A STUDY ON THE DIFFERENCE OF FOREST SOUNDSCAPE EVALUATION MODELS BASED ON GEOPHONIES

HONG Xinchén, JIANG Yu, WU Shuting, ZHANG Hao and LAN Siren

Fujian Agriculture and Forestry University, School of Landscape Architecture, Forest Park Engineering Research Centre of State Forestry Administration, Fuzhou, China

email: xch.hung@outlook.com

Probe into the difference of the relationship between the physical quantity of soundscape and the human psychological quantity in different forest spaces. In our study, we made the subjective evaluation of geophonies in broad-leaved forest and coniferous forest spaces through Semantic Differential and measured the physical index of the evaluation of position at the same time. Finally, the soundscape evaluation models of broad-leaved forest and coniferous forest were established by data fitting, and compared the differences of the correlation coefficient the two groups. The results showed that both made the evaluation have a good sense of hearing in a relatively quiet, but with the sound pressure level increased, the geophony in broad-leaved forest produced a certain sense of dislike; the geophony evaluation data in broad-leaved forest tended to Stevens' law, and the geophysical sound in coniferous forest was inclined to Fechner's law; the fitting formula of broad-leaved forest and coniferous forest was opposite in trend. These soundscape evaluation models for broad-leaved forest and coniferous forest will provide an effective method and reference for the construction and improvement of green spaces.

Keywords: soundscape, environmental acoustics, forest

1. Introduction

Soundscape perception is one of the most important parts of people's perception of landscape. With the increasing pace of urban life, urban residents are more and more inclined to get close to nature, experience and enjoy nature [1]. Fortunately, the forest around the city provides the city residents with a recreation, recuperation, summer recuperation and other multi-functional place to relax their hearts, and the soundscape of the forest plays an important role [2]. Not only psychological and physical rehabilitation can be achieved [3], but also sound signals in animal communication can be improved [4]. This is necessary for the study of sound scene, especially in the forest.

Thus, soundscape is given more research attention. The characteristics of different soundscape elements can be distinguished and transformed into corresponding subjective feelings by the subjects using a soundwalk procedure [5]. The study of non-semantic sound with the same semantic sound and physical characteristics shows that there is a significant difference in subjective evaluation between the two. [6]. At the same time, In describing the basic elements of soundscape evaluation, Blesser, et al [7] identifies three semantic levels: the semantic and physical properties of the soundscape, and the acoustic landscape is divided into three semantic levels, including Sound Sources, Sound Descriptor and Soundscape Descriptors. The spatial and acoustic characteristics of a sound scene are not the only factors that affect the perception of sound; psychological factors play a role as well [8]. The physical properties of soundscape and subjective feelings of human beings have mutual influence, restriction and even can transform each other [9,10]. While previous researches have been carried out using laboratory tests and public questionnaires, the psychoacousti-
cal characterization of forest soundscape as it relates to the underlying landscape has not been paid enough attention. Such information would be useful for subjective and objective transformation model of forest soundscape to the urban planners and the public.

The aims of this research are: 1) to recognise the role of soundscape of geophony in forest; 2) to reveal the relationships between subjective and objective data of soundscape of geophony in forest; 3) to analyse difference of soundscape evaluation models between broad-leaved forest and coniferous forest.

2. Method

2.1 The laws of psychological physics related to the study

2.1.1 Weber's Law

Weber, an anatomist and physiologist, finds that the threshold of weight change is proportional to the initial weight of the object by studying the threshold of weight difference, which is Weber's law [11]. By representing $\Delta I$ as the original amount of physical stimulation, $I$ represents the increase in the amount of physical stimulus that can cause a stronger sense. Then Weber's Law can be expressed by the formula $k = \frac{\Delta I}{I}$, where the constant $k$ is the Weber fraction. Taking into account the intrinsic noise $I_0$ of the sensing system, a modified Weber's law is proposed [12]:

$$k = \frac{\Delta I}{I + I_0},$$

(1)

2.1.2 Fechner's Law

Fechner, a psychophysicist, uses a logarithmic function to associate the physical stimuli $I$ with the psychosensory $s$. On the basis of Weber's law, the conversion relationship between psychological sensation scale and physical stimulus intensity scale is established, which is Fechner's Law [12]:

$$\Delta s = k' \frac{\Delta I}{I + I_0},$$

(2)

In the formula, $\Delta s$ is the equal increment or minimum perceptible difference of the psychological perception amplitude, $k'$ is the constant used to correctly represent the increment unit of the psychological perception amplitude.

By integrating the two sides of the formula (2) at the same time, we obtain that the psychological perception which conforms to Fechner's law is as follows [12]:

$$s(I) = \int ds = k' \int \frac{dI}{I + I_0} = a + b \log(I + I_0),$$

(3)

2.1.3 Stevens's Power Law

Stevens studied the relationship between the intensity of different physical stimuli and the psychological perception by means of amplitude estimation, and put forward a functional expression of the psychosensory based on index which is different from Fechner's law, which is Stevens' Power Law[13].

$$s(I) = aI^p + b,$$

(4)

In the formula, $a$ and $b$ are constants, which are determined by the type of sensation and the amount of stimulus.
2.2 Study area

The research area is located in Fuzhou National Forest Park in Xindian Town, Jinan District, Fuzhou City, Fujian Province. The eastern side of the park is bounded by Fufei Road, the west side borders with the lake top and Yeyang Village, the south side is a reservoir, and it is adjacent to Fuzhou Zoo. The north side is adjacent to the Bijia Mountain. The geographic coordinates are 119° 16' E and 26° 07' N, which belong to the subtropical oceanic monsoon climate. The average annual rainfall is about 1438.5 mm. The frost-free period is 328 days, the average wind speed is 1.8 m/s, the relative humidity is 75 m/s, and the average sunshine is 1848 h. The broad-leaved forest area and the coniferous forest area are located in the west and east of the forest park respectively. The main tree specie in the broadleaved forest area is Lychee fruit, and the main tree specie in coniferous forest area is Masson's Pine.

2.3 Soundscape data

In soundscape research, capturing sounds generated from ambient natural sources is essential. According to Krause[14] and Pijanowski, Farina, et al.[15], a soundscape comprises three main-class active acoustic sources: biophony—non-human biological sounds produced by all organisms in a given habitat; geophony—non-biological natural sounds originating from the geophysical environment, which includes wind, water, thunder, geophysical activity, etc.; and anthrophony—anthropogenic sounds arising from stationary (e.g., air conditioner) and moving (e.g., vehicles) man-made objects. In this study, the subjective evaluation experiment used Semantic Difference Method to measure the geophysical acoustic evaluation of broad-leaved forest and coniferous forest. Semantic Differential Method is a method of measuring psychological feelings through speech scale [16]. The reviewers’ feelings can be quantified and recorded.

When we need to determine the adjectives related to the evaluation model, it is used to indicate the psychological intensity of the evaluator to the described object, which can more accurately reflect the psychological magnitude of the evaluator to the soundscape. Therefore, this study adopted the method of questionnaire, choosing the adjectives of "like-hate" as the content of the questionnaire, which was used to reflect the degree of preference to sound scene. The degree of preference for geophysical sound in the forest was measured. On this basis, the subjective evaluation rating was determined to be grade 5 [17], and used very much, prefer, average, dislike, very dislike to distinguish, and from left to right assign the value of 2, 1, 0, -1, -2, respectively, for quantitative analysis.

Eighteen healthy participants, aged 20-35 years and having normal hearing, were selected to provide subjective evaluations of soundscape. All were familiar with the forest area under evaluation [18]. The 18 trained evaluators rated 5-minute exposures to soundscapes at each of 60 locations within the broadleaf and coniferous forest regions. The survey time was selected as a sunny day without a holiday, and they were evaluated for each 5 minute independent soundscape preference at 60 points in the broad-leaved forest and the coniferous forest, while LAeq test of 5 minute was performed using the sound level meter.

3. Results

3.1 Data distribution

From figure 1, we can see that the psychological quantity of geophony in broad-leaved forest is distributed in the interval [-2,2]. With the increasing of SPL obtained from objective measurement, the distribution of psychological quantity is changed from the interval [0,2], down to the interval [-2,1]. The results show that geophysical sound in broad-leaved forest can make they evaluator have a better or general feeling of preference at low sound pressure levels, but it will produce a certain sense of dislike when the sound pressure level increases. From figure 2, we can see that the psychological quantity of geophony in coniferous forest is distributed in the interval [0,2]. With the increasing of the SPL observed by the guest, the distribution of the psychological quantity rises from
[0,2] to the maximum of the interval, which indicates that the geophony in the coniferous forest could make the evaluator produce better or general preference feeling when the SPL increased, and could produce a better taste after the SPL increased.

3.2 Data fitting
The maximum value of the total score of preference evaluation was normalized. The Fechner's law formula (3) and Stevens' law formula (4) were used to fit the normalized value of the total score of preference evaluation and the SPL measured objectively.
3.2.1 Fitting Analysis of Geophony Evaluation in Broad-leaved Forest

![Graph showing data fitting analysis of geophony evaluation in broad-leaved forests](image)

The data of soundscape of geophony preference evaluation in broad-leaved forest are fitted, as shown in figure 3. The results show that the $R^2$ of fitting coefficient of formula (3) is 0.853 and formula (4) is 0.927. That was to say, the preference of geophony in broad-leaved forest accorded with the above psychophysical laws, and it is more inclined to Stevens' Power law than Fechner's law. It showed that it had practical psychophysical significance. The relationship between the psychological perception $s_1$ of the preference of geophony in broadleaved forest and the objectively obtained SPL $I$ could be expressed as follows:

$$s_1(I) = -55.889 \log(I+562.001) + 156.032,$$

(3)

$$s_1(I) = 24.726I^{7.749} + 0.966,$$

(4)

3.2.2 Fitting analysis of geophony evaluation in coniferous forests

The data of geophony preference evaluation in coniferous forest are fitted, as shown in figure 4. The results of formula (3) show that the value of goodness of fit (R-squared) is 0.920, and that of formula(4) is 0.894. That was, the preference evaluation results of geophony in coniferous forest accorded with the above-mentioned psychophysical rules, relatively more inclined to Fechner's law. It showed that it had practical psychophysical significance, the relationship between the psychological perception $s_2$ of the preference degree of geophony in coniferous forest and the objectively obtained SPL $I$ could be expressed as follows:

$$s_2(I) = 0.758 \log(I - 23.551) + 0.021,$$

(5)

In conclusion, it was not difficult to find that the fitting formula (5) of broad-leaved forest and the fitting formula (6) of coniferous forest were opposite in trend. The results showed that subjects were more likely to feel geophony with lower SPL (less than 39.6 dBA) in broad-leaved forest and geophony with higher SPL (more than 36.8 dBA) in coniferous forest.
4. Conclusion

Broad-leaved forest and coniferous forest are important landscape resources in forest. This study established a geophysical sound scene preference evaluation model of coniferous forest and broad-leaved forest through the theory of sound scene ecology and psychophysics. The main conclusions are as follows:

1) The geophony in broad-leaved forest can make the evaluator feel better or generally when it is quieter, but when the sound pressure level increases, it will produce a certain sense of dislike. 2) the geophony in the coniferous forest can make the evaluator produce better or general preference feeling when being quiet, and can generate better taste feeling after the sound pressure level is increased; 3) The trend of geophony preference evaluation data is in accordance with the law of psychophysics, and the geophony evaluation data in broad-leaved forest tend to Stevens’ law. The geophysical sound in coniferous forest is inclined to Fechner’s law. 4) The fitting formula of broad-leaved forest and coniferous forest is opposite in trend.

The quantitative evaluation of soundscape is the application trend of landscape planning and development in the future. The theories of soundscape ecology and psychophysics can be used to classify and qualitatively analyze many elements of soundscape. The purpose of this study is to provide an effective method for deep and comprehensive soundscape resource management and to make a new contribution to the construction of sound landscape beautiful forest environment.

REFERENCES


