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Review

Health Benefits of Airborne Terpenoids and Aeroanions: Insights from Thematic Review of Chinese-Language Research on Forest Sensory Experiences

Ralf Buckley [1,2,*,†], Linsheng Zhong [1,†], Hu Yu [1], Dongfang Zhu [1] and Mary-Ann Cooper [3]

[1] Institute for Geographical Sciences and Natural Resources Research, Chinese Academy of Sciences, Beijing 100101, China
[2] School of Environment & Sciences, Griffith University, Gold Coast 4222, Australia
[3] Faculty of Tourism & Hospitality, Andrés Bello University, Santiago 75500196, Chile
* Correspondence: r.buckley@griffith.edu.au or ralf.c.buckley@gmail.com
† These authors contributed equally to this work.

Abstract: Most research on air chemistry and human health has focused on negative consequences of air pollution from cities, rural dust, mining, or industrial sites. Research on nature tourism and nature therapy, in contrast, focuses on positive benefits of air quality for physical and mental health, e.g., via "clean air clean water" holidays. Aeroanions and terpenoids in forests have received particular attention, especially in China, Japan, and Korea. We review and analyse several hundred articles published in English and Chinese. With a few recent exceptions, English-language research has tested indoor negative ion generators, and concluded that they have no measurable health benefit. It has tested terpenoids in indoor aroma marketing. Chinese-language research, in contrast, has analysed fine-scale components of outdoor environments that affect concentrations of aeroanions and terpenoids: ecosystem, latitude, altitude, temperature, proximity to water, and individual plant species. Historically, health outcomes have been taken for granted, with little rigorous testing. Air quality research has shown that aeroanions can become attached to fine water droplets, e.g., after rain in forests, or in mists produced locally by waterfalls. We hypothesise that the health benefits of aeroanions in natural environments may arise through the scavenging of airborne particulates by negatively charged mists, creating especially clean, dust-free air. We propose that this particularly clean-tasting air, contrasting strongly with polluted urban air, creates positive effects on human mental health and perhaps, also on pulmonary physical health. Mechanisms and outcomes remain to be tested. We also propose testing psychological health effects of airborne terpenoid scents from forest trees.

Keywords: therapy; psychology; mental; senses; sight; sound; smell; taste; touch; temperature; terpenoids; aeroanions

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1. Introduction

Air affects human health via four main mechanisms. First, breathing oxygen is essential for survival. This is of concern at high altitudes, in sealed spaces such as submarines, and in breathing apparatus, e.g., for firefighting or underwater diving. Second, the physical characteristics of air, such as temperature and humidity extremes, high velocity winds, and very loud sounds, can cause discomfort, danger, or sometimes death. Third, a range of trace components can cause damage to health, even though they may be undetectable by people breathing them. Damage mechanisms may include: physical and physiological, e.g., silica dust, asbestos fibres, or radon gas; chemical and biochemical, e.g., carbon monoxide or other gaseous pollutants and toxins; and biological and microbiological, such as airborne transmissible pathogenic viruses and bacteria. These are studied extensively in epidemiological contexts. Fourth, a very wide range of air components and characteristics

affect human physical and mental health via the senses. These include: temperature and humidity; airborne sound; and various gases, vapours, volatiles, and emulsions detectable by smell. These are our focus here (Table 1).

Table 1. Major characteristics of breathable air affecting human health.

Category	Parameter	Examples and Comments
Physical	Temperature	Human Comfort Index®, extreme temperatures
	Humidity	Health effects of very dry or humid air
	Movement	Wind, e.g., cyclones; sound, pleasant or warning
	Particulates	Airborne dust concentrations, different grain sizes
Chemical	Fundamental	Nitrogen and oxygen: environmental cf. artificial air
	Aeroanions	Negative oxygen ions, additional to O_2 molecules
	Inert gases	Trace, unimportant for human health except radon
	Carbon dioxide	Concentration important as breathing trigger
	Toxic gases	Wide range, natural and industrial sources
	Unpleasant	Unpleasant smells are chemical/biochemical
	Pleasant scents	Wide range of chemical/biochemical aromas
	Particulates	Some dusts are toxic because of chemistry
	Emulsions	Some chemicals are carried in water mists
Biological	Pathogens	Wide range of pathogenic airborne microbiota
	Bio-origins	Smells of biological origin, pleasant or unpleasant

These four mechanisms interact and overlap. For example, detectability and intensity of scents may depend on temperature and humidity. Their effects on human wellbeing also depend on individual physical and mental states, personalities, and life history events. For example, particular smells such as plants or petrichor [1] or sounds such as birdsongs [2] may trigger positive or negative memories of past events. There are also cultural and lifestyle components, e.g., sensory experiences from childhood. The psychological effects of any one sense may be modified by simultaneous experiences through other senses; what a person sees or hears may influence how they respond to smell. Therefore, in analysing the wellbeing effects of any one constituent of air, we must also consider the setting, the person, and their simultaneous experiences through other senses.

Here, we focus on long-standing controversies over the health effects of two constituents of breathable air, especially in forest ecosystems. The first of these is aeroanions, which are oxygen molecules with a negative charge derived from two additional electrons. Every person breathes air containing aeroanions, but relative concentrations differ substantially across different circumstances, in nature and in urban and indoor settings. Machines to generate aeroanions artificially as potential health aids are also widely available. The second is terpenoids, volatile organic chemicals derived from plant resins in many tree species, broadleaf as well as coniferous [3]. These occur naturally, but concentrations vary greatly both at large scales, e.g., mountaintops cf. forests, and at local scales, e.g., near particular tree species. They are also used commercially in indoor air fresheners and aroma generators.

The critical controversies are whether or not aeroanions or terpenoids, separately, improve human physical or mental health. Different opinions hold sway in different bodies of research. Chinese-language literature holds that both yield positive effects, whereas most English-language literature, with a few recent exceptions, dismisses any effects as equivocal. These views are hence in conflict, affecting both research and therapeutic applications. Here, we attempt to reconcile these conflicting views through review and comparison of the two bodies of research. Research literatures on the same topic in different

languages are often divergent [4–7]. Comparative analysis is not straightforward in this case, because individual mental health parameters are also influenced by domestic, demographic, and socioeconomic factors, personality characteristics, and other sensory experiences. In assessing each study, we must consider its context and what factors were controlled for.

Even though the focus is on air chemistry, this is a cross-cultural study. Everything with a human component has a cultural dimension. In the arts, architecture, humanities, human geography, business, law, economics, policy, and politics, that is assumed and addressed routinely. In the social and behavioural sciences, including environmental, health, and leisure sciences, it is sometimes addressed and sometimes ignored. In the hard natural sciences, such as physics and chemistry, it is routinely ignored. Even in those fields, however, there are cultural differences in how analyses and experiments are conceived and conducted, and what research topics are prioritized and published.

Even though English is seen as the de facto *lingua franca* of international academic research, there are also large volumes of research published in other languages. Researchers at universities or national government institutions may face incentives or requirements to publish either in their own languages or in English, or both, depending on national policies [4]. Each nation may consider its own language of highest importance and rank, and may encourage or demand the construction of corresponding bodies of knowledge.

Our theme here is nature therapy, focusing on sensory experiences in forest ecosystems. This has strong components from health and environmental sciences, each with local geographical and cultural dimensions, and large bodies of research published in a variety of languages. These typically overlap with English-language research, but are not the same. English-language research on nature therapies includes studies conducted in many different countries, most notably Japan and China. Japanese-language research has been reviewed in English, but Chinese-language research has not.

Here, therefore, we review Chinese-language research on one aspect of nature therapies, namely sensory experiences of forest visitors, and we compare directions, emphases, and findings against English-language counterparts. In particular, we search for topics covered only, or more thoroughly, in Chinese-language than English-language research, or those where Chinese-language research yields different or conflicting findings from English-language counterparts. That aim sets constraints on our methods. We are searching for differences rather than overlaps, so broad content-mapping methods are not suitable. We need an iterative process that can first identify similarities, but then focus on distinctions. To achieve this, we use an iterative qualitative thematic analysis. This identifies airborne terpenoids and aeroanions as key differences.

2. English-Language Literature and Theoretical Framework

The positive effects of minor constituents of air on human health arise through two principal mechanisms: via pulmonary, cardiovascular, and biochemical functions, e.g., in reducing asthma [8]; and via the senses and emotions, for mental health. Our focus here is on the latter, and our theoretical framework is thus the role of senses and emotions in self-perceived wellbeing and externally measurable mental health [9–14]. As summarised in Figure 1, place and activity create sensory experiences; personality and senses create emotional experiences; sensory and emotional experiences create memories; and memories contribute to mental health and wellbeing. We focus on forest ecosystems [15,16] and compare Chinese-language against English-language research (Table 2). There is also extensive research on the broader wellbeing effects of forest immersion [17–22], but with less reference to atmospheric components.

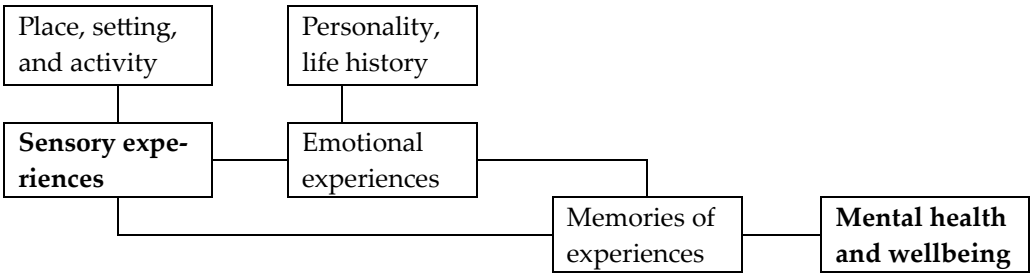

Figure 1. Mechanism of sensory effects on mental health and wellbeing.

Table 2. English-language research on airborne senses in nature-based tourism.

Component	Sensory Experience and Effect	Ref.
Air humidity, temperature	Summer weather perception	[23]
	Seasonal weather variation	[24]
Air chemistry, odours, aromas	Forest volatile organics	[25]
	Nature, smells, wellbeing	[26]
	Smells trigger emotions	[27]
	Smell sensory memories	[28]
	Culture and smells	[29]
	Volatile terpenoids	[30,31]
	Aeroanions and health	[32]
Airborne sound	Patagonia forest sounds	[33]
	Tropical forest birdsong	[34]
	Birdsong boosts wellbeing	[35]
	Birdsong alleviates anxiety	[36]
	Birdsong in China	[37]

3. Materials and Methods

There are no general protocols for multi- or cross-language reviews of research literature [38]. We therefore conducted a literature search in Chinese for relevant Chinese-language publications, analysed them qualitatively both in Chinese and in English translation, and compared Chinese findings against those published in English. We searched broadly for publications on forest sensory experiences, and then analysed them in four stages: all senses; airborne senses; air chemistry and smell; and finally, aeroanions and terpenoids specifically. The rationale for this multi-stage approach is that, whilst there are no relevant differences between the two bodies of literature for most senses, there are substantial differences for terpenoids and aeroanions. Therefore, we returned iteratively to the search and analysis, so as to focus on these components but also to place them in a broader context, as above. This review thus adopts an iterative directed-content qualitative thematic analysis of documentary sources, namely Chinese-language research publications on sensory experiences in forest ecosystems.

We obtained these materials by searching the Chinese National Knowledge Inventory, CNKI (see Figure 2), using the Chinese words for "sense" and each sense individually coupled with "forest" or "woodland". This includes forest ecotourism, forest tourism, and forest therapy. The full articles were screened and analysed in Chinese by the Chinese-speaking authors, and the analyses translated to English. In parallel, the titles and abstracts were translated to English, and analysed by the English-speaking authors. The two analyses were checked against each other. This is a technique adopted in previous cross-lingual

analyses of qualitative data in Chinese and English [39]. Patterns derived from the Chinese-language literature were then compared against those in the English-language literature.

For English-language researchers who do not speak Chinese, the Chinese-language sources are not directly accessible. Readers rely on authors to present patterns in English. We therefore refer to Chinese-language articles as sources in the tables presenting our qualitative analyses. There are also many bilingual Chinese researchers, however, who can access the primary materials as well as reading this article. We therefore list Chinese-language sources in full in Appendix A, translated to English so that titles are available to English-speaking readers. Some, but not all, also have English-language abstracts searchable via Google Scholar®.

4. Results

4.1. Chinese-Language Publications and Themes

We found ~250 relevant items in CNKI. They were published in forestry, ecology, tourism, and medical journals. We excluded 141 items that did not directly report sensory experiences of forest visitors, leaving 119 articles (Figure 2). These are listed in full in Appendix A. That list provides our primary dataset of source materials for this analysis. From both direct Chinese-language and translated English-language analyses, we identified five principal themes within the Chinese-language research literature. These are outlined below, in order from broader to narrower scale and focus. They are: forest therapy; physical and mental health; stress recovery via sensory experiences; airborne terpenoids; and aeroanions. In the sections below, we have tabulated subthemes within each of these five main themes, with examples from the list in Appendix A. Note that Tables 3–7 include only examples to illustrate the subthemes, 85 in total, but the other 34 source articles listed in Appendix A were also used in the thematic analysis.

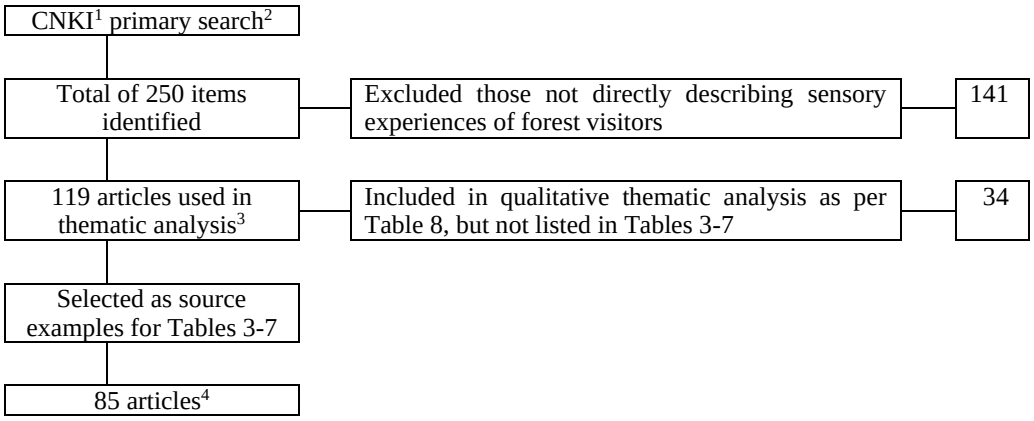

Figure 2. Numerical summary of CNKI search results. Note that this is a qualitative thematic analysis, not a PRISMA systematic analysis. [1] China National Knowledge Inventory, 2024, https://oversea.cnki.net/index/products/en/index.html (accessed on 9 April 2024) (English), or https://cnki.net (accessed on 9 April 2024) (Chinese, as used here).[2] Chinese terms for: ["sense" OR "sight" OR "see" OR "sound" OR "hear" OR "smell" OR "scent" OR "taste" OR "touch" OR "temperature"] AND ["forest" OR "woodland"]. [3] Listed in full in Appendix A. [4] Listed as sample sources in Tables 3–7, inclusive.

4.2. Forest Visitation in China Is Intended to Be Therapeutic

Forest visits and visitor infrastructure in China are designed and evaluated with mental health as a specific goal (Table 3). Chinese approaches to forest therapy are on a far larger scale than English-language approaches [18,20], including over 1000 Forest Healthy Life Centres under construction to provide a billion person-days per year [11].

Table 3. Examples of Chinese-language research on forest therapy.

Subtheme	Research Site or Topic	Chinese Sources *
Forest therapy as primary goal of forest visits in China	Dongping Forest Park, Chongming	Chen, Kong et al., 2007
	Suyukou National Forest Park (NFP)	Du et al., 2019
	Forest therapy functional index	Pan, Liu et al., 2018
	Forest recuperation index	Pan, Zeng et al., 2018
	Forest therapy product design	Xue & Bao, 2010
	Forest therapy convalescence	Yan et al., 2020
	Heilongjiang Jiangdaqi NFP	Wang et al., 2022
Forest Healthy Life Centres (FHLCs) to national standards	Demand for FHLC	Cong et al., 2023
	Planning and design of FHLC	Dan et al., 1999
	Comparison of Japanese designs	Hu & Wang, 2023
	FHLC architecture	Li et al., 2022
	FHLC product construction, Jiangxi	Liu, Z., 2019
	Forest tourist perceptions	Qiu et al., 2021
	Case study, Guangdong	Zhang, J., 2019
	Planning and design, Guangdong	Zhang, Z.Q., 2018
	Product design, scent landscape	Zhu, 2019
	Product development	Zhuang et al., 2022
	Effective construction of FHLC	Ren et al., 2021
	Supply of FHLC products	Xie et al., 2021
	FHLC ecosystems, Beijing Songshan	Yuan et al., 2022

* Sources in Appendix A.

4.3. Both Physical and Mental Health Benefits

Chinese-language research identifies a wide range of health benefits, both physical and mental, from forest tourism and recreation (Table 4). English-language research with East and South-East Asian authors is similar [14,17–19,21,40,41].

Table 4. Examples of Chinese-language research on physical and mental health benefits.

Subtheme	Research Site or Topic	Chinese Sources *
Multiple health parameters	Cardiopulmonary and psychological	Chu et al. 2020
	Review of multiple parameters	Chen, H.X. et al., 2020
	Multiple parameters, Beigong NFP	Han et al., 2012
	Multiple parameters, Fuzhou NFP	Li et al., 2017
	Multiple parameters, Yushe NFP	Zhang et al., 2019
	Development of forest medicine	Yang et al., 2019
	Physical and mental health recovery	Zhou et al., 2020
	Healthcare functions, Shimen NFP	Zhu et al., 2021
Cardiovascular, pulmonary	Chronic obstructive pulmonary disease	Dang et al., 2020
	Vascular function, hypertension	Lan et al., 2017
	Blood pressure, lipid, heart function	Zheng, Mo et al., 2017
	Pneumoconiosis	Lu, 1997
	Lung function, middle-aged, elderly	Tan et al., 2019

Table 4. *Cont.*

Subtheme	Research Site or Topic	Chinese Sources *
Schizophrenia	Schizophrenia alleviation	Li et al., 1998
Forest type, visit frequency	Visitor mental health, Fuzhou NFP	Li et al., 2009
	Effects on college students	Liu W.H., 2019
	Huangjialong National Forest Park	Liu Y.Q., 2019

* Sources in Appendix A.

4.4. Stress Recovery via Sensory Experiences

Chinese-language research focuses strongly on sensory experiences as an aid in stress recovery (Table 5). It argues that stress is alleviated by: sights of forest colours and shapes; sounds of forest birdsong, running water, windblown leaves, or silence; cool air temperatures and microclimates acting on skin; and scents and air chemistry, as outlined below in the fourth theme. English-language research on smellscapes [25–28] and soundscapes [42–44] is less prolific and less detailed, with limited application so far in forest therapy [45,46].

Table 5. Examples of Chinese research on forest senses and stress recovery.

Subtheme	Research Site or Topic	Chinese Sources *
Shapes and colours	Forest colour, Jiuzhaigou NFP	Zhang, Z., 2017
Sounds or silence	Soundscape, Meiling NFP	Chen et al., 2016
	Soundscape, Shenzhen urban forest	Hao et al., 2019
	Sound source detection, Fuzhou NFP	Liu et al., 2019
Temperature, microclimate	Microclimate, Sichuan	Chen, Hu et al., 2007
	Microclimate variation	Geng & Geng, 2015
	Microclimate, Harbin	Wang et al., 2012
	Microclimate, Hubei Daba Mountain	Dai et al., 2023

* Sources in Appendix A.

4.5. Airborne Terpenoids

Chinese-language research pays strong attention to volatile organic chemicals such as terpenoids, which give characteristic scents to trees such as firs, pines, cypresses, cedars, cinnamon, holm oaks, and beeches (Table 6). Emissions differ between species and depend on the weather. There is limited English-language research on terpenoid concentrations in forest air and their role in forest therapy [8,25,30,31,47]. Artificially released terpenoids are used for mood management in retail sales.

Table 6. Examples of Chinese research on airborne forest terpenoids.

Subtheme	Research Site or Topic	Chinese Sources *
Airborne forest terpenoids	Phytoncides, 5 forest species	Lin et al., 2018
	Comparing forest stands, Shimen NFP	Liu S.X. et al. 2021
	Volatile organics, 23 species, Beijing	Wang et al., 2003
	Plant extracts	Wu & Zheng, 2005
	Plant extracts	Wu et al., 2010
	Volatile organics, Baiyun NFP	Wu et al., 2023
	Volatile organics, plant sources	Xu et al., 2023

* Sources in Appendix A.

4.6. Aeroanions

Chinese research (Table 7) argues that breathing airborne negative ions is good for human health, and these ions occur at much higher concentrations in forests than cities and are generated differentially at particular forest sites, such as waterfalls. Different forest structures, plant cover, and individual tree species have been compared as sources of anions under different climate and weather conditions and at different altitudes and seasons. That is, this research is very detailed and fine-grained, designed for practical management applications. English-language research on aeroanions has been based largely on indoor anion generators, which apparently have little or no effect on physical or mental health [31,48–51]. It appears that human noses do not detect aeroanions directly but do recognise the scent of cool, fresh forest air, which may depend on aeroanions, as discussed below.

Table 7. Examples of Chinese research on forest aeroanions.

Subtheme	Research Site or Topic	Chinese Sources *
Health benefits from breathing aeroanions	Research review monograph	Lin et al., 2006
	Effects on hyperlipidemia	Zhou et al., 2015
Concentrations higher in forests than cities	Aeroanions in pine forest	Wu et al., 1998
	Xishan National Forest Park	Yang et al., 2022
Differential generation patterns	Forest recreational areas	Shi et al., 2004
	Variation between forest stands	Shi et al., 2002
	3 forest types, Beijing	Xu et al., 2023
Effect of plants	Review, effects of plant species	Li, 2008
	Plant diversity, Fushoushan NFP	Li et al., 2022
Differential generation near waterfalls	Beijing area	Shao et al., 2005
	Chebaling National Reserve	Zhang et al., 2004
Depends on forest structure	Yunyong Forest Park, 6 stands	Zhao, Qian et al., 2018
	Zhaichangshan Forest Park	Xie et al., 2014
Depends on forest age	Multi-site study	Wu et al., 2001
Depends on plant cover	Research review monograph	Lin et al., 2006
Varies between species	Shimen National Forest Park	Liu et al., 2021
	Recreational forests, Beijing	Wang, 2008
	Urban forests, Beijing	Xu, 2019
Varies with climate and weather	Longyan National Forest Park	Chen et al., 2016
	Tianjiling National Forest Park	He, 2014
	Beijing area	Shao et al., 2000
	Diaoluoshan Tropical Rainforest	Si et al., 2014
	Aeranions and meteorology	Ye et al., 2000
	Shennong Gu NFP	Zhang, 2011
	Beijing Songshan NR	Zhao, 2018
	Haikou Crater National Geopark	Peng et al., 2020

Table 7. *Cont.*

Subtheme	Research Site or Topic	Chinese Sources *
Varies with altitude	Research review monograph	Lin et al., 2006
Changes with seasons	Shunanzhuhai Forest	Di, 2018
	Beijing area	Shao et al., 2005
	Urban forests	Wang, 2004
	Guangdong Yunyong Forest Park	Zhao et al., 2018

* Sources in Appendix A.

4.7. Differences between Chinese- and English-Language Research

There are thus strong overlaps but also substantial differences between Chinese-language and English-language research in this field (Table 8). English-language research examines sensory experiences in destination marketing, with little focus on forest visitor sensory experiences and mental health [52]. Chinese research, in contrast, strongly emphasises senses as part of the forest tourism experience. It has long been argued that forest tourism relieves cardiovascular and pulmonary disease, schizophrenia, and stress, with effects dependent on forest type, frequency, and duration of tourist visits. The closest corresponding English-language review, including both mental and cardiovascular effects, is much more recent [14].

Table 8. Chinese-language cf. English-language research on senses in forest therapy.

Theme and Topic	Chinese-Language Research	English-Language Research
Infrastructure design	Therapeutic benefits	Tourist satisfaction
Role of senses	Heavily studied > 20 years	Less, though increasing recently
Importance of sound	Specific sounds: birdsong, streams, wind in leaves	Broad soundscapes, plus some studies of birdsong
Importance of smell	Specific smells: terpenoid chemistry and concentrations cf. species, terrain, weather	Broad smellscapes, plus limited studies of terpenoids, mainly in marketing
Touch and skin Temperature	Individual tourist experience cf. forest sites and microclimates	Climatic comfort index, one study on respiratory mucosa
Aeroanions	Detailed distribution factors, relative to forest type, structure	Discounted as ineffectual, based only on indoor anion generators

Chinese research also argues that health can be improved even by subtle or subliminal forest sensory experiences, including specific sights, sounds, smells, tastes, touch, and temperature. All these have been analysed in detail, comparing altitudes, seasons, forest types, and tree species. English-language research has only recently begun to measure the effects of forest air chemistry and microclimate on respiratory function [8,21,53,54].

5. Discussion

5.1. Cross-Linguistic Comparison and Consequences

We identified, listed, and conducted thematic analysis of Chinese-language articles on the sensory experiences of forest visitors, not previously available to English-speaking researchers. Most English-language research is already available to Chinese-speaking researchers, who are either bilingual or have access to national research translation programmes, but the reverse does not apply. Including Chinese-language research more

than doubles the pool of research on this topic and reduces the existing bias towards English-language research [55].

We found differences in emphasis, with Chinese-language research in this field showing greater attention to air chemistry, notably aeroanions and airborne terpenoids. We identified conflicts in our findings, specifically with regard to aeroanions, and constructed a hypothesis to reconcile them. This hypothesis is derived from Chinese- rather than English-language research. It can be tested in any language, but it would not have been apparent without the Chinese-language research.

There are two principal limitations. The first is that we considered only Chinese- and English-language research. Japanese-language research on forest therapies has been summarised in English [22,45], but we do not know what may have been published in other languages. The second is that this study considers only contemplative visits to forest environments. Comparable research on other natural ecosystems and activities would also be valuable.

There has been increasing recognition in recent years that research and practice in fields such as health and environment should incorporate cross-linguistic and cross-cultural components. IUCN conservation guidelines, such as those for tourism and recreation in protected areas [56], are therefore published in multiple languages. Cross-linguistic quality control for the wording of interpretive signs in geoparks has recently been analysed in detail [57]. Our approach here, examining the role of sensory experiences for the mental health of forest visitors, showed that there have been substantial cultural differences in research directions, which are relevant not only for forest therapy but for research on air chemistry.

5.2. Aeroanion Hypothesis

The most significant difference between Chinese- and English-language research findings is in regard to aeroanions. English-language research essentially dismisses aeroanions as having zero effect, even though anion generators are available commercially [31,48–51]. Chinese research has assumed therapeutic effects rather than testing them experimentally, but has measured how aeroanion concentrations vary with a wide range of forest parameters (Table 7). Chinese research has shown that aeroanions occur at much higher concentrations in forests than in cities, especially at waterfalls and in forest canopies. Concentrations depend on forest structure, age, cover, tree species, climate, weather, altitudes, and season (Table 7).

We note that the forest sites where Chinese research shows the highest aeroanion concentrations are the same sites that have moist, cool, unpolluted, clean-tasting air; and that irrespective of any physiological or biochemical effects, these clean-air factors improve self-perceived human psychological wellbeing [58]. This suggests a possible therapeutic mechanism for aeroanions via mental rather than physical health. We also note that one major difference between urban and forest air is in concentrations and composition of fine airborne particulates. City air is often dusty, whereas forest air is generally not. Aeroanion concentrations are high near waterfalls and in wet forest canopies, where the air also contains fine water mists. There is some evidence that aeroanions scavenge atmospheric particulates [31]. Fog droplets do likewise [59].

We therefore hypothesise that aeroanions may bind to water droplets, creating negatively charged mists that scavenge dust very effectively, producing moist and particularly unpolluted air. Human senses detect this as especially fresh and pleasant, generating psychological wellbeing. We suggest that experimental tests of indoor artificial anion generators may not have produced any outcomes since they were operating in hot, dry, dusty air, and since the experimenters searched only for physical outcomes.

This hypothesis could reconcile the conflicting bodies of research on aeroanions, but it is still only a hypothesis. It could be tested through two experimental approaches, preferably in combination. The first would be through field measurements of the electric charge on water mist droplets near forest waterfalls. This would need a method to extract

water droplets from misty air without any change in electrical charge. One option might be to use fog collectors, used commercially in regions with limited rain but reliable fogs. They are passive structures that cause water to condense and run down into collectors. For example, a vertical screen holding several layers of closely spaced vertical lengths of nylon fishing line, draining to a water collector channel at the bottom, could sample mists effectively.

The second approach would be to repeat tests on indoor anion generators, but operated in conjunction with evaporative air coolers to produce water mists, and using psychological rather than physiological outcome measures. Since water mists and cool air can themselves improve perceived wellbeing, experimental tests would need to measure marginal gains from an evaporative air cooler plus a negative ion generator, as compared to an evaporative air cooler alone. These would be straightforward to run, especially at sites where evaporative air coolers are used more widely than refrigerative air coolers and where urban air has a high dust content. Tropical and subtropical cities in developed, developing, and newly industrialised nations could provide opportunities.

6. Conclusions

For practical implementation of forest therapies, the Chinese-language research reviewed here indicates that the scents of forest trees and moist air near water are likely to make significant contributions to mental health of forest visitors, even though they have not been a focus of English-language research. This matches the reported experiences of park and forest visitors, who seek out those experiences where they are available [22,45]. For research on mechanisms of mental health benefits from nature exposure, Chinese-language publications indicate that research priorities should include quantifying the psychological effects of smelling volatile terpenoids from trees and breathing moist air laden with aeroanions, as well as the possible physical effects of aeroanions in scavenging airborne particulates. Both English-language research, and the Chinese-language research reviewed here, indicate that signs on forest trails, guides for forest tours [60], and instructors at forest therapy centres should draw the attention of visitors, tourists, and clients to subtle scents, including tree resins and moist air near running water.

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Appendix A

Chinese-Language Source Materials, Translated Titles

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