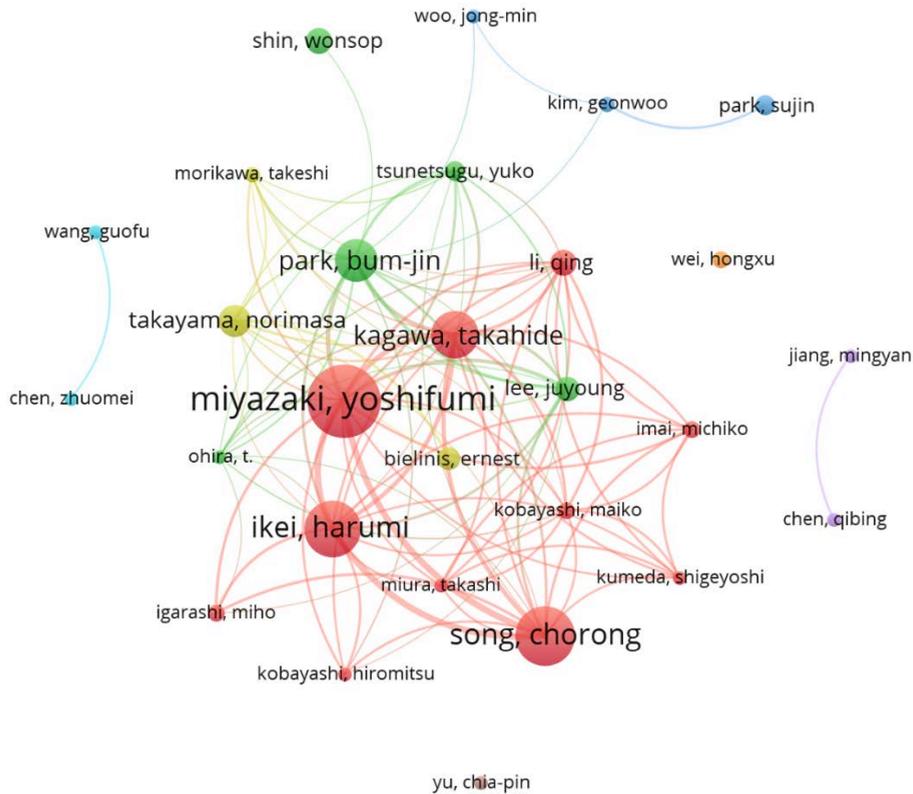


Figure 3: Interrelations of co-authors publishing on forest bathing. Each node (29 in total) represents a prolific author, and its size represents its productivity/influence. The lines between them represent their relationships, the thickness of the line the frequency of these relationships. Eight groups of contributors are represented by each color. These are: (1) Red: Y. Miyazaki, H. Ikei, C. Song, T. Kagawa, Q. Li, M. Imai, M. Kobayashi, S. Kumeda, T. Miura, H. Kobayashi and M. Igarashi. (2) Green: B.J. Park, J. Lee, T. Ohira, Y. Tsunetsugu and W. Shin. (3) Yellow: N. Takayama, E. Bielinis, T. Morikawa. (4) Blue: J.M. Woo, G. Kim and S. Park. (5) Light blue: G. Wang and Z. Chen. (6) Purple: M. Jiang and Q. Chen. (7) Orange: H. Wei. (8) Brown: C.P. Yu.

Abbildung 3: Beziehungen zwischen Koautoren mit Publikationen zum Thema Waldbaden. Jeder Knoten (29 insgesamt) zeigt einen Autor und die Größe des Knotens dessen Produktivität / Einfluss. Die Linien zeigen die Beziehungen zwischen den Autoren und die Linienstärke die Häufigkeit der Beziehungen. Die acht Gruppen werden mit Farben dargestellt: (1) Rot: Y. Miyazaki, H. Ikei, C. Song, T. Kagawa, Q. Li, M. Imai, M. Kobayashi, S. Kumeda, T. Miura, H. Kobayashi und M. Igarashi. (2) Grün: B.J. Park, J. Lee, T. Ohira, Y. Tsunetsugu und W. Shin. (3) Gelb: N. Takayama, E. Bielinis, T. Morikawa. (4) Blau: J.M. Woo, G. Kim und S. Park. (5) Hellblau: G. Wang und Z. Chen. (6) Purpur: M. Jiang und Q. Chen. (7) Orange: H. Wei. (8) Braun: C.P. Yu.

To identify the prominent co-authors the most cited articles (documents with 47 or more cites), according to the h-index, and prolific co-authors (5 or more documents) were combined, identifying 22 authors with at least one paper among the most cited

papers on forest bathing. Yoshifumi Miyazaki emerged as the prominent co-author (47 articles and 2208 citations, 18 most cited papers). Table 2 shows the prominent co-authors in the field of study.

Table 2: Prominent co-authors on forest bathing. Numbers in brackets (asterisk) indicate number of documents included in the set of most cited documents (table S1).

Tabelle 2: Wichtige Koautoren zum Thema Waldbaden. Zahlen in Klammern (Stern) zeigen die Anzahl Publikationen, die auch unter den meist zitierten Publikationen sind (Tabelle S1).

Authors	Affiliation (Country/Region)	Articles (*)	Citations
Miyazaki, Yoshifumi	Chiba University (Japan)	47 (18)	2208
Song, Chorong	Chiba University (Japan)	35 (9)	1291
Ikei, Harumi	Chiba University (Japan)	33 (9)	1287
Kagawa, Takahide	Forestry Forest Products Research Institute (Japan)	26 (8)	2069
Park, Bum-Jin	Chungnam National University (South Korea)	23 (9)	1500
Takayama, Norimasa	Forestry Forest Products Research Institute (Japan)	15 (5)	804
Li, Qing	Nippon Medical School (Japan)	12 (9)	1016
Lee, Juyoung	Chiba University (Japan)	11 (4)	594
Bielinis, Ernest	University of Warmia Mazury (Poland)	10 (1)	229
Tsunetsugu, Yuko	Chiba University (Japan)	8 (7)	1347
Kobayashi, Maiko	Forestry Forest Products Research Institute (Japan)	7 (6)	652
Imai, Michiko	Chiba University (Japan)	7 (4)	355
Igarashi, Miho	Chiba University (Japan)	7 (2)	281
Morikawa, Takeshi	Chiba University (Japan)	6 (2)	269
Kim, Geonwoo	Korea Forest Research Institute (South Korea)	6 (1)	56
Ohira, T.	Forestry Forest Products Research Institute (Japan)	5 (3)	619
Kumeda, Shigeyoshi	Forestry Forest Products Research Institute (Japan)	5 (4)	341
Miura, Takashi	Forestry Forest Products Research Institute (Japan)	5 (4)	341
Woo, Jong-Min	Inje University (South Korea)	5 (3)	226
Wang, Guofu	Zhejiang Forestry Acad (China)	5 (2)	225
Yu, Chia-Pin	National Taiwan University (Taiwan)	5 (2)	192
Chen, Zhuomei	Zhejiang Forestry Acad (China)	5 (2)	151

The set of papers consisted of 280 articles written in English, 4 in French and 1 in German. Japan (78 articles, 4011 citations), South Korea (69 articles, 1665 citations), China (49 articles, 788 citations) and United States of America (34 articles, 1876 citations) were the countries with the highest number of publications, among the 35 countries found, publishing on the subject. Figure 4 shows the interrelationships between countries, the size of the node is a function of the number of articles cited from each country, while the colour is a function of the average date of publication, where it can be seen how there are countries that have been adding to the subject in recent years (Method: Fractionalization. Attraction: 10. Repulsion: -6). The lines between the nodes (countries) would indicate scientific collaborations between researchers from different countries in the publication of scientific articles.

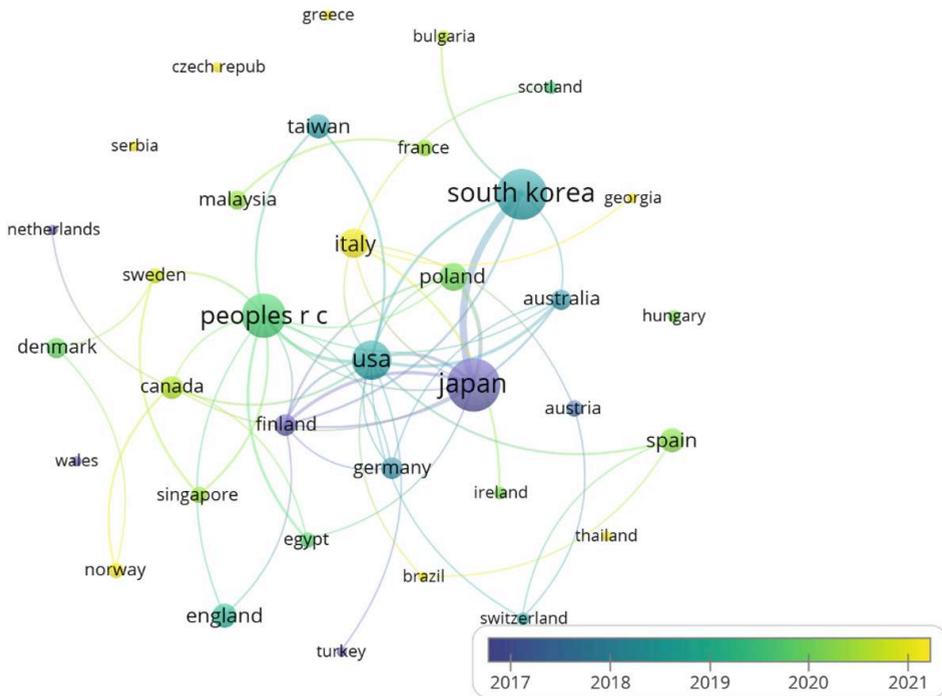


Figure 4: Interrelations of countries/regions and citations on forest bathing. Each node (35 in total) represents a region/country, and its size represents the number of citations that each one accumulates. The lines between them represent the collaborations between them, the thickness of the line the frequency of these. The color of each node represents the average year of publication.

Abbildung 4: Beziehungen zwischen Ländern/Regionen und Zitate zu Waldbaden. Jeder Knoten (insgesamt 35) zeigt ein Land/Region und die Größe zeigt die Anzahl der Zitate, die dieser gesammelt hat. Die Linien dazwischen zeigen die Kollaborationen an und die Linienstärke deren Häufigkeit. Die Farbe der Knoten zeigen das Jahresmittel der Publikationszeitpunkte.

Forty-seven articles were found with at least 47 citations, these being the most prominent articles on the object of study. The most cited article was a review entitled “Exploring connections among nature, biodiversity, ecosystem services, and human health and well-being: Opportunities to enhance health and biodiversity conservation” with 486 citations (Sandifer et al., 2015), followed by “The influence of urban green environments on stress relief measures: A field experiment” (432 citations) (Tyrväinen et al., 2014) and “The effect of contact with natural environments on positive and negative affect: A meta-analysis” (265 citations) (McMahan & Estes, 2015). Table S1 (Supplementary materials) shows the 47 most cited articles.

Applying Zipf's Law to the keywords used most by the authors, 26 words stood out, used in at least 8 articles, being: forest therapy (74 occurrences), forest bathing (64), shinrin.yoku (37), heart rate variability (28) and blood pressure (21). Figure 5 shows the interrelationship graph of the 26 keywords most frequently used by the authors.

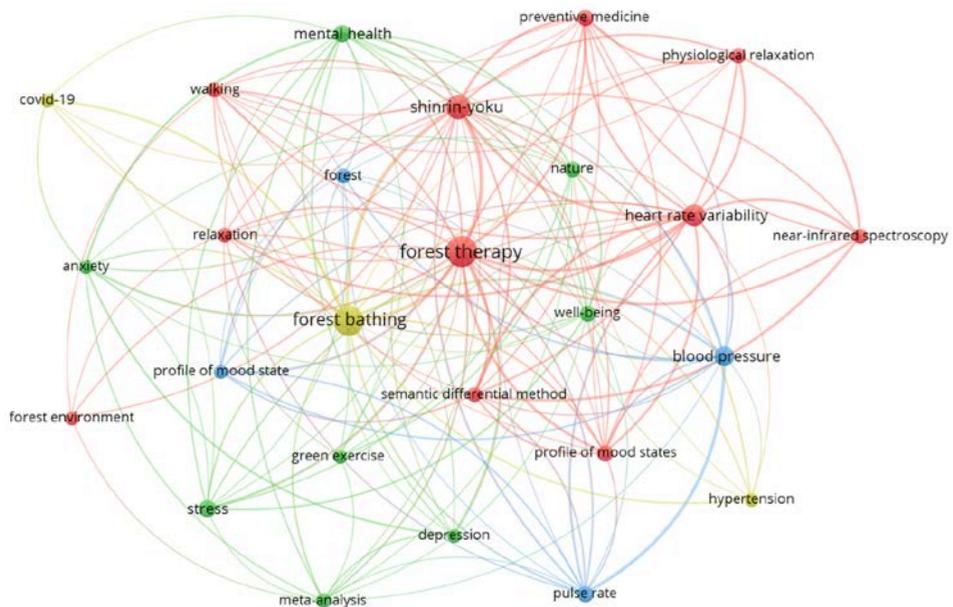


Figure 5: Interrelationships of the most used keywords on forest bathing. Each node (26 in total) represents an author keyword, and its size represents the number of occurrences it has. The lines between them represent the number of times they appear together; the thickness of the line represents their frequency. The color represents the groupings formed according to the occurrences. These are: (1) Red: Forest therapy, shinrin-yoku, heart rate variability, semantic differential method, profile of mood states, forest environment, relaxation, walking, preventive medicine, physiological relaxation and near-infrared spectroscopy. (2) Green: Well-being, nature, mental health, anxiety, stress, green exercise and meta-analysis. (3) Blue: Forest, blood pressure, profile of mood state and pulse rate. (4) Yellow: Forest bathing, hypertension and covid-19.

Abbildung 5: Beziehungen zwischen den am häufigsten verwendeten Schlagwörter in Publikationen zum Thema Waldbaden. Jeder Knoten (26 insgesamt) zeigt ein Schlagwort und die Größe die Häufigkeit der Verwendung. Die Linien zeigen gleichzeitige Verwendung zweier Schlagwörter und die Linienstärke die Häufigkeit. Die Farben zeigen identifizierte Gruppen. (1) Rot: Forest therapy, shinrin-yoku, heart rate variability, semantic differential method, profile of mood states, forest environment, relaxation, walking, preventive medicine, physiological relaxation and near-infrared spectroscopy. (2) Grün: Well-being, nature, mental health, anxiety, stress, green exercise and meta-analysis. (3) Blau: Forest, blood pressure, profile of mood state and pulse rate. (4) Gelb: Forest bathing, hypertension and covid-19.

4 Discussion

This is the first bibliometric analysis based on published research on forest baths on the WoS database (285 documents), verifying the trend followed by annual publications on the subject, identifying the most productive and cited co-authors and journals, the countries most involved in this object of study, the most referenced documents and the mostly used keywords by co-authors. However, we found similar bibliometrics based on the Scopus database (Paletto *et al.*, 2024), two mappings of research in the field of natural therapies (Rodríguez-Redondo *et al.*, 2023; X. Wang *et al.*, 2022), and a review using a different methodology than our study, which does not use the traditional laws of bibliometrics (Hansen *et al.*, 2017), in addition to literature reviews, scoping reviews and systematic reviews (Antonelli *et al.*, 2019; Corazon *et al.*, 2019; Hansen & Jones, 2020; Ideno *et al.*, 2017; Jones *et al.*, 2021; Langemeyer *et al.*, 2021; I. Lee *et al.*, 2017; Oh *et al.*, 2017; Rojas-Rueda *et al.*, 2019; Vibholm *et al.*, 2020; Wolf *et al.*, 2020).

We found that annual publications on forest baths followed a trend of exponential growth, with a very high volume of publications in the last three years, far exceeding the number of publications accumulated in the previous 20 years. These findings show the high interest of researchers, journals and publishers in this topic, giving support to a study like this one. Although they did not demonstrate exponential growth in annual publications on forest therapies, X. Wang *et al.* (2022). found a massive increase in annual publications on the topic. We also find growing interest outside the scientific field, in Germany organizations have promoted projects such as Kur- und Heilwald, which focus on the promotion of health and well-being through contact with nature. Projects of this type favor the discovery of this type of therapies making them more visible to the population.

Two journals that made up Bradford's core, International Journal of Environmental Research and Public Health (MDPI) and Urban forestry & Urban Greening (Elsevier), standing out as the most productive journals in the subject, coincided with the most productive journals found in the bibliometrics of Wang *et al.* (X. Wang *et al.*, 2022). In this study, journals such as Forests (MDPI), Sustainability (MDPI) and Frontiers in Psychology (Frontiers Media) also appeared in the top 10 journals with the highest number of publications.

The term Shinrin-yoku (forest bathing) has its origins in Japan (B. J. Park *et al.*, 2010), from where it became established in the rest of Eastern Asia countries, and later expanded to the rest of the world. Thus, Japan is the country with the highest number of publications, followed by South Korea and China, something that has been reflected in the most productive authors: Miyazaki, Song, Ikei, Kagawa, Takayama, Li, among others, all of them Japanese; Park, Shin or Kim, co-authors from South Korea; and Wei, Chen, or Jiang, co-authors from China. All of them are among the prolific co-authors, coinciding with the most productive countries in forest therapies (X. Wang *et al.*,

2022). Similarly, many of the most cited papers were published by authors from those countries (J. Lee *et al.*, 2009, 2011, 2014; Q. Li *et al.*, 2008; Morita *et al.*, 2007; B. J. Park *et al.*, 2011). Among the prominent co-authors, a single co-author from a Western country is present, Bielinis (Poland), co-authored 10 papers, with "The effect of winter forest bathing on psychological relaxation of young Polish adults" (Bielinis *et al.*, 2018) being his most cited paper. However, the three most cited papers were published by co-authors from the USA (McMahan & Estes, 2015; Sandifer *et al.*, 2015) and Finland (Tyrväinen *et al.*, 2014). The most cited paper assessed the state of knowledge on the relationships between human health and nature and biodiversity, as well as the positive health effects found (Sandifer *et al.*, 2015), concluding that more initiatives and research by administrations and researchers are needed. Tyrväinen *et al.* (2014) investigated the psychological and physiological effects of short-term visits to urban natural environments, suggesting that short-term visits to natural areas have positive effects on the relief of perceived stress compared to the built environment, similar to the third most cited paper by McMahan and Estes (McMahan & Estes, 2015).

The effects of forest baths on mental health, such as anxiety and depression states, psychological discomfort or stress have been highly concerned among researchers and so numerous articles and reviews have been found that have evaluated this, finding positive health effects (Bielinis *et al.*, 2019; Chen *et al.*, 2018; J. G. Kim *et al.*, 2020; Kotera *et al.*, 2022; Q. Li, 2019; Song *et al.*, 2018), although results have been found in which they have reported that these effects are not clear (Vibholm *et al.*, 2020). Therefore for the above pathologies, forest baths have been presented as alternative non-pharmacological treatments (Rosa *et al.*, 2021), as well as means of prevention of mental pathologies, or of other pathologies such as hypertension (Bielinis *et al.*, 2021; Ochiai *et al.*, 2015; Wajchman-Świtalska *et al.*, 2021; Yeon *et al.*, 2021; Zhang *et al.*, 2020), finding positive effects on blood pressure. Relaxation exercises, physical activity and exercise in natural spaces, such as green exercise, or walking in green spaces, have been some of the topics of interest for researchers in which positive effects on the physical and mental health and well-being of participants have been evaluated (Kondo *et al.*, 2018; H. Li *et al.*, 2021; Rogerson & Barton, 2015; Shin *et al.*, 2012; Yamaguchi *et al.*, 2006) even in virtual reality forest (Hejtmánek *et al.*, 2022).

When comparing what we found with what was found by Paletto *et al.* (2024) we observed that 285 documents were found in WoS, compared to the 224 found by them. In both cases, the oldest document is the one written by Ohtsuka *et al.* (1998), entitled "Shinrin-yoku (forest-air bathing and walking) effectively decreases blood glucose levels in diabetic patients"; although they also found another document in the same year by the same author. The annual growth curves are similar in both databases, finding a gap between 1999 and 2005, both included. The most cited keywords coincide and when analyzing the connections between them we find a similar distribution, in the case of the review carried out in Scopus they did not apply Zipf's law to check the most relevant set of words, so they selected the words with four or more appearances, this being what is observed in their network graph. When we compare countries

between both databases we observe that Japan and the United States present a similar number of documents, but that South Korea and China present a difference of 41 documents in the first case and 24 documents in the second, the number of publications located in Scopus being lower. Finally, when comparing the most powerful organizations resulting from the Scopus analysis with the most relevant authors in the WoS analysis, we find a certain discrepancy. The analysis carried out by Paletto *et al.* (2024) indicates that “Forestry and Forest Products Research Institute” (Japan) is the most powerful organization and “Chiba University” (Japan) the second, in the present analysis the opposite is found, the authors of “Chiba University” (Japan) accumulate a greater number of documents than those of “Forestry and Forest Products Research Institute” (Japan), this may be due to the difference in the number of documents that exists between both databases. We could say with this comparison that when locating documents related to forest toilets it would be more appropriate to use the Web of Science, since it provides a greater number of documents.

More research is needed to explore the effects of forest bathing in different populations, with different cultural characteristics, on the mental and physical health and quality of life of its practitioners. Recently in other countries research is emerging, with new researchers joining in and collaborations established between research groups are filling the gaps in this field of knowledge.

4.1 Limitations and Practical applications

This study was based on the publications of journals indexed in the WoS main collection, despite being the most widely used database in bibliometric studies and one of the most prestigious in the scientific field, this study presents a selection bias, as it does not include documents that could be published in journals indexed in other databases, this being an important limitation. Future research could carry out bibliometric studies that take into account other databases. This research provides important information on who are the most important researchers in the field of forest baths, which journals are most involved, most cited papers and most important research trends. This could facilitate both collaboration between researchers and the identification of research trends.

5 Conclusions

Forest bathing is a growing interest in the scientific field, with annual publications following an exponential growth trend. Countries such as Japan, South Korea and China are the leading producers in this field, with Yoshifumi Miyazaki, the prominent co-author, and International Journal of Environmental Research and Public Health, the journal with the highest number of publications.

The effects of forest bathing on mental health, such as depression, anxiety or stress, are the topics of greatest interest among researchers, and positive effects of forest bathing have been found on the symptomatology of all of them.

Forest baths have been proposed as a preventive treatment to improve mental health and reduce blood pressure. Among the activities to be carried out during forest bathing, relaxation exercises, physical exercise in nature or green exercise, or walking in the natural environment, are some of the activities that have been found in published research.

In short, given the growing interest in this practice from a scientific point of view and taking it to a more practical dimension, we believe that it is necessary to promote this type of therapeutic tourism based on natural resources, whose benefits could be defined in two ways: on the one hand, by promoting the socio-economic development of rural populations, while having a minimal impact on the environment. And, on the other hand, in terms of health, with all the benefits that this immersion in nature means for the health of the people who practise it. To this end, it would be necessary to increase the number of projects such as Kur- und Heilwald in Germany, which promote the use of natural resources.

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Supplementary Material

Table S1: Most cited articles on forest bathing.

Tabelle S1: Meist zitierte Artikel zum Thema Waldbaden.

Article Title. Author (Year)	Type	Citations	Publisher	Journal Abbreviation
Exploring connections among nature, biodiversity, ecosystem services, and human health and well-being: Opportunities to enhance health and biodiversity conservation. Sandifer et al. (2015)	Review	486	ELSEVIER	ECOSYST SERV
The influence of urban green environments on stress relief measures: A field experiment. Tyrvaïnen et al. (2014)	Article	432	ACADEMIC PRESS LTD- ELSEVIER SCIENCE LTD	J ENVIRON PSYCHOL
The effect of contact with natural environments on positive and negative affect: A meta-analysis. McMahan et al. (2015)	Article	265	ROUTLEDGE JOURNALS, TAYLOR & FRANCIS LTD	J POSIT PSYCHOL
Effect of forest bathing on physiological and psychological responses in young Japanese male subjects. Lee et al. (2011)	Article	260	W B SAUNDERS CO LTD	PUBLIC HEALTH
Psychological effects of forest environments on healthy adults: Shinrin-yoku (forest-air bathing, walking) as a possible method of stress reduction. Morita et al (2007)	Article	212	W B SAUNDERS CO LTD	PUBLIC HEALTH
Shinrin-Yoku (Forest Bathing) and Nature Therapy: A State-of-the-Art Review. Hansen et al. (2017)	Review	177	MDPI	INT J ENV RES PUB HE
Visiting a forest, but not a city, increases human natural killer activity and expression of anti-cancer proteins. Li et al. (2008)	Article	174	SAGE PUBLICATIONS INC	INT J IMMUNOPATH PH
A systematic review of evidence for the added benefits to health of exposure to natural environments. Bowler et al. (2010)	Article	160	BMC	BMC PUBLIC HEALTH
Restorative effects of viewing real forest landscapes, based on a comparison with urban landscapes. Lee et al. (2014)	Article	154	TAYLOR & FRANCIS AS	SCAND J FOREST RES
Relationship between psychological responses and physical environments in forest settings. Park et al. (2011)	Article	139	ELSEVIER SCIENCE BV	LANDSCAPE URBAN PLAN
Influence of Forest Therapy on Cardiovascular Relaxation in Young Adults. Lee et al. (2014)	Article	139	HINDAWI LTD	EVID-BASED COMPL ALT
A forest bathing trip increases human natural killer activity and expression of anti-cancer proteins in female subjects. Li et al. (2008)	Article	137	BIOLIFE SAS	J BIOL REG HOMEOS AG
Physiological Effects of Forest Recreation in a Young Conifer Forest in Hinokage Town, Japan. Park et al. (2009)	Article	129	FINNISH SOC FOREST SCIENCE- NATURAL RESOURCES INST FINLAND	SILVA FENN
Physiological Effects of Nature Therapy: A Review of the Research in Japan. Song et al. (2016)	Review	126	MDPI	INT J ENV RES PUB HE
Green spaces and mortality: a systematic review and meta-analysis of cohort studies. Rojas-Rueda et al. (2019)	Review	122	ELSEVIER SCI LTD	LANCET PLANET HEALTH
Green Perspectives for Public Health: A Narrative Review on the Physiological Effects of Experiencing Outdoor Nature. Haluza et al. (2014)	Article	120	MDPI	INT J ENV RES PUB HE
Emotional, Restorative and Vitalizing Effects of Forest and Urban Environments at Four Sites in Japan. Takayama et al. (2014)	Article	114	MDPI AG	INT J ENV RES PUB HE
Physiological and Psychological Effects of Forest Therapy on Middle-Aged Males with High-Normal Blood Pressure. Ochiai et al. (2015)	Article	106	MDPI	INT J ENV RES PUB HE
Therapeutic effect of forest bathing on human hypertension in the elderly. Mao et al. (2012)	Article	101	ELSEVIER	J CARDIOL
Physiological effects of Shinrin-yoku (taking in the atmosphere of the forest) in a mixed forest in Shinano Town, Japan. Park et al. (2008)	Article	96	TAYLOR & FRANCIS AS	SCAND J FOREST RES
The effects of exercise in forest and urban environments on sympathetic nervous activity of normal young adults. Yamaguchi et al. (2006)	Article	88	CAMBRIDGE MED PUBL	J INT MED RES
Phytoncides (wood essential oils) induce human natural killer cell activity. Li et al. (2006)	Article	88	TAYLOR & FRANCIS INC	IMMUNOPHARM IMMUNOT
Physiological and Psychological Effects of a Forest Therapy Program on Middle-Aged Females. Ochiai et al. (2015)	Article	88	MDPI	INT J ENV RES PUB HE

The Effect of Cognitive Behavior Therapy-Based Forest Therapy Program on Blood Pressure, Salivary Cortisol Level, and Quality of Life in Elderly Hypertensive Patients. Sung et al. (2012)	Article	87	TAYLOR & FRANCIS INC	CLIN EXP HYPERTENS
Physiological and Psychological Effects of a Walk in Urban Parks in Fall. Song et al. (2014)	Article	85	MDPI	INT J ENV RES PUB HE
Does green space matter? Exploring relationships between green space type and health indicators. Akpinar et al. (2016)	Article	85	ELSEVIER GMBH	URBAN FOR URBAN GREE
Can Natural and Virtual Environments Be Used To Promote Improved Human Health and Wellbeing?. Depledge et al. (2011)	Article	80	AMER CHEMICAL SOC	ENVIRON SCI TECHNOL
Physiological and psychological responses of young males during spring-time walks in urban parks. Song et al. (2014)	Article	80	BMC	J PHYSIOL ANTHROPOL
The effect of winter forest bathing on psychological relaxation of young Polish adults. Bielinis et al. (2018)	Article	78	ELSEVIER GMBH, URBAN & FISCHER VERLAG	URBAN FOR URBAN GREE
Effects of Short-Term Forest Bathing on Human Health in a Broad-Leaved Evergreen Forest in Zhejiang Province, China. Xiang et al. (2012)	Article	77	CHINESE CENTER DISEASE CONTROL & PREVENTION	BIOMED ENVIRON SCI
Does spending time outdoors reduce stress? A review of real-time stress response to outdoor environments. Kondo et al. (2018)	Review	76	ELSEVIER SCI LTD	HEALTH PLACE
Shinrin-yoku (forest-air bathing and walking) effectively decreases blood glucose levels in diabetic patients. Ohtsuka et al. (1998)	Article	73	SPRINGER	INT J BIOMETEOROL
Health and well-being benefits of spending time in forests: systematic review. Oh et al. (2017)	Review	72	SPRINGER	ENVIRON HEALTH PREV
Effect of Forest Walking on Autonomic Nervous System Activity in Middle-Aged Hypertensive Individuals: A Pilot Study. Song et al. (2015)	Article	70	MDPI	INT J ENV RES PUB HE
Effects of Forest Therapy on Depressive Symptoms among Adults: A Systematic Review. Lee et al. (2017)	Review	68	MDPI	INT J ENV RES PUB HE
Effects of Short Forest Bathing Program on Autonomic Nervous System Activity and Mood States in Middle-Aged and Elderly Individuals. Yu et al. (2017)	Article	66	MDPI	INT J ENV RES PUB HE
The effect of virtual reality forest and urban environments on physiological and psychological responses. Yu et al. (2018)	Article	66	ELSEVIER GMBH	URBAN FOR URBAN GREE
The effects of forest therapy on depression and anxiety in patients with chronic stroke. Chun et al. (2017)	Article	62	TAYLOR & FRANCIS LTD	INT J NEUROSCI
Effects of Horticultural Therapy on Asian Older Adults: A Randomized Controlled Trial. Ng et al. (2018)	Article	56	MDPI	INT J ENV RES PUB HE
Effects of viewing forest landscape on middle-aged hypertensive men. Song et al. (2017)	Article	52	ELSEVIER GMBH	URBAN FOR URBAN GREE
Effects of forest bathing (shinrin-yoku) on levels of cortisol as a stress biomarker: a systematic review and meta-analysis. Antonelli et al. (2019)	Review	52	SPRINGER	INT J BIOMETEOROL
The Effects of Forest Therapy on Coping with Chronic Widespread Pain: Physiological and Psychological Differences between Participants in a Forest Therapy Program and a Control Group. Han et al. (2016)	Article	49	MDPI	INT J ENV RES PUB HE
The Prefrontal Cortex Activity and Psychological Effects of Viewing Forest Landscapes in Autumn Season. Joung et al. (2015)	Article	48	MDPI	INT J ENV RES PUB HE
Evaluating the relaxation effects of emerging forest-therapy tourism: A multidisciplinary approach. Ohe et al. (2017)	Article	48	ELSEVIER SCI LTD	TOURISM MANAGE
Community greenness, blood pressure, and hypertension in urban dwellers: The 33 Communities Chinese Health Study. Yang et al. (2019)	Article	47	PERGAMON-ELSEVIER SCIENCE LTD	ENVIRON INT
Therapeutic Potential of Volatile Terpenes and Terpenoids from Forests for Inflammatory Diseases. Kim et al. (2020)	Review	47	MDPI	INT J MOL SCI
Lower COVID-19 mortality in Italian forested areas suggests immunoprotection by Mediterranean plants. Roviello et al. (2021)	Article	47	SPRINGER HEIDELBERG	ENVIRON CHEM LETT

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