Function of Forests as Noise Screen

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Intrusive noise, particularly traffic noise has been a form of public nuisance. It is most effective to control noise sources for preventing noise, but it may be considerably difficult. Therefore, we generally prevent noise by making use of noise barrier walls, windows with sound proof equipments, and others. Vegetation, trees and shrubs are known to have some effects to reduce sound level, as is shown by the name "forest abating noise". In the field of engineering or acoustics, however, it is considered that the forests as noise screens may provide psychological or only a slight effect for noise control. Sound level reduces naturally due to the attenuation by distance, atmospheric absorption, temperature and other effects, even though there are no obstacles in the sound propagation path.

Considering that the effectiveness of forests as the mass of trees and shrubs in reducing sound level should be studied, although that of roadside trees is uncertain, the investigation was carried out. The result obtained by the present author, and those by others (cited in the paper) are presented briefly.

Sites and methods of experiment

Forest stands which were used for the purpose of this study are Japanese redwood, Japanese cypress, Japanese red pine, Japanese black pine, deciduous broad-leaf trees, and evergreen broad-leaf. They were selected on flat ground. White noise was recorded on magnetic tape to provide the sound source. The sound source was placed at 5 m distance from the front edge of tree belts. Both the sound source and the sound level meters were installed at the height of 1.2 m above ground. Measurements were made in dBA with the sound level meters and in dBC with octave band level analyzer at various distance from the sound source in the forests. Measurements were repeated at the lawns or farm lands without crops, adjacent to each forest stand. The noise-attenuation by forests was evaluated by the difference in the sound level with and without the forests at given distance from the sound source.

Results

Conditions of the major forest stands used in this investigation are shown in Table 1. The attenuation caused by forests differed greatly with different stands, as given in Table 2. The attenuation at the front edge of tree belt often showed negative values, probably due to the reflection from forest trees. The attenuation showed a tendency to be greater in the forest stands with high tree density and low clear length (Nos. 1 and 3 in Table 2), as well as with abundant undergrowth (Nos. 2 and 5). On the whole, it is considered that forests with low tree density, high clear length and lacking of undergrowth provide slight effect of reducing the sound level in a range of 20 m distance in the belt depth. In the stand No. 12, the attenuation was not so much as might be expected, considering higher density and lower clear length. This unexpected attenuation may be due to the travelling sound over the lower forest canopy into the shielded areas by the process of diffraction. In the stand No. 6, the attenua-

Table 1. Stands used for the study

Stand No.	Species	Tree density (No./ha)	Mean height (m)	Mean clear length (m)	D.B.H (cm)	Undergrowth density
1	Cryptomeria	3,500	5.5	1.3	9.5	none
2	Cryptomeria	1,850	11.2	6.1	14.7	abundance
3	Cryptomeria	3,400	6.5	2.6	8.9	abundance
	secondery stand	1,288	4.0	—	6.0	
4	Cryptomeria	1,763	11.9	6.2	14.6	scanty
	secondary stand	50	2.3	—	2.0	
5	Japanese cypress	1,467	18.3	14.8	20.5	abundance
	secondary stand	4,084	2.3	0.7	2.1	
6	Japanese red pine	1,214	14.2	10.3	20.7	abundancs
	secondary stand	6,486	1.9		1.4	
7	Japanese black pine	3,451	8.3	3.6	9.6	none
8	Japanese black pine	710	15.0	9.4	23.7	many
	secondary stand	355	5.6	2.5	6.9	
9	Japanese black pine	2,076	9.5	5.6	12.6	none
	secondary stand	1,200	2.8	0.1	2.2	
10	White oak et al.	1,657	10.1	5.1	10.7	many
	secondary stand	629	4.3	—	3.3	
11	White oak et al·	2,840	7.1	3.5	5.8	none
	secondary stand	3,400	3.7	2.4	2.2	
12	Japanesr sacred tree	9,783	2.4	0.9	2.5	none

Table 2. Noise attenuation at various distance in forest

Stand No.	Noise attenuation (dBA)						
	Distance from the front edge (m)						
	(front) 1	10	20	30	40	50	60
1	2	4	6	9			
2	1	3	5	6	7		
3	−1	3	5	7	8		
4	−2	1	2	3	4	6	8
5	0	2	3	5	6	8	10
6	−1	2	3	4	6	7*	
	0	1	2	3	4	5**	
7	1	2	3	4	5	6	8
8	0	1	2	2	3	4	5
9	3	3	4	5	7	9	10
10	−1	2	2	2	3	4***	
	−2	0	2	2	3	5	
11	1	1	2	2	2	3	4***
	1	1	2	3	4	6	7
12	1	3	4	6	7		

* with undergrowth
** without undergrowth
*** in defoliation season

tion was apparently decreased after the cleaning cutting of undergrowth. In the deciduous broad leaf tree forests (Nos. 10 and 11), the attenuation was decreased slightly in the defoliation season. Based on these findings, it is presumed that the noise-attenuating function of forests is considerably correlated with undergrowth and tree leaves.

It was recognized that the noise attenuation of forests(y) is relatived to the distance in the forest depth(x) as follows when x is more than 10 m:

$$y = ax + b$$

The results of the investigation showed that attenuation caused by the forest stands without particular cultural works is about 4-8 dBA per 30 m of the forest depth.

Regarding the attenuation of octave band sound pressure level, it was found that the attenuation at frequency band with the center frequency of 8000 Hz was more than others in most measurements.

Conclusion

Results in the past reports of this type of study contain partly contradicting conclusions.

By examining the results of research by the author and others[1,2,3], the following conclusion may be drawn regarding the noise abating function of forests:

1) In the forest stands without any particular tending, the noise attenuation is approximately 4–8 dBA per 30 m of distance in the belt depth, in excess of the natural attenuation.

2) Noise attenuation caused by forests shows no definite trend in a range of about 10 m distance in the belt depth. However, when the distance is beyond that range, the attenuation increases almost proportionally with the distance in the belt depth.

3) As sound reaches to the shielded areas over the forests by the process of diffraction, taller species may offer the longer sound propagation distance, and consequently greater effect of attenuation. However, species don't appear to differ greatly in their abilities to reduce sound level. In deciduous tree species, the attenuation decreases apparently in the defoliation season.

4) Stand structure is an important factor determining noise abating function of forests. The higher the tree density, and lower the clear length, the greater is the noise abating function. Accordingly, when the compound storied forest is established with as much shrubs and undergrowth as possible, it will become a stand with the most effective noise abating function. In the stand with such a structure, the attenuation more than 10 dBA per 30 m of distance in the belt depth can be expected, in excess of natural attenuation. The attenuation 10 dBA is felt approximately half as human response to loudness; a considerably large effect in noise prevention.

5) Sound level reduces naturally with distance from sound source, and is affected by atomospheric absorption, ground absorption and other effects, even when there are no obstacle in the sound propagation path. Since forest, by itself offered a medium for natural reduction, the total attenuation, including the natural attenuation, caused by the presence of the forest can reach 21–25 dBA per 30 m of the belt depth with a simple sound source at 5 m from the front edge of tree belt, and more than 27 dBA in case of tree belt with the most effective structure.

6) It was clearly recognized that the attenuation of octave band sound pressure level attributable to forests increases for high frequency bands, in particular for a frequency band with mean frequency of 8000 Hz. For other frequency bands, no clear conclusion is made.

Thus, there is a limit in their abilities in reducing noise due to forests. However, by keeping forests at the most effective condition, forests may have considerably good effect to control noise.

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(Received for publication, October 20, 1980)