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Seasonal Effects of a Tree Belt on Community Response to Road Traffic Noise: A Social Survey in Tomakomai, Japan

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A series of social surveys was carried out in Tomakomai, Japan, to examine the effects of a tree belt on community response to road traffic noise and its seasonal changes. The deciduous tree belt, 4.8 kilometers long and 15 meters wide, was sited along the north side of the road and the houses surveyed were divided into three groups; houses separated from the road by the tree belt, those in areas where there is no tree belt, and those in areas where the tree belt is on the opposite side of the road. The respondents were asked to answer the questionnaires every season. In order to prevent the respondents from dropping out, the purpose of the study was explained to the respondents as a survey of energy consumption. The effect of the tree belt on noise annoyance and the living environment was examined by comparing three groups of houses. It was concluded that the tree belt did not mitigate the road traffic noise annoyance, whereas it enhanced the total impression of the living environment. These results were consistent in each season.

Keywords: tree belt, traffic noise annoyance, living environment, social survey, seasonal change.

1. INTRODUCTION

Noise barriers or tree belts have been considered effective for noise abatement from traffic road. The physical aspects of them have been investigated considerably, whereas the psychological effects have not been examined sufficiently. Yano et al. [1] conducted a social survey to examine the effects of noise barriers on community response to road traffic noise. It was shown that people living in areas without a noise barrier were more annoyed by the same noise level than those in areas with a barrier. Shirako et al. [2] and Misawa et al. [3] conducted experimental studies in the laboratory and in the field. They showed that vegetation made people less annoyed. Suzuki et al. [4] reported in their laboratory experiment that vegetation made noise more annoying in some circumstances and less annoying in the other cases. On the other hand, Anderson [5] et al. and Mulligan et al. [6] found that loudness increased with vegetation. Watts [7] et al. also showed that visual masking with trees increased noise annoyance. As mentioned above, it was found that there were discrepancies in the findings among researchers. Also, it was found that no social survey had been conducted to examine the psychological effects of tree belts. To clarify the effect of tree belts on noise annoyance in real life, investigations with social survey methodology are necessary.

The present paper discusses the effects of a tree belt on community response to road traffic noise and its seasonal changes using the data obtained from a series of social surveys carried out in Tomakomai, Japan.

2. OUTLINE OF THE SURVEY

Tomakomai has a population of about 170,000 and is located in the northern part of Japan, which has a comfortable summer temperature and cold winters. The meteorological data during the periods of the survey are shown in Appendix 1. A residential area along an arterial road with a tree belt was selected as the target area. It lies east and west and detached houses stand along both sides of the road. The deciduous tree belt, 4.8 kilometers long and 15 meters wide, was sited along the north side of the road. Trees sprout in spring and grow their leaves densely and richly in summer. The leaves change the color into red or yellow in autumn and fall down in winter. Seasonal changes in conditions of foliage in the tree belt may affect the evaluation of noise or living environment. This study contributes to consider the temporal design of living environment. Traffic volume is about 30,000 per day and there are crosswalks with stoplight and overpasses at several points. All of the houses surveyed were detached and situated in the front row, facing the road. The houses surveyed were divided

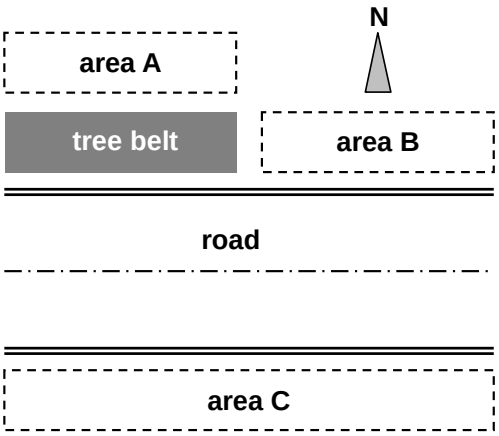

Fig. 1. Outline of the area surveyed.

into three groups: houses separated from the road by the tree belt (area A), those in areas where there is no tree belt (area B), and those areas where the tree belt is on the opposite side of the road (area C) as shown in Fig. 1 and Appendix 2. In the northern part of Japan, windows are generally set on the south side of the living room or the private rooms to take sunshine in. Only small window is set on the north side even if the room needs it. The garden is also placed at south side of the houses. Since the road lies east and west, people living in the area A see the tree belt, whereas those living in the area C see neither the tree belt nor the road from their houses. People living in the area B do not see the tree belt but they see the road. Whether the residents see the tree belt or the road is very important for this study. For this reason, the areas were divided into three groups and were analyzed separately. The respondents were asked to answer the questionnaires every season. The questionnaire contained 52 questions in summer (the first questionnaire) and 28 questions in autumn, winter and spring. The key questions concerned annoyance, activity disturbance and related effects caused by the road traffic and they were answered on a five-point verbal scale. Question wordings and the scales cited in the present paper are shown in Appendix 3. It is conceivable that some respondents make the same answer or drop out in repeated surveys. In order to overcome this tendency, the purpose of the study was explained to the respondents as a survey of energy consumption, which was contrived by Griffiths et al. [8]. They explained the logic of this strategy, "Since energy use patterns are likely to change with the seasons, it would be logical to respondents that the interviews should be repeated at various times during the year." The respondents, from 20 to 75 years of age were randomly selected from the list of registered voters at Tomakomai municipal government on a one-person-per-family basis. The outline of the study design is summarized in Table 1. The questionnaires were delivered to 437 people in summer and were collected from 274 respondents. In the other seasons, the 274 people who responded in summer were asked to answer the questions. Actual number of samples was reduced to 272 or 247 in each season because some people rejected our request. The numbers of respondents were 250 in autumn, 226 in winter and 225 in spring. After the questionnaires were completed, two types of physical measurements were made on a weekday in each season. One was a 24-hour continuous noise measurement at a reference point six meters distant from the road shoulder, 1.2 meters above the ground. The other was a noise reduction measurement at 5, 10, 20 and 40-meter points from the reference point on the three types of ground surfaces: tree belt, asphalt and grass. Noise measurement points are shown in Appendix 2. Equations for estimating the distance reductions were formulated by regression analysis. The noise exposure to each

Table 1. Outline of the study design.

Season	Summer	Autumn	Winter	Spring
Survey year	2003(2004)	2003	2004	2004
Questionnaire Distribution	Aug.20-21	Nov.18	Feb.16	May.17
Questionnaire Collection	Aug.26-27	Nov.25	*	*
Noise measurement	Sep.1-2, (2004)	Nov.20	Feb.24-25	Jun.2
Number of samples	437	272	247	247
Number of respondents	274	250	226	225
area A**	47	44	40	44
area B**	101	93	82	80
area C**	126	113	104	101
Traffic volume per day	30,897	-	27,804	-
Noise exposure level LAeq(24) [dBA]	42-70	43-70	40-69	44-70

* The questionnaires were collected by postal method in winter and spring.

**Area A, area behind tree belt; area B, area not behind tree belt; area C, area south of road.

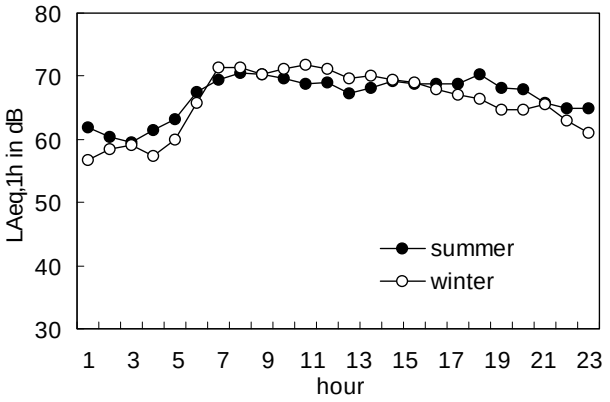

Fig. 2. Seasonal comparison of noise level.

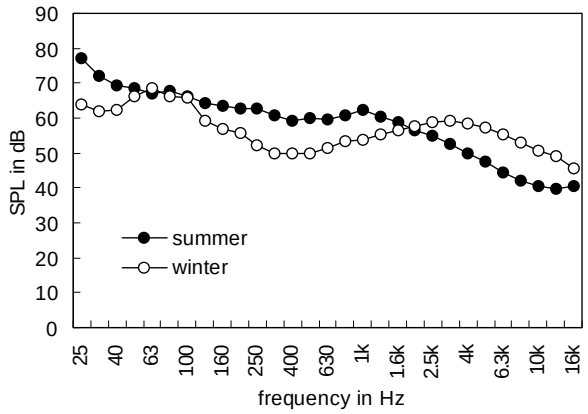

Fig. 3. Seasonal comparison of frequency characteristics of noise.

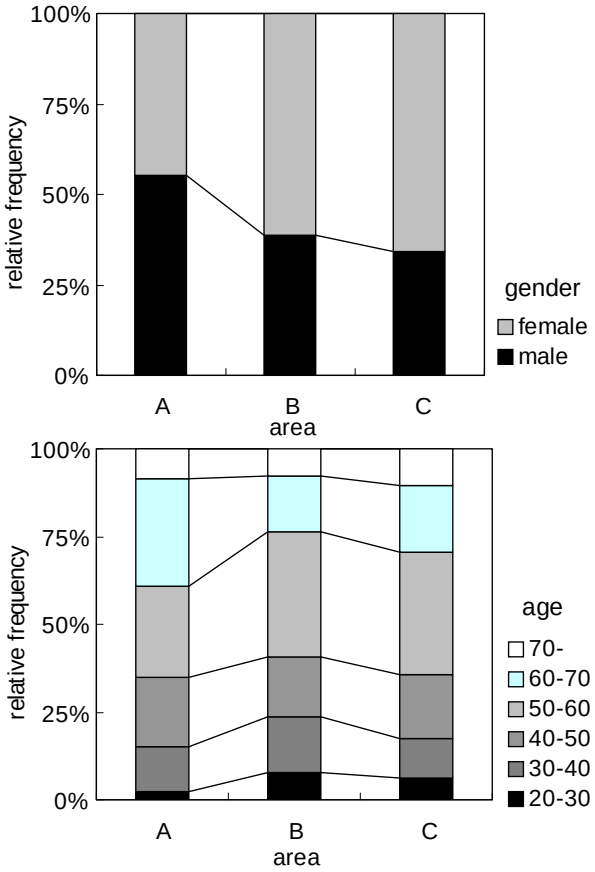

Fig. 4. Comparison of personal factors of respondents. Area A, area behind tree belt; area B, area not behind tree belt: area C: area south of road.

house, that is defined here as the noise level at the closest point to the road, was calculated from LAeq at the reference point and the distance reduction. The distance reductions to the houses more than 40 meters apart from the road were estimated from the extrapolation. The numbers and kinds of vehicles passing in front of the reference point were manually counted during the 24-hour measurement period.

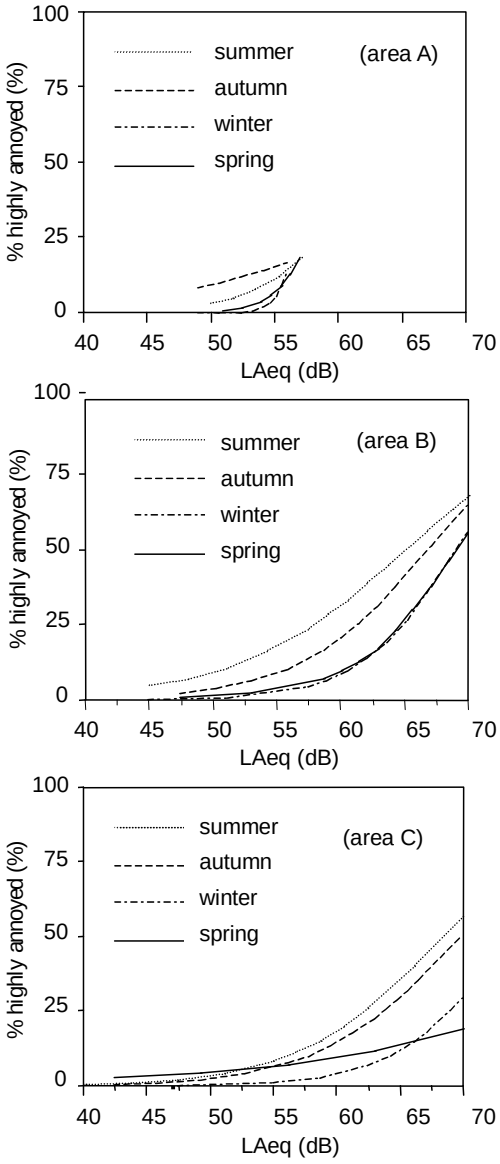

Fig.5. Comparison of community response to noise among seasons. Area A, area behind tree belt; area B, area not behind tree belt: area C: area south of road.

3. RESULTS AND DISCUSSION

Figures 2 and 3 compare the noise levels and the frequency characteristics of noise at the reference point between summer and winter. Noise measurements were made under fair weather conditions in both seasons, but the road surface was wet in winter due to melted snow. Although the spectra are different between the two seasons due to the tire characteristics (“studless” winter tire is used in winter) and the surface conditions of the road, the A-weighted noise levels are almost the same. Figure 4 shows the personal factors of respondents. The females are more than the males in the areas B and C, but the differences in age among the three areas are small. People living in the three areas made almost the same answers to the questions on access to work place or school, energy

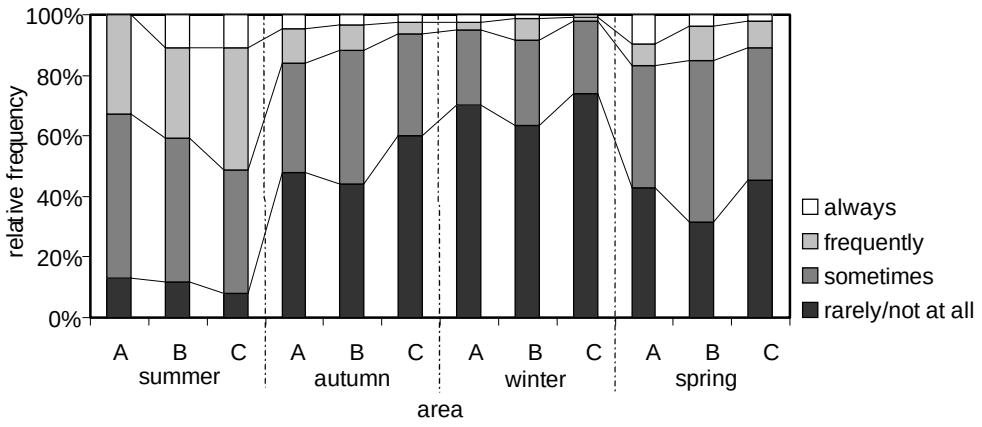

Fig. 6. Comparison of the answer to the question, "Thinking about the last month, do you open a window when you are relaxing in the living room?" Area A, area behind tree belt; area B, area not behind tree belt: area C: area south of road.

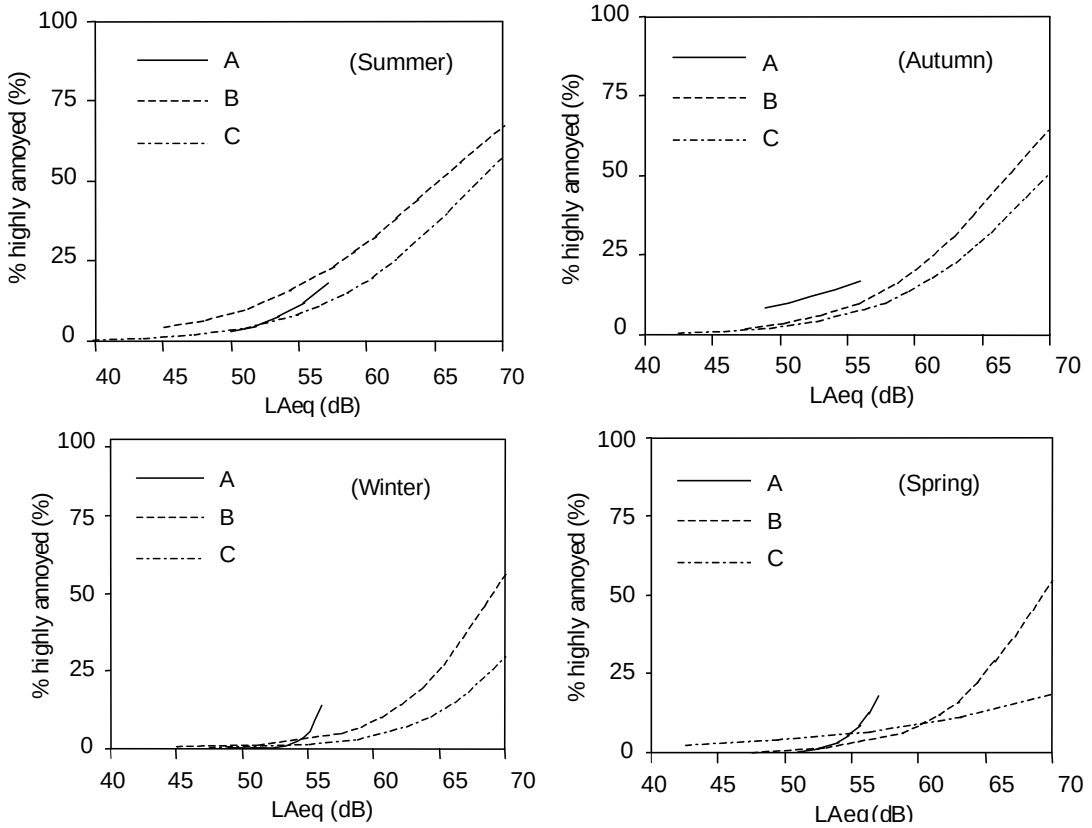

Fig. 7. Comparison of community response to noise among areas. Area A, area behind tree belt; area B, area not behind tree belt: area C: area south of road.

supply facilities and transportation system.

Community responses were compared among seasons, as shown in Fig. 5, in relation to the extent of highly annoyed and noise exposure levels by using logistic regression analysis. The % highly annoyed is defined here as the percentage of people who responded with the highest category of the five-point verbal scale at that range of noise exposure level. The Wald chi-square test was used to test for difference among seasons as dummy variable and showed that it was statistically significant only in the area B ($p>0.05$). In this figure, it is seen that people reported less annoyance in spring and winter, and most annoyance in summer in the areas B and C, probably owing to open windows, as shown in Fig. 6. This result corresponds with that of Miedema et al. [9]. It is also seen that people living in the area A reported less annoyance in summer than in autumn, which differ from the other areas. It suggests the effect of rich foliage, but the seasonal differences are statistically insignificant in the area A.

Figure 7 compares the dose-response relationships among areas in each season. It is seen that people living in the area A

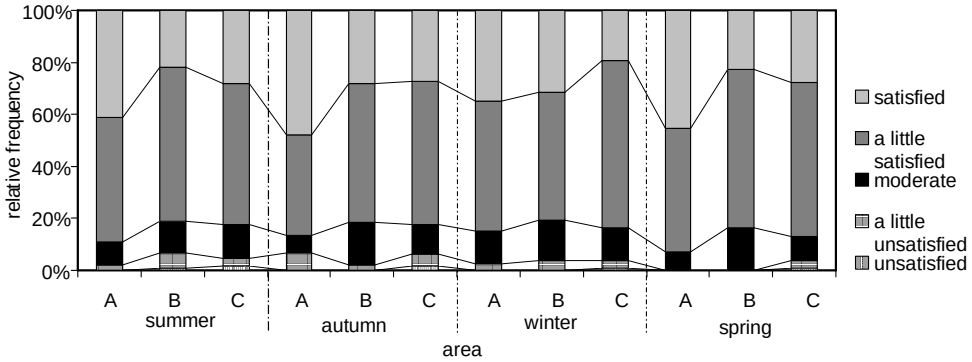

Fig. 8. Comparison of the answers to the question on satisfaction level with the living area. Area A, area behind tree belt; area B, area not behind tree belt: area C: area south of road.

reported more annoyance in autumn, winter and spring, whereas they reported less annoyance in summer than those living in the area B. It also suggests the effect of rich foliage, but there were no statistical differences among three areas in all seasons. Although the differences are statistically insignificant, it is seen that people living in the area C reported less annoyance than those living in the other two areas. It may possibly be related to the orientation of the houses because the main windows are generally set on the opposite side of the road in the area C, as mentioned above. Discussions on the way to define the noise exposure of each house are needed to clarify this problem.

Figure 8 compares the answer to the question on satisfaction level with the living area. It was found that people living

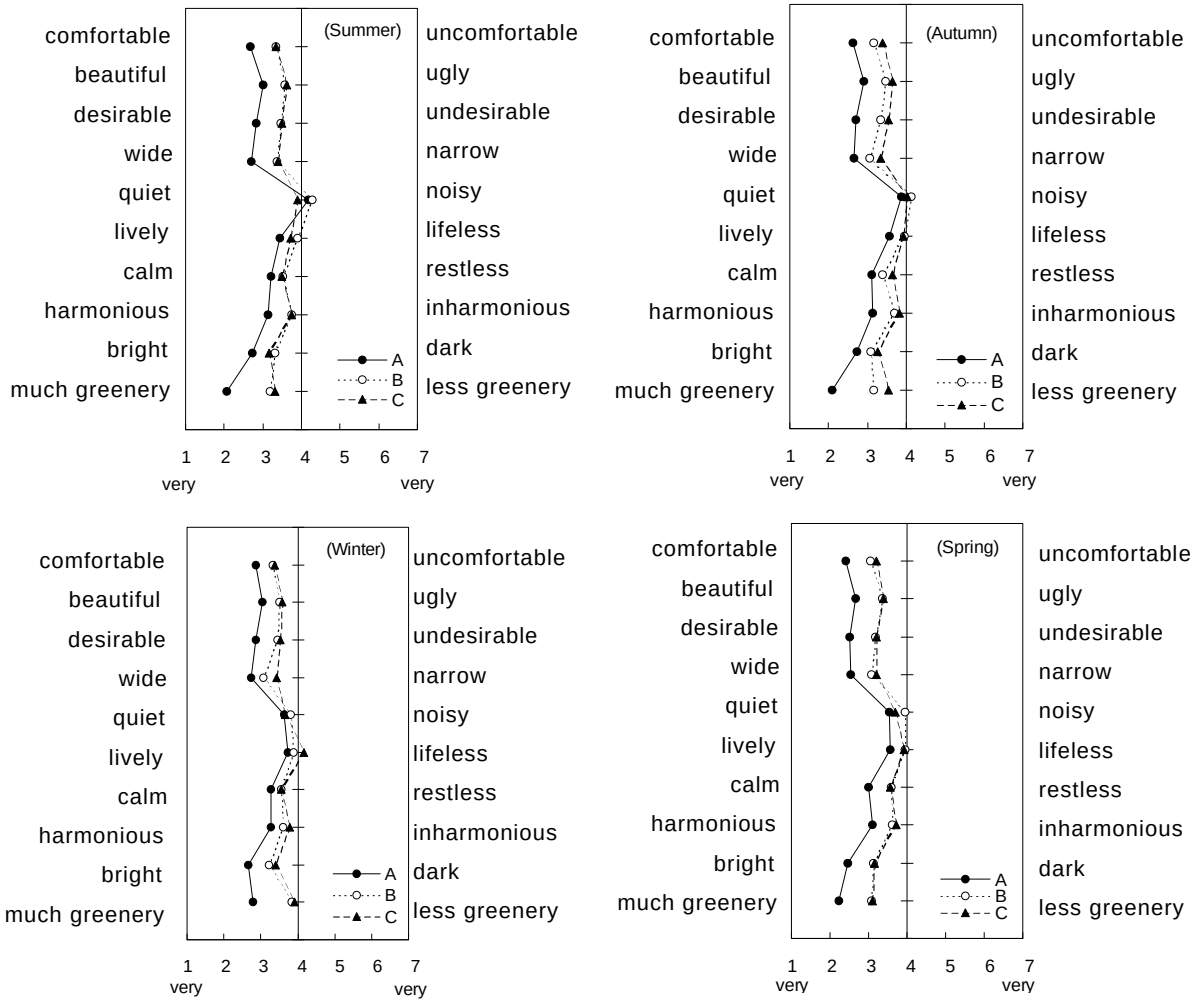

Fig. 9. Comparison of the answers to the questions on environmental images around home. Area A, area behind tree belt; area B, area not behind tree belt: area C: area south of road.

in the area A were more satisfied with the living area than those living in the other areas. Figure 9 shows the answer to the questions on environmental images around home. In all seasons, it is seen that people living in the area A have favorable impressions of the living environment except for auditory impression, "quiet or noisy." They seem to keep an intrinsic value of the tree belt even when they live in no foliage seasons.

As many studies have been indicated, annoyance due to noise is an important factor in people's quality of life. However, the results of this study showed that environmental satisfaction with tree belt did not affect the noise annoyance.

5.SUMMARY

A series of social surveys was carried out in Tomakomai, Japan, to examine the effects of a tree belt on community response to road traffic noise and its seasonal changes. The effect of the tree belt on noise annoyance and the living environment were discussed among three areas divided by relative positions with the tree belt. The main results are summarized as follows: 1) people living along the tree belt are not less annoyed by the same amount of noise than those living in the other sites; 2) people living along the tree belt are more satisfied with their living environment than those living in the other sites; 3) these results were consistent in each season. It was concluded that the tree belt did not mitigate the road traffic noise annoyance, whereas it enhanced the total impression of the living environment.

ACKNOWLEDGMENTS

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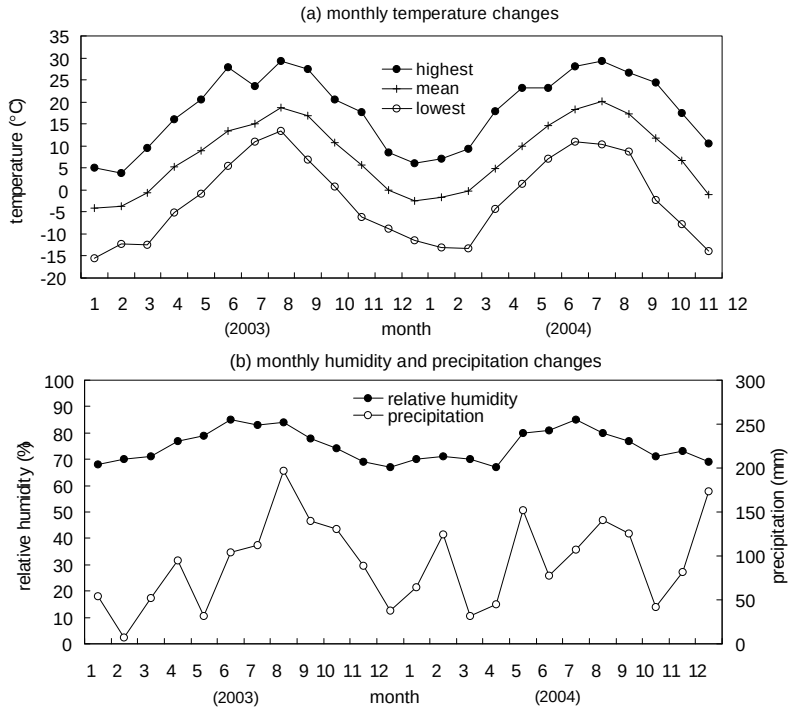
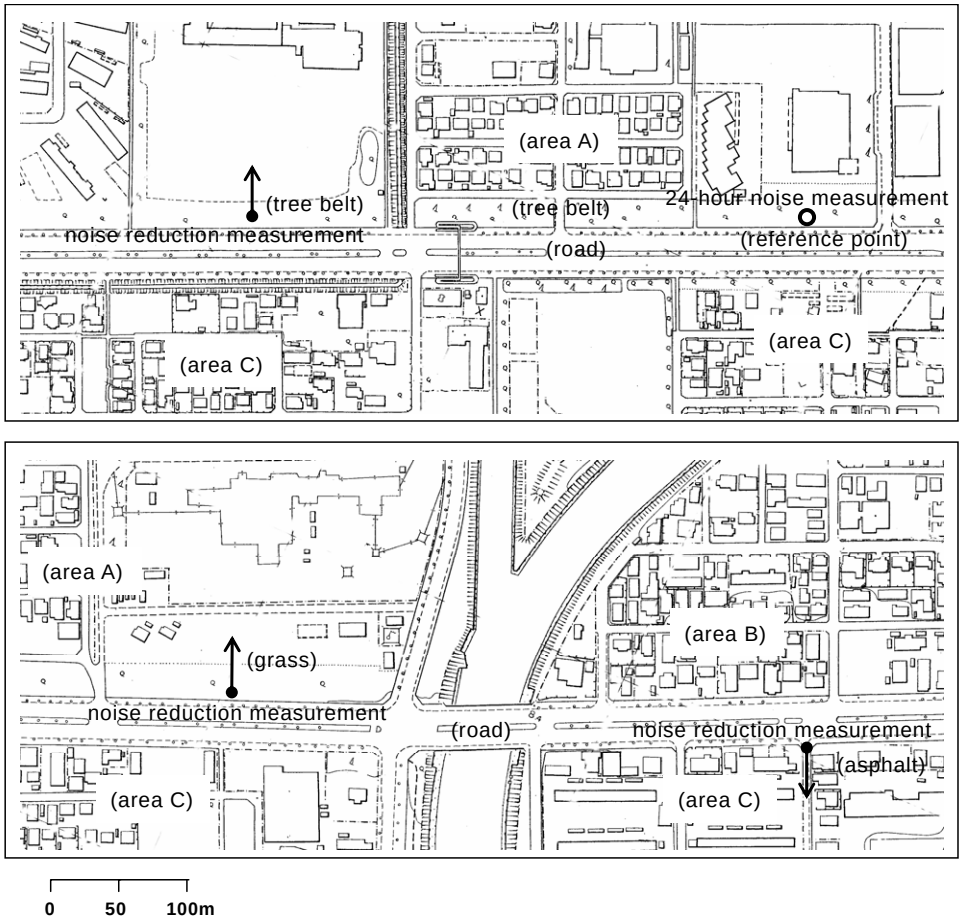


Appendix 1. Temperature, humidity and precipitation changes in Tomakomai.



Appendix 2. Examples of the areas surveyed and noise measurement points.

1) For Figures 5 and 7.
Thinking about the last month, when you are here at home, how much does noise from road bother, disturb, or annoy you?
( ) not at all ( ) slightly ( ) moderately ( ) very ( ) extremely

2) For Figure 6.
Thinking about the last month, do you open a window when you are relaxing in the living room?
( ) rarely/not at all ( ) sometimes ( ) frequently ( ) always

3) For Figure 8.
Thinking about the last month, are you satisfied with living area?
( ) satisfied ( ) a little satisfied ( ) moderate ( ) a little unsatisfied ( ) unsatisfied

4) For Figure 9.
Thinking about the last month, what is your image to the environment around home?

	very						very	
comfortable	1	2	3	4	5	6	7	uncomfortable
beautiful	1	2	3	4	5	6	7	ugly
⋮								⋮

Appendix 3. Question wordings and the scales cited in the present paper.

Summer

Area	LAeq in dB	1	2	3	4	5	Total
A	50-55	4	4	7	12	3	30
	55-60	0	0	8	6	2	16
B	45-50	1	5	8	1	3	18
	50-55	0	4	4	2	0	10
	55-60	0	6	20	10	11	47
	60-65	1	1	7	5	5	19
	65-70	0	0	0	1	5	6
C	40-45	2	5	3	0	0	10
	45-50	3	8	3	0	1	15
	50-55	2	15	7	4	1	29
	55-60	0	2	13	6	5	26
	60-65	0	2	19	6	6	33
	65-70	0	1	4	1	7	13

Autumn

Area	LAeq in dB	1	2	3	4	5	Total
A	45-50	0	0	2	0	0	2
	50-55	0	6	16	10	6	38
	55-60	0	0	3	1	0	4
B	45-50	0	4	6	4	0	14
	50-55	0	5	4	1	1	11
	55-60	1	6	15	12	6	40
	60-65	0	2	10	5	5	22
	65-70	0	0	0	2	4	6
C	40-45	1	2	1	0	0	4
	45-50	0	10	3	0	1	14
	50-55	3	11	12	2	1	29
	55-60	0	2	14	5	2	23
	60-65	0	4	14	8	4	30
	65-70	0	1	2	3	7	13

Winter

Area	LAeq in dB	1	2	3	4	5	Total
A	45-50	0	0	1	0	0	1
	50-55	3	7	16	6	3	35
	55-60	0	1	2	1	0	4
B	45-50	2	8	7	2	0	19
	50-55	0	1	4	2	1	8
	55-60	3	7	13	8	4	35
	60-65	0	0	10	2	2	14
	65-70	0	0	0	3	2	5
C	40-45	3	6	1	1	0	11
	45-50	4	5	2	0	0	11
	50-55	0	12	11	2	1	26
	55-60	0	7	8	6	0	21
	60-65	0	3	13	5	5	26
	65-70	1	0	3	4	1	9

Spring

Area	LAeq in dB	1	2	3	4	5	Total
A	50-55	1	12	8	5	1	27
	55-60	0	3	6	4	2	15
B	45-50	0	2	10	0	0	12
	50-55	1	2	5	1	0	9
	55-60	0	4	20	8	3	35
	60-65	0	0	9	8	1	18
	65-70	0	1	0	2	3	6
C	40-45	1	3	1	0	0	5
	45-50	0	8	2	0	1	11
	50-55	2	13	9	0	1	25
	55-60	0	3	12	6	1	22
	60-65	1	5	14	3	3	26
	65-70	0	1	2	6	2	11

Appendix 4. Number of respondents giving each answer to the annoyance scale.