Study on the Noise Reduction Effect of Vegetation Communities in Northeast China – Taking Forest Park in Yingkou City as an Example

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Abstract. In this study, the greenland tree and shrub communities in Forest Park, a typical park greenland in Yingkou City, Liaoning Province, were used as the research object to compare the noise reduction of different communities, and to study the degree of noise reduction of the plant communities in summer. The results show that the noise reduction level of vegetation communities in summer is in the following order: M2 cypress + cypress + acacia > M1 poplar + Euphorbia + maple > M3 cypress + yellow thorn rose + ginkgo tree.

1 Preface

The impact of noise on people's daily life is increasing day by day with the development of the times.[1] When the sound of man-made machinery and the sound of traffic on the road become the perennial background sound of urban life, the prevention and control of noise becomes more and more important.

On 5 January 2023, the Ministry of Ecology and Environment (MOE), together with 15 other relevant departments and units,[2]released the "14th Five-Year Plan of Action for Noise Pollution Prevention and Control". The main objective of the document is to continuously improve the quality of the acoustic environment during the 14th Five-Year Plan period. The Action Plan sets out in detail five key control directions, aiming to strengthen the prevention and control of noise pollution more effectively.[3]Firstly, to strictly manage and control the sources of noise while further improving the relevant planning standards. Secondly, the prevention and control of noise pollution from industrial enterprises will be stepped up, and industrial noise will be promoted to be included in the management system of emission permits and key emission units. Thirdly, the prevention and control of noise pollution from construction has been strengthened,[4]especially in areas where noise-sensitive buildings are concentrated, and higher normative standards have been put forward for construction activities. Fourthly, the prevention and control of noise pollution from transport has been strengthened, and noise emissions from motor vehicles,[5]ships and other means of transport have been strictly regulated. Finally, for social life noise pollution, a more harmonious social environment is jointly created by optimising management measures.

In order to respond positively to the national[6] policy and have considerable relevance to the discipline of landscape architecture, this study is carried out for the fifth point of the above five key control directions. For the prevention and control of noise[7] standards from the initial relevant regulations in 1989, the relevant prevention and control law was introduced in 1996, which was improved and modified in 2018, and formally implemented in 2022. In this study, we chose the forest park in Yingkou City with summer as the research object to investigate the role of vegetation communities on noise attenuation.

2 Research Content and Methods

2.1 Sample site selection

Three vegetation communities in the forest park in the western city of Yingkou City, Liaoning Province, were selected for the study, as well as the blank space of the square on the north side of the forest park as the control site. The size of each vegetation community was taken as 20m×20m, all of which were tree-shrub structures, and the vegetation species, crown width, height, community depression, planting density, and the number of trees and shrubs were recorded and measured in each selected area respectively (Table 1).

Table 1. Various vegetation communities in the Forest Park sample site.

Community number	Community name	Vegetation type	Plant species	Number of trees	Number of shrubs
M1	Populus tremula + Fagus sylvatica + Fagus sylvatica	Deciduous broad-leaved forest	Populus tremula + Fagus sylvatica + Fagus sylvatica + Hawthorn + Robinia pseudoacacia + Pinus sylvatica + Populus tremula	13	7
M2	**Lateral cypress**	Broad-leaved	Lateral cypress + cypress +	18	8

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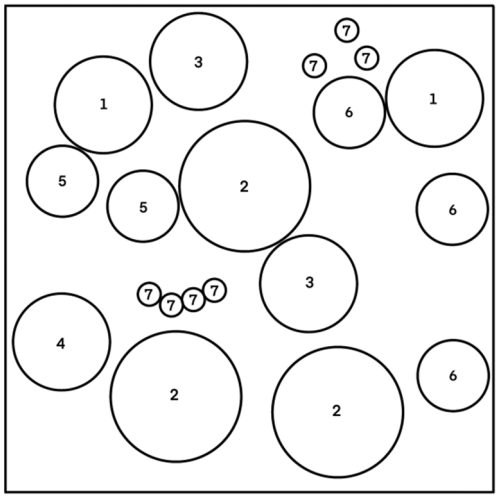
	+ **cypress** + **acacia**	evergreen forest	acacia + pine + luan + boxwood + Phellodendron Bark + silver maple		
M3	Round cypress + yellow bramble + ginkgo biloba	Deciduous broad-leaved forest	Round cypress + yellow bramble + ginkgo biloba + chaste tree + gold and silver honeysuckle + silver poplar + downy ash + small-leaved boxwood + red bramble	7	16

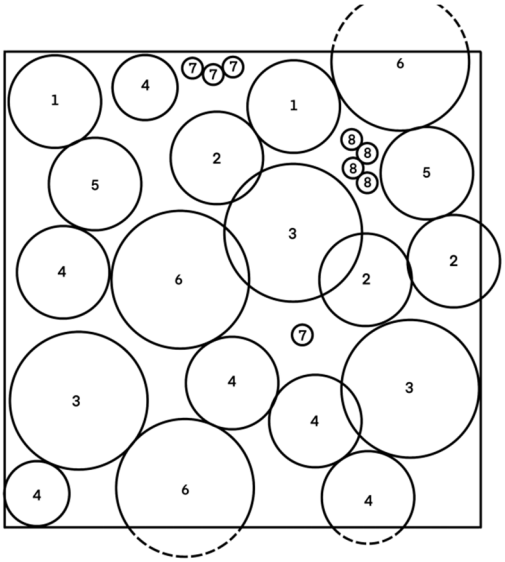
The distribution of vegetation in the M1 area is shown on the fig.1.



1. Populus tremula 2. Fagus sylvatica 3.Fagus sylvatica 4.Hawthorn 5.Robinia pseudoacacia 6.Pinus sylvatica 7.Populus tremula

Fig. 1. The distribution of vegetation in the M1.

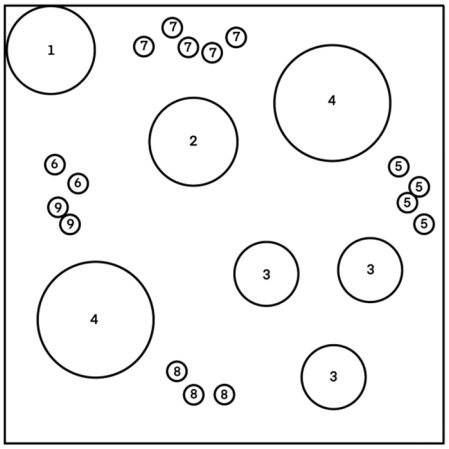
The distribution of vegetation in the M2 area is shown on the fig.2.



1. Lateral cypress 2.cypress 3.acacia 4. pine 5.luan 6. silver maple 7.boxwood 8.Phellodendron Bark

Fig. 2. The distribution of vegetation in the M2.

The distribution of vegetation in the M3 area is shown on the fig.3.



1.Round cypress 2.ginkgo biloba 3.silver poplar 4.downy ash 5.yellow bramble 6.chaste tree 7.gold and silver honeysuckle 8.small-leaved boxwood 9.red bramble

Fig. 3. The distribution of vegetation in the M3.

2.2 Data monitoring content and methods

The style for the names is First Name, typed in italic 10-point Times, then Last Name, typed in 10-point Times, with a comma after all except the last author, which is separated by comma + "and". Do not use academic titles.

Affiliations of authors should be typed in 9-point Times.[8]They should be preceded by a numerical superscript corresponding to the same superscript after the name of the author concerned. Please ensure that affiliations are as full and complete as possible and include the country.[9]

2.2.1 Monitoring of the noise reduction degree of the morning and evening peaks of the community

As the park is surrounded by four vehicular roads, the morning peak and evening peak periods are selected, and the noise reduction effect of traffic noise in these two time periods can have a significant numerical difference between[10] the 25th of June 2023 and the 15th of July 2023, and the monitoring time periods are as follows: 7:30~9:30 and 16:30~18:30, and the wind speed in this time period is < 1.5m/s, and the temperature, humidity are relatively stable, and the experimental instrument is AS824 professional noise sound level meter measuring instrument. Three monitoring points were set up at 0m, 10m and 20m from the edge of each community, and the measurement height was 1.2m from the ground, and each measurement lasted for 10 min, and the measured data were selected as A-weighted sound level.

2.2.2 Data Processing

The attenuation rate of green space to noise is calculated by the formula:

$$N_i = \frac{L_{0i} - L_{xi} - \Delta L_{xi}}{L_{0i}} \quad (1)$$

Where, N_i is the net noise attenuation rate of the ith sample site; L_{0i} is the decibel value at the noise source of

the ith sample site; L_{xi} is the noise value at a distance of x from the noise source; x=10m, 20m. ΔL_{xi} is the natural attenuation of noise at a distance of x.

3 Results and analyses

Since the time of the measurement experiment is summer, the trees in Northeast China show the densest form of branches and leaves in summer, the measured results can be regarded as the most significant data value of the noise reduction effect in all seasons of the year, as it was found in the previous research and investigation that the attenuation effect of the vegetation on the sound in the distance of up to 30m is with the growth of the width of the distance, and once exceeding the 30m, its effect of the attenuation of the noise will be become less and less effective once it exceeds 30m.

3.1 Experimental site and process

Since the seasonal changes in Yingkou City are more obvious, and the density of the leaves of the trees changes due to the seasonal changes, the noise attenuation effect will also be affected, so the most dense leaves in the summer were selected for the measurements. The experimental measurements were carried out from 6.18 to 6.30 in clear weather with a wind speed of less than 5 m/s.

The instrument used in this experiment is AS824 professional noise level meter. The range is 30dB-130dBA, 35dB-130dBC, the accuracy is ±1.5dB, with a large HD backlit screen, A-weighted and C-weighted, dynamic characteristics covering fast and slow, AC/DC analogue signal output, and the power supply is a 9V battery. A steel tape measure was used for tree spacing measurements. As show in figure 4.

Fig. 4. AS824 Sound level meter Measuring instrument.

Tree stands with different degrees of enclosure were selected in five urban integrated parks and experimental measurements were carried out separately. Tree species identification and tree spacing measurements were recorded for the selected tree belts, and a plan view of the tree belts was drawn. During data collection, the outer edge of one side of the green belt in the sample plots was set up as the sound point of the noise source, and the decibel values of the sound were measured at a distance of 1.2m from the ground in a straight line perpendicular to the boundary of the outer edge at distances of 0m, 10m, 20m.

The experimental data determination method was referred to "Acoustics Description, Measurement Pre-evaluation of Environmental Noise Part II: Determination of Sound Pressure Level" (GB/T 3222.2-2022/ISO 1996-2:2017). In the experiment, the sampling interval was set at 1s, and a total of 10min was measured, with a total of 600 samples. After sampling, the measured decibel value was output by calculation. As show in figure 5.

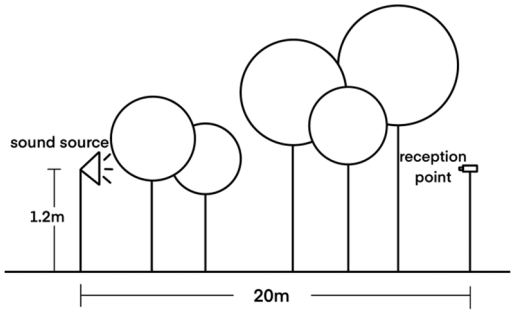


Fig. 5. Schematic diagram of the experiment.

3.2 Conclusion of noise reduction results of each vegetation community

The measurement results of the three vegetation communities show that they all play a certain role in noise reduction, when the distance increases, the degree of noise reduction is also relatively obvious, the more the number of trees with strong shading and the higher the density of trees and shrubs, the better the effect of noise reduction.

3.3 Analysis of noise reduction differences of each vegetation community

In the three vegetation communities of the research sample site, the noise reduction rate at 20m from high to low is M2 cypress + cypress + acacia > M1 poplar + Euphorbia + maple > M3 cypress + yellow rose + ginkgo biloba, M2 cypress + cypress + acacia has the highest noise reduction rate of 9.32%, and the sound pressure level decreases by 7.32dB, and the worst is M3 cypress + yellow rose + ginkgo biloba, with a noise reduction rate of 6.46% and a sound pressure level decreases by 6.54dB. The worst noise reduction rate is M3 cypress + yellow bramble + ginkgo tree with 6.46 per cent and 6.54 dB decrease in sound pressure level. As show in figure 6.

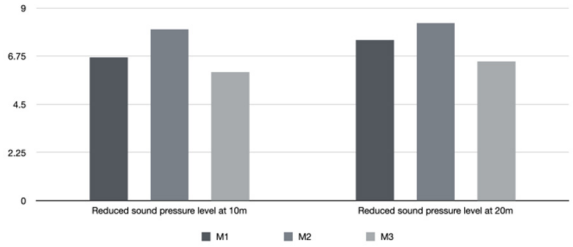


Fig. 6. Reduction of sound pressure level by vegetation communities in the sample plot.

4 Conclusion

The measured noise reduction SPLs of the vegetation communities in the sample plots were all greater than those in the control open space, and the noise reduction effect was more obvious in the 20 m than in the 10 m. The noise reduction effect was more obvious in the 20 m than in the 10 m plots. In summer, the degree of noise reduction of vegetation communities in descending order is as follows: M2 cypress + cypress + acacia > M1 poplar + Euphorbia + maple > M3 cypress + yellow thorn rose + ginkgo tree. The noise reduction effect is better if the plant specification is bigger and more luxuriant, but the transparency of the view will be affected if the degree of depression is too high, the enclosing characteristic in the form of semi-enclosure can effectively isolate the noise of the side corresponding to the middle side, and the noise reduction effect is better if there are more trees and the degree of depression of the vegetation is big.

4.1 optimisation strategy

Tree belts can be planted in the areas of comprehensive parks in Yingkou City that are easily disturbed by motor vehicle noise from outside to isolate the noise, and tree and shrub belts can be planted around the places with high noise decibel values inside the parks to effectively prevent the noise from disturbing the other visitors who are looking for quietness.

4.2 Shortcomings and Prospects

The effect of vegetation on sound attenuation has been recognised by scholars, but based on the type of vegetation, i.e. whether it is a coniferous or broad-leaved forest belt, there is no effective and recognised research result on the difference of the effect on sound decibel attenuation so far, due to the low temperature in winter time in the north-eastern part of China, which is able to reach minus 30 degrees Celsius, and most of the broad-leaved trees wither their leaves during winter time, while the dense foliage of coniferous vegetation is not affected by temperature. However, coniferous vegetation is not affected by temperature, and the attenuation of sound by vegetation is mainly due to the obstruction and absorption of sound by foliage, so summer and winter can be used as the background for the study of the effect of coniferous and broadleaf vegetation on sound attenuation, and the difference in results can be compared more effectively.

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