

# Psychophysiological Responses of the Elderly to Audio-Visual Landscape on Forest Trails: A Case Study of the Hufu Forest Trail

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## Abstract

**This study investigates the impact of audiovisual landscapes on elderly users' physiological and psychological well-being along Suzhou's Hufu Forest Health Trail. Experimental measurements bloodpressure, SpO<sub>2</sub>, heartrate, POMS revealed that natural visual elements effectively reduce heart rate and blood pressure, while auditory stimuli e.g., birdsong, flowingwater induce emotional stability and positive fluctuations. Proximity to nature alleviates fatigue and enhances diverse emotional experiences. Findings suggest future trail designs should prioritize elderly-centric audiovisual diversity using local resources, with further exploration needed on materials and lighting. Practical evaluations integrating user feedback and physiological data are recommended to scientifically optimize health trail efficacy for aging populations. Generated by AI for reference.**

## Keywords

**Forest health; The elderly; Audio-visual landscape; Trail design.**

## 1. Research Background

With the development of society, new ways of temporarily leaving the city and relieving stress have emerged, such as leisure agricultural parks, rural farm stays, and forest tourism. Among these, the trend of using the forest environment, a beloved choice for its ability to reduce psychological stress and prevent diseases, is becoming increasingly popular. The State Forestry Administration announced that China's forest area has reached 3.12 billion mu, with a forest coverage rate of 21.66%. This presents a broad prospect and development potential for the forest health industry. Both domestic and international scholars believe that the development of forest health will be a major direction for the transformation and upgrading of forestry development for a considerable period.

In recent years, with the increasingly severe aging of the population and growing attention to suboptimal health, there has been an increase in domestic research on the needs of the middle-aged and elderly population. As early as 1982, China proposed the concept of providing retirees with "support for living," "medical care," "employment," "learning," and "enjoyment." In the year 2000, the idea of "support for learning" was added, forming six goals for the well-being of the elderly. This provided guidance for research on the needs of the middle-aged and elderly population.

Wu Cangping redefined the essence of quality of life, encompassing six aspects: material living, spiritual and cultural life, life quality, physical fitness, rights and privileges enjoyed, and living environment. She believes that the quality of life for the elderly should be measured from multiple dimensions. Simultaneously, she points out that the essence of quality of life is fundamentally the degree to which different needs are satisfied.

In China, research on forest health primarily centers around the development of the forest health industry, the utilization of forest bath tourism resources, and the physiological and psychological impacts of forest bathing on the human body. Scholars identify factors in the

forest environment, such as phytoncides, negative air ions, forest microclimates, green visual effects, air purification, and noise reduction, as beneficial to human health. Internationally, researchers have conducted empirical studies on the physiological and psychological responses of the human body to the forest environment. Findings suggest that the forest environment can positively influence hormone secretion, autonomic nervous function, improve insulin sensitivity, and lower blood sugar.

In conclusion, both domestic and international studies highlight the positive effects of forest health on various physiological and psychological aspects. This includes enhancing immune function, improving insulin sensitivity, lowering blood sugar, alleviating stress and mental disorders, enhancing sleep, and promoting cardiovascular health. This empirical research provides crucial theoretical foundations for future forest health studies<sup>[1]</sup>.

## **1.1. Purpose and Significance**

### **1.1.1. Investigating Elderly Individuals' Physical and Mental Responses to Visual and Auditory Landscapes on Forest Trails**

The five senses are crucial for human perception, influencing psychological and physiological reactions. Aging-related sensory declines, such as vision and hearing loss, can impact well-being<sup>[2]</sup>. Forest environments, with their beneficial factors like phytoncides and negative ions, have shown positive effects on health. This study aims to understand how activating the senses, particularly vision and hearing, in forest health activities benefits the elderly<sup>[3]</sup>.

(1) Vision accounts for 83% of information processing, and exposure to natural environments has stress-reducing effects. This study explores the potential benefits of visual stimuli in forest environments.

(2) Hearing, the second-largest sensory organ, affects communication. Utilizing forest auditory elements can enhance forest health benefits. This study addresses the impact of noise and the potential benefits of soothing sounds.

### **1.1.2. Enhancing the Association Between Hufu Forest Health Trail Design and Health Benefits**

(1) Providing theoretical foundations and methodological guidance for forest health trail planning. Current research in China is in the early stages, focusing on empirical studies of forest health factors. This study proposes optimization strategies for the Hufu Forest Health Trail.

(2) Presenting design approaches for utilizing visual and auditory landscapes on the Hufu Forest Health Trail. Forest health involves sensory experiences, and this study focuses on meeting the visual and auditory needs of the elderly, providing insights for trail planning and design.

## **2. Methods and materials**

### **2.1. Measurement method**

#### **2.1.1. Participants**

The classification of the elderly according to different standards have different divisions, according to the physiological characteristics of different types of elderly, we need to target their design of suitable trail landscape, and equipped with appropriate supporting facilities, so as to meet the physiological needs of the elderly. In the "Building Design Code for Elderly Facilities", according to the behavioral ability of the elderly and the degree of self-care, the elderly are divided into three categories: self-care elderly, assisted elderly and nursing elderly. Considering that the natural terrain of Hufu Forest Trail has certain undulations, we selected 36 self-care elderly people who are all over 60 years old for the study according to this specification.

The exclusion criteria were as follows<sup>[4]</sup>: (1) persons who lack communication skills, (2) persons with Parkinsonism or motor-impairing neurological disorders, (3) persons whose musculoskeletal disorders in the lower extremities could affect the performance of walking during a clinical examination, and (4) persons who have taken neuroleptics or benzodiazepines and major depression drugs.

We informed each participant in writing about the procedure and the equipment to be worn during the experiment. All participants signed informed consent forms.(Table.1)

Table. 1 Classification and characteristics of the elderly

Typology	Characteristic	Capacity
The elderly capable of self-care	Elderly persons who are fully able to take care of themselves and are not dependent on others for assistance	Able to do some exercise such as jogging, gymnastics, hiking, etc; Able to take care of their own food, clothing, housing and transportation, and maintain their body functions at a healthy level
The elderly requiring assistance from outside facilities	Elderly persons who need some help with external facilities to accomplish life behaviors	Beginning to show symptoms of aging, such as osteoporosis, tardiness, and the tendency to fall; Difficult to walk sometimes, but can move around with the help of external facilities
The elderly dependent on others	Elderly persons who are dependent on others for care and assistance	Disabled or suffering from being bedridden for a long time, incapable of taking care of themselves and needing the care of others to maintain their basic living

### 2.1.2. Variable and Grouping

In this study, Forest Density (FD) and Forest Sounds (FS) in forest trail landscapes were used to manipulate visual and auditory perception, respectively.

In the field of visual perception, research has focused on the importance of specific visual elements, such as forest density (FD), in people's visual preferences for natural landscapes<sup>[5]</sup>. FD had three levels: high (Hd), medium (Md), and low density (Ld). Differences in other visual elements were controlled to reduce the interference of nonmanipulated variables. The high, medium, and low FDs used in this study refer to relative rather than absolute FDs.

Sounds with different characteristics induce different physiological and psychological effects for the listener and may trigger corresponding emotional responses. Anthropogenic and natural sounds are mixed in urban forests<sup>[6]</sup>. In this study, we mainly focused on the natural sounds. FS were collected from real urban forest trails and included natural sounds (the sound of water in various forms in nature, the sound of wind blowing through leaves, and the sounds of birds, mammals, and insects). FS had two levels: quiet natural sounds (Qn) and loud natural sounds (Ln). We referred to the International Organization for Standardization (ISO) and China's "Sound Environmental Quality Standard (GB 3096-2008)" to determine the recommended sound pressure level. The amplitude of loud (high intensity) sounds in this study was set at 65 dB, and the amplitude of quiet (low intensity) sounds was set at 45 dB.

The levels of these two variables were combined to generate 6 experimental conditions as follows: high forest density-quiet natural sounds (Hd-Qn), high forest density-loud natural sounds (Hd-Ln), medium forest density-quiet natural sounds (Md-Qn), medium forest density-loud natural sounds (Md-Ln), low forest density-quiet natural sounds (Ld-Qn) and low forest density-loud natural sounds (Ld-Ln).

### 2.1.3. Study Locations

This study was conducted at Hufu Forest Trail, which is located in Huqiu Mountain Scenic Spot, with a route length of 5.7 kilometers. The main line is 1.7 kilometers long and the branch line is four kilometers long, consisting of three parts: the upper mountain road, the mountain trail, and the ring road. We can find some cultural preservation and old green trees scattered along the route. Hufu Forest Trail really makes the ecological environment and history and humanities one. The ecological environment and history and humanities are truly integrated. The landscape design of Huqiu can be said to be "from nature, above nature". It utilizes the regional vegetation style, mountain topography, hydrogeology and so on to present the characteristic of the landscape, showing the feelings of the landscape designers towards nature. Huqiu Scenic Area concentrates the landscape advantages of geomorphology, biological landscape, water scenery, religious architecture and culture, as well as the culture of historical celebrities, etc., and it is the ideal outdoor fitness area.

Since different landscape nodes of the trail have different forms of composition, and there is also some variability in the audiovisual landscape effects of different sections of the trail. Therefore, according to the classification of variables above, we selected six representative sample sites in the Hufu Forest Trail, and the distribution of the locations of each site is shown in (Figure. 1), and the basic profiles are shown in Table 2.(Table.2)

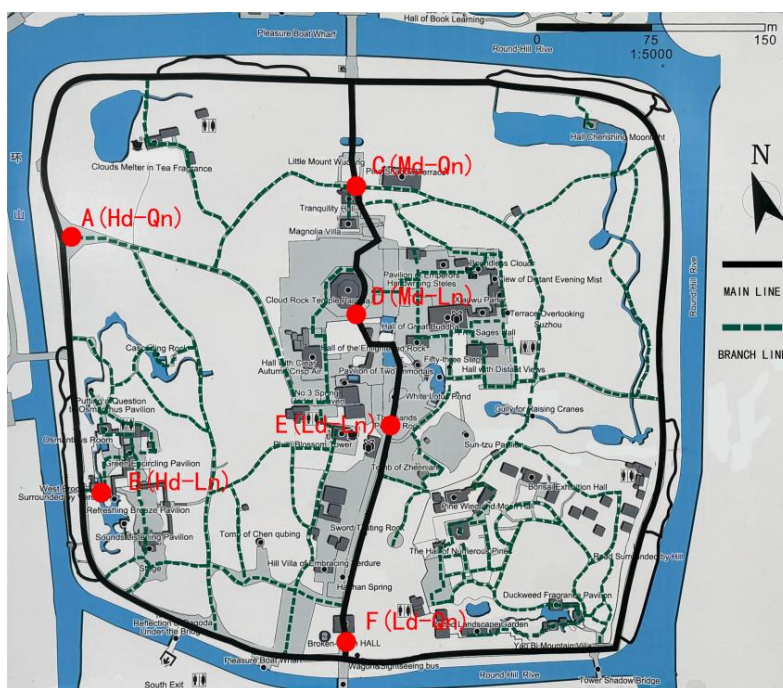








Figure 1: Plot location distribution

Table 2: Overview of research plots

Code	Grouping	On-site photo
A	high forest density-quiet natural sounds	
B	high forest density-loud natural sounds	
C	medium forest density-quiet natural sounds	
D	medium forest density-loud natural sounds	
E	low forest density-loud natural sounds	
F	low forest density-quiet natural sounds	

## 2.2. Experimental Design

### 2.2.1. Experiment Procedure

Before the experiment started, a staff member guided the subjects to the testing area in the classroom and helped them to don the Emotiv EPOC X device, which was used to collect EEG data. Participants were asked to remain in a seated position for 30 min. During that period, the Profile of Mood States (POMS) was completed and the subjects' blood pressure, SpO2, and heart rate were measured.

Following the pre-measurements, the intervention was performed. Subjects walked a guided pre-determined course at a comfortable and relaxing pace. We randomly divided the participants into six groups and went to the six typical sample plots A-F in the Hufu Forest Recreation Trail, where they were free to move around without interference for 30 min before the staff brought them back together to prepare for the post-test.

As in the pretest, 5 min of EEG data were collected in the posttest, followed by measurements of blood pressure, SpO<sub>2</sub> (using a finger monitor), heart rate, and mood. The experiment finished once the posttest had ended.

### 2.2.2. Collection of Physiological and Psychological Data

Physiologic indicators include EEG, blood pressure, oxygen saturation, and pulse rate. EEG signals were collected using the Emotiv EPOC X EEG device. The accuracy and safety of this device has been demonstrated in many previous studies<sup>[7]</sup>. It uses 14 channels covering 4 brain regions (AF3 et al.). The occipital area supports visual functions and the temporal area supports auditory processing and language functions; this study focuses on four electrodes (O1 and O2 in the occipital lobe, and T7 and T8 in the temporal lobe) associated with audiovisual processing. Different EEG frequency bands reflect specific states. The  $\alpha$  (8-13 Hz) band represents active and awake states with complete relaxation. The  $\beta$  (14-30 Hz) frequency band is higher and reflects mental alertness and concentration as well as emotions such as anxiety, anger, tension and excitement. Considering a large number of relevant studies, the present study used the  $\beta/\alpha$  index to assess physiological stress<sup>[8]</sup>. The higher the  $\beta/\alpha$  value, the more anxious and irritable the individual is, and conversely, the lower the value, the more relaxed and calm the individual is.

Blood pressure and heart rate were measured using an automatic electronic sphygmomanometer to evaluate vascular risk factors, which are risk factors for dementia. The participants were placed on a curve with one arm relaxed and constant breathing. SpO<sub>2</sub> and the pulse rate were measured using a Yuwell finger pulse oximeter (YX301). The data were averaged over three measurements. Blood pressure and the pulse rate are commonly used to evaluate stress in the cardiovascular system. The higher the indicator is, the more stressed the individual. SpO<sub>2</sub> reflects the amount of oxygenated hemoglobin in the blood as a percentage of all hemoglobin and is a physiological parameter related to the respiratory system; normal values should exceed 95%.

Psychological indicators mainly involved emotional state as assessed with the POMS. This study adopted the POMS model developed by Grove and Prapavessis. The POMS contains 40 sensations, and subjects mark how often they experience these sensations on a 5-point scale (starting with less extreme). The scores for the 40 sensations are used to calculate 7 mood scores: stress, anger, fatigue, depression, panic, energy, and self-esteem. These 7 mood scores were further combined into 3 metrics: positive mood (energy + self-esteem), negative mood (stress + anger + fatigue + depression + panic), and total mood disorder (TMD=negative mood-positive mood + 100). A high TMD indicates an unfavorable psychological state.

### 2.2.3. Statistical Analysis

SPSS 22.0 was used for the analysis. All indicators will be analysed using analyses of covariance (ANCOVAs) to observe group differences. The data from the pretest were used as covariates in the ANCOVAs, and FD and FS were independent variables. We examined the main effects of FD and FS as well as the effects of the interaction (FD $\times$ FS). If the interaction was significant, post hoc simple effects analysis was performed.

### 2.3. Questionnaire survey

The main purpose of the questionnaire survey is to further understand what aspects of the Hufu Forest Trail need to be upgraded from the perspective of the influencing factors of visual stimulation and auditory stimulation.

After designing the initial questionnaire and distributing 50 pre-survey questionnaires, we analyzed the results of the pre-survey, and adjusted the language expression or deleted the questions that were weak in resolution or not easy to understand, and finally formed the official questionnaire. The questionnaire consists of two parts, the basic personal information and the main part of the questionnaire, the basic personal information part of the questionnaire is the survey of the gender, age, education, health status of the questionnaire fillers, and the main part of the questionnaire is the measurement of the visual factor needs and the auditory factor needs (Table.3). In order to let the questionnaire fillers better understand and effectively fill in the questionnaire, the definition of forest recreation and forest recreation trail was given at the beginning of the questionnaire. The questionnaire was based on a five-point Likert scale in order to normalize the data.

It should be noted that after completing the research of the questionnaire, we still need to analyze the results for reliability and validity to ensure the validity of the questionnaire.(Table.3)

Table 3:Questionnaire content

Latent	Serial number	Measurement indicators
Visual Factor	V1	I think the quality of the scenery in the distance around the perimeter along the trail (not the trail scenery) is important
	V2	I think the visual quality of the infrastructure in the trail (size, material of paving, gazebos, etc, shape, etc.) is important
	V3	I think the rich quality of color along the trail (paving, gazebos infrastructure, etc., as well as plant color) is important
	V4	I think the plant configuration and form along the trail is important
Auditory Factor	H1	I think the quality of the natural sound environment in the trail (water flow, wind blowing, foliage sound, etc.) is important
	H2	I think the quality of the animal acoustic environment in the trail (insect song, bird song etc.) is important
	H3	I think it is important that there is no man-made noise in the trail (traffic, sports, playful traffic, sports, playfulness, etc.) is important

## 3. Results and discussion

### 3.1. Definition and Classification of Audiovisual Landscape

Audiovisual landscape refers to the combination of natural and artificial environments that can be perceived through both visual and auditory senses<sup>[9]</sup>. In forest trails, the audio-visual landscape mainly includes the visual experience brought by natural landscapes (such as trees, water flow, mountain scenery, etc.) and artificial landscapes (such as trail design, recreational facilities, signs, etc.), as well as the auditory experience composed of natural environment sounds (such as bird songs, wind sounds, water sounds, etc.) and artificial sounds (such as

tourist conversations, music playback, etc.). These landscape elements interact with each other and together influence the physical and mental experience of trail users.

The audiovisual landscape mainly includes the following three classifications: natural landscape, (primarily natural), mixed landscape (mixed) artificial landscape (anthropogenic). Suzhou Hufu Forest Trail is a total length of 5.7 kilometers of forest trail, of which the main line is 1.7 kilometers long and the branch line is 4.0 kilometers long. The trail is mainly characterized by hiking for fitness and visiting ancient places, and passes through many historical and humanistic monuments, such as the Hall of Broken Leaves, the Sword Pond, and the Huqiu Pagoda, etc., which show the characteristics of Huqiu's landscape and cultural integration. On the Hufu Forest Trail, visitors can enjoy a rich audio-visual landscape.(Figure. 2)

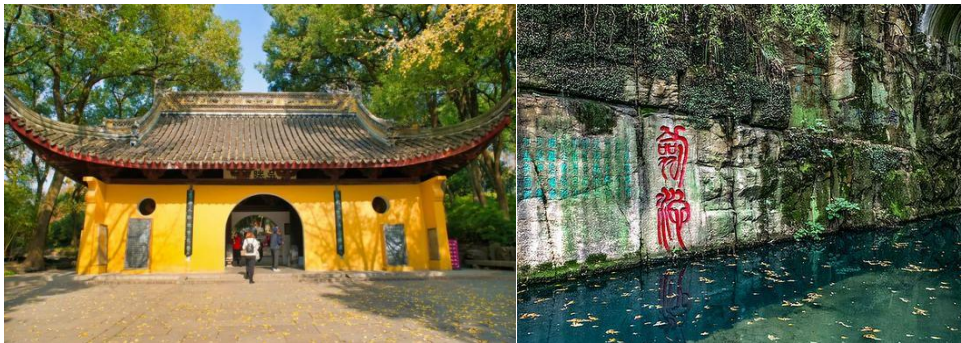


Figure 2: Hall of Broken Beams and Sword Pond

### 3.2. Empirical research results on the effects of audio-visual landscapes on the physical and mental responses of elderly people

Through on-site observations and questionnaire surveys of elderly people on the Hufu Forest Trail, this study found that audio-visual landscapes have a significant impact on the physical and mental responses of the elderly.

#### 3.2.1. Impact of Visual Landscape

The richness and diversity of the visual landscape in the Hufu Forest Trail in Suzhou provides a unique experience for older adults. Recent studies have shown that visual landscapes have a significant impact on the physical and mental responses of older adults.

First, on a physiological level, beautiful visual landscapes can lower the heart rate and blood pressure of older adults and reduce their physiological stress. In Suzhou Hufu Forest Trail, this sense of closeness to nature helps them relax and relieve fatigue. Second, from the psychological level, changes in the visual landscape can also trigger different emotional experiences for the elderly. For example, when they see monuments such as Huqiu Pagoda and Sword Pond, they may feel the heaviness of history and the magnificence of culture, and this emotional resonance can enhance their self-identity and sense of belonging. And when they stand on the observation deck and look at the skyline of Suzhou city from afar, they may feel the anticipation of the future and the love of life, and this positive state of mind can help them better face the challenges in life. In addition, visual landscapes can stimulate older people's desire to socialize and participate. In the trails, the elderly can exchange ideas and share their feelings with other visitors, and this kind of social interaction not only enriches their spiritual life, but also strengthens their social support system<sup>[10]</sup>.

#### 3.2.2. Impact of auditory landscape

Analysis of the results revealed that changes in the auditory landscape had a significant impact on the mood of older adults. For example, when the elderly walk on a trail and hear the sound of crisp birdsong, the gurgling of a brook, the chanting of a temple, or the sound of bells in the distance, it may trigger memories and thoughts of the past and cause positive psychological

mood swings. Physiologically, studies have also found that auditory landscapes have a positive effect on the heart rate and blood pressure of older adults, enabling them to tend to show a smoother heart rate and blood pressure.

### **3.3. Strategies for improving health and wellness effects**

Building upon existing research linking forest trail design to elderly health, this study proposes four enhancement strategies for optimizing geriatric recreational experiences:

**Natural Landscape Conservation:** Prioritize ecological preservation by restricting excessive commercial development, controlling tourist density, and curbing illegal activities. Simultaneously, leverage local biodiversity e.g., vegetation, water features to enrich multisensory engagement.

**Trail Design Optimization:** Employ non-slip, eco-friendly materials e.g., natural stone for pavement, minimize steep slopes with gradual inclines and rest platforms, and enhance safety through handrails and adequate lighting.

**Rest Facility Planning:** Integrate age-appropriate seating, shaded areas, and waste bins at regular intervals to accommodate reduced stamina and mobility.

Regulate visitor noise levels via crowd management, off-peak scheduling, and reduced machinery usage to maintain tranquility.

These evidence-based interventions aim to harmonize ecological integrity with geriatric needs, fostering therapeutic outcomes in forest trail environments.

### **3.4. Outlook on future research directions**

Although this study has achieved some results in the design of recreational trails for the elderly, we are well aware that this is only the beginning. Elderly people are a unique and complex social group with different characteristics from young people in terms of physical function, cognitive ability and psychological needs. Therefore, future research needs to explore more deeply how to optimize the design of recreational trails according to these characteristics.

#### **3.4.1. More in-depth research on the design of health and wellness trails for the elderly**

First, future research could further explore other types of trails, such as curved, circular, and linear. Different types of trails may have different effects on older adults' walking experience and physical and mental health. For example, curved trails may be more conducive to relaxation for older adults, while circular trails may be more suitable for regular walking activities. Second, regarding the environmental elements of the walkway, this study focused on the design of the audiovisual landscape, but future research could further expand to other elements such as color, material, and light. The way these elements are presented in the trail environment may directly affect the psychological feelings of the elderly. For example, soft colors and natural materials may make older people feel more comfortable and relaxed, while adequate lighting may help improve their mood.

Finally, we also need to pay attention to the evaluation of the effectiveness of recreational trails in actual application. By collecting feedback and physiological data from the elderly, we can more accurately understand the impact of trail design on their physical and mental health, thus providing a more scientific basis for subsequent design. (Figure.3)

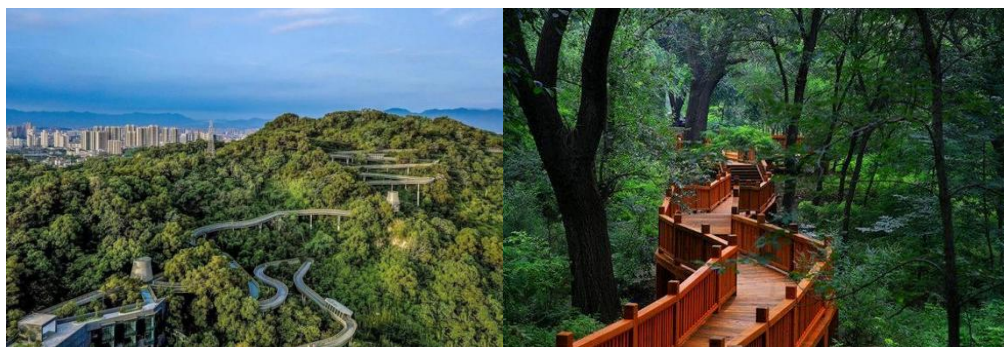


Figure 3: Types and colors of trails

## 4. Results and discussion

With the rapid growth of forest therapy as an innovative integration of nature and wellness, China's vast forest resources 3.12 billionmu,21.66 provide a solid foundation for its development. Targeting the diversified needs of middle-aged and elderly groups—redefined beyond material needs to include mental health and quality of life—forest therapy leverages environmental factors like phytoncides, negative ions, microclimates, and sensory stimulation sight, hearing

## 5. Conclusion

This study investigates the physiological and psychological responses of elderly individuals to audiovisual landscapes along Suzhou's Hufu Forest Therapy Trail against the backdrop of China's aging population and growing forest therapy industry. Through controlled experiments measuring blood pressure, SpO<sub>2</sub>, heart rate, and POMS scores, findings reveal that visual landscapes reduce physiological stress e.g., lowered heartrate and enhance emotional experiences, while auditory stimuli e.g., birdsong, flowingwater stabilize physiological indicators and evoke positive mood shifts. The research highlights the need for tailored trail designs leveraging local natural resources and diverse sensory elements. Future studies should expand to materials, lighting, and practical efficacy evaluations through user feedback to optimize geriatric-friendly forest therapy infrastructure.

## Acknowledgements

Thanks to Professor Zheng for her guidance to this article.

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