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An Experimental Study on the Effects of Greenery in the Assessments of Residential Street Scenes Using Scale-models

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Abstract

The main object of this paper is to clarify the effect of greenery on residential street scenes, using scale-models. For this purpose, eye-level color slides of the scale-models and color slides of real residential streets were used as the stimuli of two experiments respectively, and 35 students of University assessed the stimuli. The authors showed the importance of visual greenery and showed the difference of the results between from the scale-models and from the real street scenes. Furthermore, the authors can point out the feasibility of simulation by the scale-models for this purpose.

Key Words: Residential street scene, Greenery, Scale-model, Assessment.

1. Introduction

The scenic value of a residential neighborhood is an important component of its livability. In recent years, some investigations have been made to clarify certain factors that effect the scenic value. Most of them have reported that greenery (vegetation) in residential areas has a great influence on the satisfaction or preference of people.[2,9,11,17,18,20,26]

At a rough estimate, it seems that the amount of visual greenery is not all that different from the vegetation-covered area in residential areas. But in detail, visual greenery may owe a great deal to street side vegetation and the three dimensional volume of them.[3] Thus, when we assess street scenes, an on-site test is desirable to reflect the direct experience of the subjects. But in practice, however, on-site tests have some empirical and analytical problems, such as the difficulty of presenting adequate samples of landscape views to large samples of respondents. Consequently, photographic displays as a substitute have been used in many studies. In this context, Shuttleworth (1980)[24] and Kellomak and Savolainen (1984)[15] reviewed and reported on the validity and effectiveness of photographs in representing landscapes.

Meanwhile, using photographs of real street scenes only, has its limitations also. In particular, it is difficult to examine the effects of each factor independently. Consequently, some simulation techniques such as photomontages, scale-models and computer graphics are in need of development.[5,19]

Although some researches which attempted to show the effects of trees on street landscaping, used the photomontage technique,[6,7,22,23,25] research on the use of street scale-models for this objects is rarely found. This report delas with the effects of greenery on residential street scenes and compares the results from color slides of scale-models with those of real street scenes.

2. Method

Experiment Based on Color Slides of Scale-models

Color slides of scale-model street scenes of residential areas were used as the stimuli of the experiment. Each model was made to a scale of one to one hundred meters. The details of the models are as follows.

House : A typical Hokkaido individual house with the triangle roof in style which was built by public housing corporations was made. The building size was 7.9 meters ×6.9 meters with a height 6.8 meters. The color of the walls was cream and the roof was red (Figure 1).

Street : Two types of street were used. One was 6.5 meters in width with a 1.5 meter sidewalk on each side. The other type was 7.5 meters in width with a 2.5 meters sidewalk on each side in which street trees were set. Both streets were assumed to be paved with asphalt. The street trees were assumed to be decidious and were placed in front of the houses.

Housing lot : The size of the housing lot was 200 m² of which the east-west axis was 12.5 meters and the north-south axis was 16 meters. It was assumed that the outdoor space of the housing lot except for the entrance was covered by a lawn. For tree planting, three types of housing lots, namely one without tree, one having a high tree and one having a low tree were used. For the housing lot perimeter against the three designs used one had no fence or hedge, one had a hedge and one had a concrete block fence. The height of both the fence and the hedge was 1 meter.

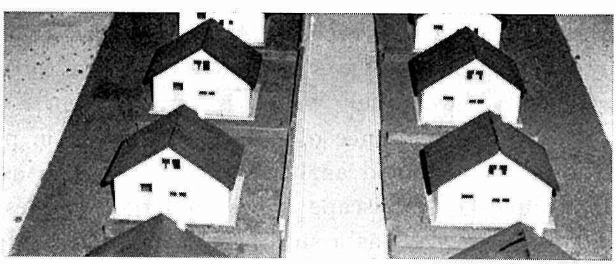

Figure 1. Photographic presentation of the model house.

Telephone pole: We used two types of streets in this experiment. One had no telephone poles and the other had telephone poles (8 meters in height).

Background: As the background of house which was placed at the end of the street, three types — hill, hill and building, lack of the above (sky only) — were used.

If these are combined 108 different models could be assembled. There were two types of street, three types of construction around housing lots, three types of trees in housing lots, three types of background, and with or without telephone pole.

Arrangement of the houses and each characteristics is shown in Figure 2 and the arrangement of the all housing lots is shown in Figure 3.

A miniature periscopic camera attachment (in this case a "borescope") was used to take "eye-level" photographs along the street (Figure 4). In order to reduce the rating test time, we chose 75 color slides both sides of the 108 possible types. The kind of color slides chosen are shown in Table 1.

In November 1981, each of the scenes (about 1 meter in projected diameter) was shown by means of a slide projector to a class of 35 students (male: 32, female: 3, including 4 students of the landscape architecture course) of the School of Agriculture at the University of Hokkaido.

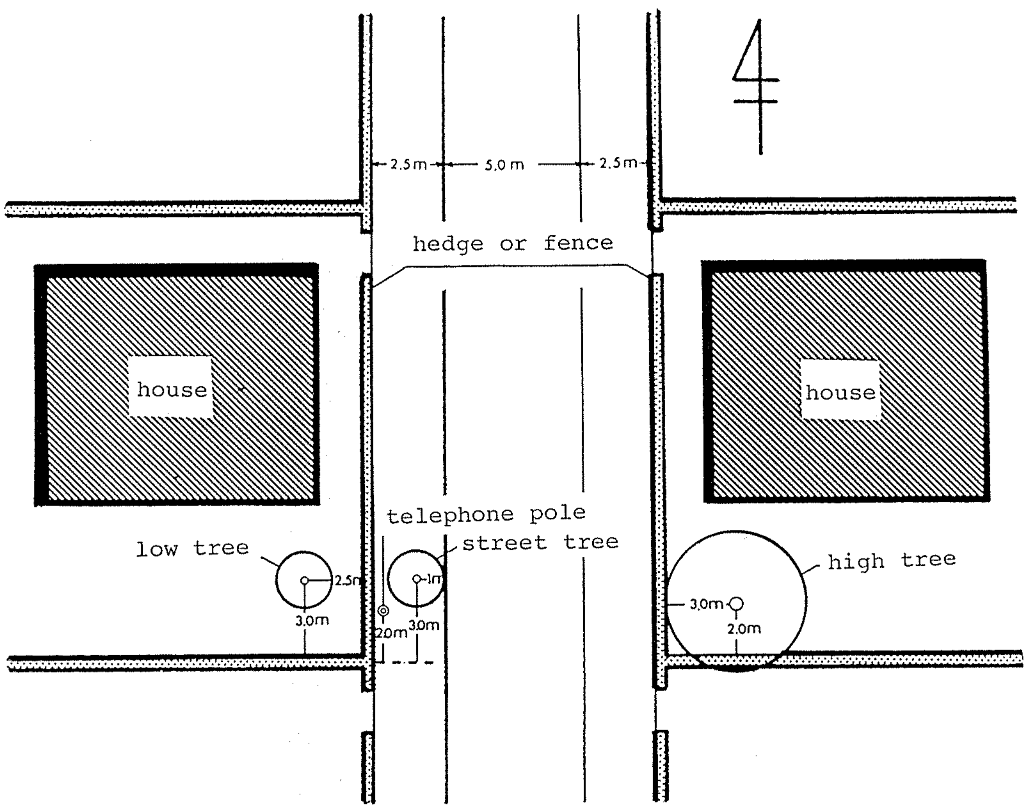

Figure 2. Placement of each house and the other characteristics.

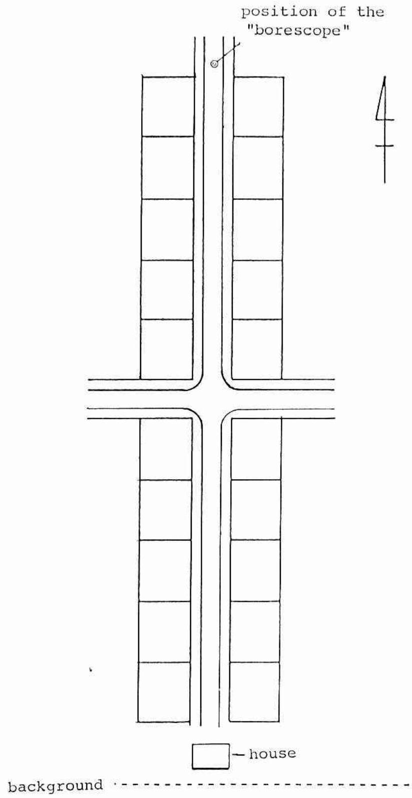

Figure 3. Arrangement of the whole housing lots.

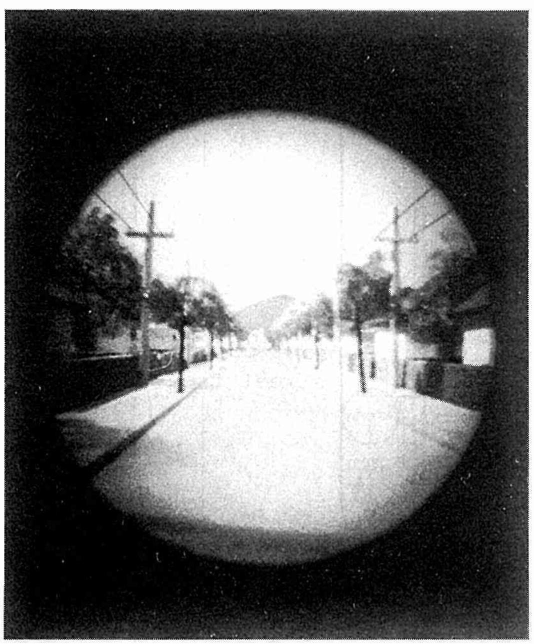

Figure 4. An example of the scale-model scenes.

Table 1. Of the scale-model slide number shown by each sub-category

Variable	Sub-category	1	2	3	4	5	6	7	8	9	10	11	12	13
Utility pole:	1) presence	48												
	2) absence	0	27											
Street tree:	3) presence	25	6	31										
	4) absence	23	21	0	44									
Fence or hedge:	5) hedge	16	8	10	14	24								
	6) concrete block fence	16	8	10	14	0	24							
	7) neither hedge nor fence	16	11	11	16	0	0	27						
Trees in housing lot:	8) low trees	16	7	8	15	9	8	6	23					
	9) high trees	15	8	9	14	7	7	9	0	23				
	10) absence	17	12	14	15	8	9	12	0	0	29			
Background*:	11) hill	15	13	11	17	10	9	9	7	8	13	28		
	12) hill and building	16	3	9	10	6	5	8	8	5	6	0	19	
	13) absence	17	11	11	17	8	10	10	8	10	10	0	0	28

* Background of the house which was placed at the end of the streets and it played a role as an "eye-stop" of the street.

The slides were arranged randomly and each scene was presented for about 10 to 15 seconds. During the time, each student was asked to judge the scene on the following 7 point scales.

(1) x) an abundance of greenery — y) lack of greenery

(2) x) good residential area — y) bad residential area

From left to right in the each scale: extremely x, quite x, slightly x, neither x nor y (or equally x and y), slightly y, quite y, extremely y. This scale ran from 7 points to one point.

Experiment Based on Color Slides of Real Street Scenes

Thirteen typical residential areas in Sapporo were chosen for this study (each chosen area was about 6–10 ha). Each area was a part of following areas: Shinkotoni, Kōyo, Azabu, Okadama, North 23 to 24 Jo and West 6 to 8 Chome, Yamanote, Meien, Sōen, Kōsai, Kōto, Misono, Hongō and Makomanai. Details of the areas were shown in previous papers.[3)]

Color slides were taken systematically at the center of streets at 50-meter intervals in the summer of 1979. Most of the scenes which were used in this study were selected from these slides but a few were added to increase the variety. A wide angle (35 mm) lens, the field of vision of which is similar to that of the human eyes was used in 1979, although a standard lens (50 mm) had been used in 1977. Each slide was taken on a clear day at eye level (about 1.5 meter in height) and with a focal point of infinity straight ahead.

The method of experiment was the same as the experiment based on the model. The subjects numbered 35 students (male: 29, female: 6, including 5 students of the landscape architecture course) of the School of Agriculture at the University of Hokkaido. The projected size of the slides was about 1.2 meter in length and 1.7 meter in width. Rating scales were the same as previously mentioned.

The results of this study were computed by SPSS at the Hokkaido University Computing Center.

3. Results and Discussion

Vegetation-covered Ratios in the Photographs

Vegetation-covered ratios in the photographs which were used as stimuli of both experiments were measured as the background for the next analysis.

Figure 5 shows the frequencies for each types of vegetation ratio (expressed as a percentage) of the color slides of the model and those of the real streets. The model was simple, thus it is natural that the ranges of frequency of the model were narrower than those of the real streets. For example, although the street tree ratios of the models ranged from 4.8% to 7.1% and the ratios of trees in housing lots ranged from 2.2% to 15.7%, the same ratios in hotographs of real streets were from 0.6% to 24.4% and from 0.3% to 40.1% (in these cases results under 0.1% were excluded).

The reasons for the wide range in the ratios of street trees in the real streets are due to the locations at which the photographs were taken, as well as to the

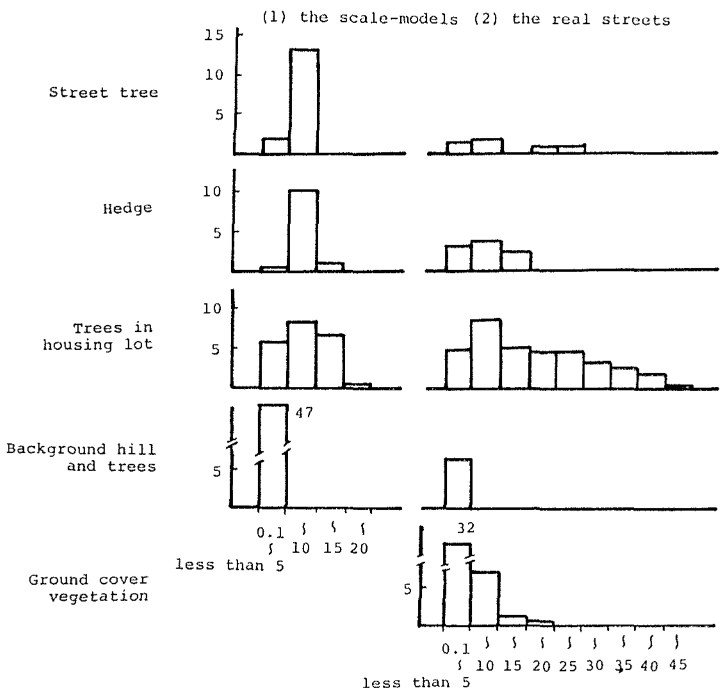

Figure 5. Frequency of each kind of vegetation ratios appearing in the photographs of the real streets and the scale-models.

Note: Photographs of which each kind of vegetation area is under 0.1% are excluded.

actual number of street trees. The wider range of ratios of trees in housing lots is mainly due to the difference in the number of trees in the area.

Relationship Between Visual Greenery ratio and Assessment

The area of vegetation in the photographs measured as a percentage of the whole was called the visual greenery ratio.

When we examine the relationships between the mean scores of the "an abundance of greenery — lack of greenery" category, the mean ratings of the "good residential area — bad residential area" category, and the visual greenery ratios, there had high correlation coefficients. Figures 6 and 7 are scattergrams which show the realtions between the mean ratings of the "an abundance of greenery — lack of greenery" and the visual greenery ratios based on the models and the real streets respectively.

If the mean ratings of the "an abundance of greenery — lack of greenery" category are used as the dependent variable and the visual greenery ratios (%) are used as the independent variable, the linear regression equations are estimated as follows :

(Based on the color slides of the models)

$$Y=0.174X+2.045 \qquad R^2=0.89 \qquad (1)$$

(Based on the color slides of the real streets)

$$Y=0.099X+2.002 \qquad R^2=0.78 \qquad (2)$$

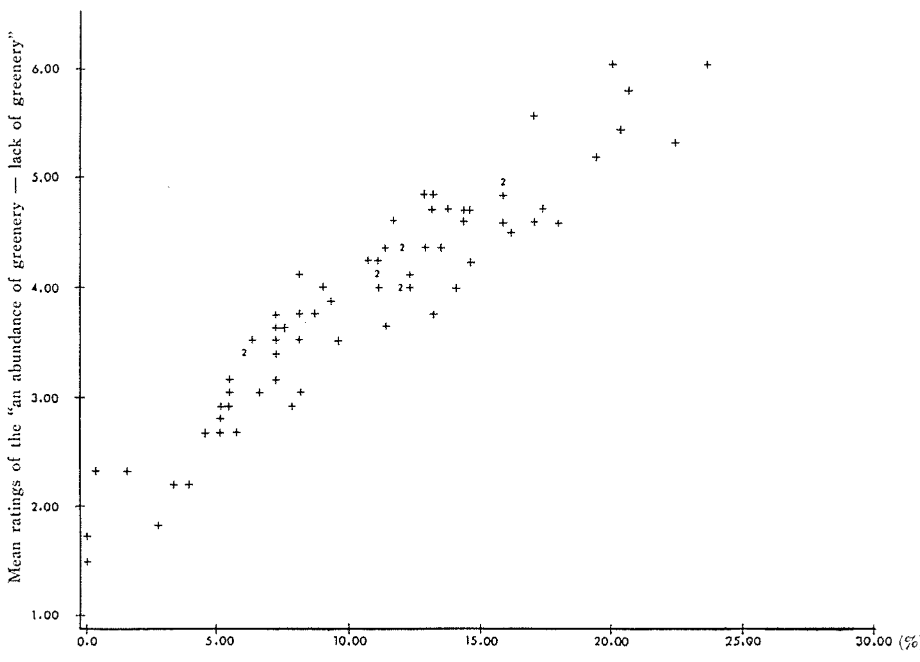

Figure 6. Relationship between vegetation covered ratios and ratings of the feeling of the greenery —the photographs of the scale-models—.

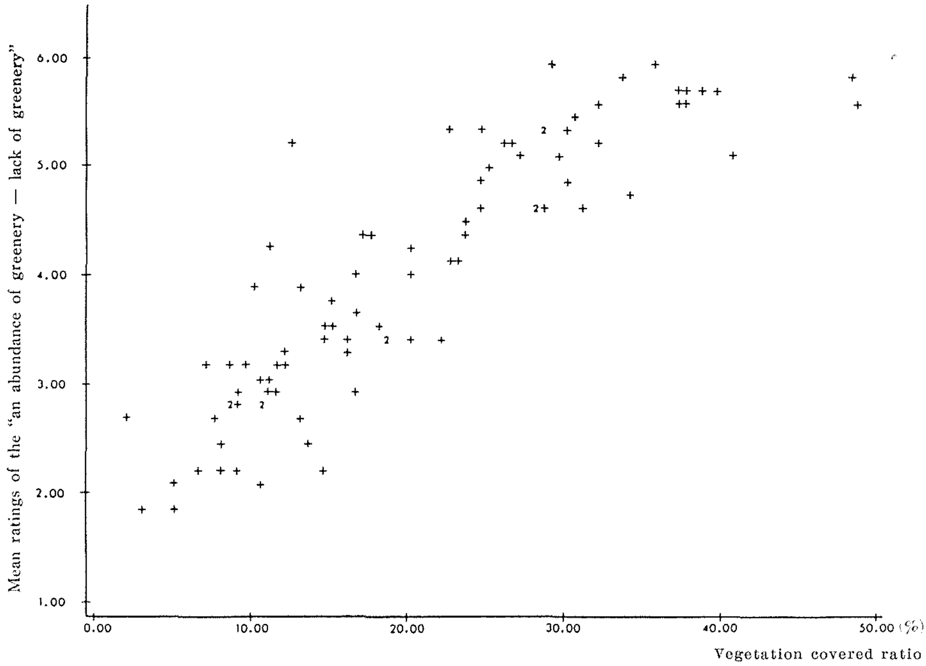

Figure 7. Relationship between vegetation covered area ratios and ratings of the feeling of the greenery —the photographs of real streets—.

If the mean ratings of the "good residential area — bad residential area" category are used as the dependent variable and the visual greenery ratios (%) are used as the independent variable, the regression equations are as follows ;

(Based on the color slides of the models)

$$Y = 0.111X + 2.904 \qquad R^2 = 0.80 \tag{3}$$

(Based on the color slides of the real streets)

$$Y = 0.065X + 2.811 \qquad R^2 = 0.61 \tag{4}$$

If the mean ratings of the "good residential area — bad residential area" category are used as the dependent variable and the mean ratings of the "an abundance of greenery — lack of greenery" category are used as the independent variable, the regression equations are as follows ;

(Based on the color slides of the models)

$$Y = 0.604X + 1.724 \qquad R^2 = 0.82 \tag{5}$$

(Based on the color slides of the real streets)

$$Y = 0.667X + 1.450 \qquad R^2 = 0.81 \tag{6}$$

The results showed that there was not all that much difference between equation (5) and (6). This means that both effects of the feeling of subjects about greenery in the assessments of residential street scenes are quite similar.

Comparing equations (1) and (2), and equations (3) and (4), sharper increases of the ratings according to the increase of the visual greenery ratios were found in the case of the models than in the case of the real streets. Although the reason is not quite clear, it seems to be due to the simple features of the models. In other words, the simplicity may make clear the effects of the greenery. Furthermore, we can suggest that because street trees, hedges and trees in housing lots were arranged in an orderly manner in the models, the effects of them on the ratings may be greater. The influence of the narrow view angle (about 41°) and circular form of photograph of the "borescope" on the result is not clear.

Using equation (1) and (2), if we want to obtain 5 points in rating the "an abundance of greenery — lack of greenery" category a 17% visual greenery for the photographs of the models and a 30% visual greenery ratio for the photographs of the real streets, would be needed. Similarly, if we wish to obtain 5 points in rating the evaluation of residential areas, 19% and 34% visual greenery ratios respectively for the two types of photographs would be needed.

Some previous papers have indicated that about 15-20% visual greenery ratio is required as a green minimum and about 25-30% is needed as a realistic goal.[8,13,18,21,25,29] In this study, the results based on the real street scenes resemble these results. Contrary to them, however, the results based on the models are about half. As mentioned above, if we can suggest that the difference is due to the orderliness of good landscaping, both results from the models and the real streets are acceptable. Although more detailed studies are needed to clarify the difference, we can suggest that about 10-20% is necessary as a visual greenery minimum and about 20-30% is necessary as a realistic goal.

In this study, the linear regression were most suitable. However, it should be noted that when the visual greenery ratios were over 40%, although it was not so clear, a decline of non-linearities was indicated by the scatter plots. Thus as a few previous papers have suggested,[18] if we examine a wider range of visual greenery ratios, non-linear equations such as logarithmic ones may be better suited.

Effects of Visual Greenery Types on the Assessments

Some studies have developed prediction models for the scenic quality of urban landscape, using physical characteristics of the landscapes.[1,4,7,8,12,16,18,22] As the physical characteristics, most of these studies included the following ratios of the photographs: area of sky, area of street surface, area of buildings and area of vegetation. And some of these studies have used more detailed features of the vegetation. Most of these studies showed the positive effects of amount and degree of vegetation and natural elements. Conversely, man-made elements have negative effects.

Although the object of these studies except in one case, have not been restricted within residential street scene, based on these previous studies, we chose some physical characteristics mainly some vegetation types or planting positions. These variables and sub-categories are shown in Tables 4 and 5.

Using the Quantification Theory 1 developed by Hayashi,[10] we examined the effects of these variables on the assessments of the subjects of the residential street scenes with the aim of clarifying them. The method seems to show the explanatory power of these variables and the contributions of each variable. With this method, the maximum difference among the sub-category coefficients for each variable or partial correlation indicates the contributive power of each variable. The multiple correlation coefficients indicate the reliability of the prediction. The scores on which these analyses depend were the mean scores or classifications for each of the characteristics of the photographs.

Firstly, the mean ratings of the "an abundance of greenery — lack of greenery" category was used as the outsider criterion. As the partial correlations in Tables 2 and 3 show the trees in housing lot category has the greatest influence on the rating of the feeling of greenery in the models and in the real streets. It is not strange, because the amount of greenery on housing lots was the greatest and had the widest range of these variables. If we examine, the sub-categories of the trees in housing lots, based on the real streets continuance high trees are the most effective. In a similar way, we can examine the importance of some vegetation types (Tables 4 and 5).

It is noteworthy that partial correlations of the street tree category, the fence of hedge category and the background category based on the models are relatively higher than those of the real street scenes. We can suggest that the reason is due to the sytematic selection of photographs of the model. Conversely, it was difficult to take many types of photographs in the real streets. For example, in Japanese cities, generally speaking, street trees are planted only in streets with wide sidewalks (over or equal 2.5 meters), thus street trees are not planted in a great proportion of streets in residential areas. Thus, we can point out that the usefulness of model simulation is shown by this result.

Meanwhile, ground cover vegetation which was mainly weeds has a relatively weak effect on the feeling of the subjects about greenery. Furthermore, it is noteworthy that in both experiments a relatively high partial correlation of the background category was present in which greenery ratios were very small. The result means that "eye-stop" greenery at focal points ("trees" in the real streets and "hill" in the models) are important.

On the same Table, we show the result of using mean ratings of the "good residential area — bad residential area" category as the ouside criterion. Roughly speaking, the partial correlation and sub-category weight of each variable is similar to the case of the "an abundance of greenery — lack of greenery" category. But we can find some difference in detail. For example in the case of the real street scenes, the street tree category has a relatively stronger effect on the total assessment than on the feeling of the subjects about greenery. These results mean that the differences are due to the difference of effects of the variables on the total assessment and on the feelings of greenery. And the reason for lower multiple correlations of the total assessments is due to the complexity of the total assessment. In other words, many variables are related to the total assessment than to the feelings of greenery. Meanwhile because the model was so simple, the

Table 2. Partial correlations of the variables of the scale-models according to the Quantification Theory 1 analysis

Variable	The feeling of greenery	The total assessment
Telephone pole	.145	.132
Street tree	.644	.540
Fence or hedge	.779	.760
Trees in housing lot	.872	.798
Background	.553	.470
R	.923	.889

Table 3. Partial correlations of the variables of the real streets according to the Quantification Theory 1 analysis

Variable	The feeling of greenery	The total assessment
Street tree	.277	.439
Fence or hedge	.315	.384
Trees in housing lot	.785	.665
Background*	.317	.353
Ground cover vegetation	.177	.301
Width of street surface**	.187	.160
Area of sky in photo	.374	.235
R	.902	.857

* Background means focal point of the street.
** Relative measurement by width of the photographs.

Table 4. Weight scores of each sub-category of the scale-model scenes according to the Quautification Theory 1 analysis

Variable	Sub-category	Number	The feeling of greenery	The total assessment
Telephone pole:	presence	48	−.043	−.029
	absence	27	.076	.052
Street tree:	presence	31	.403	.243
	absence	44	−.284	−.171
Fence or hedge:	hedge	24	.651	.503
	concrete block fence	24	−.520	−.348
	neither hedge nor fence	27	−.116	−.138
Trees in housing lot:	low tree	23	.103	.142
	high tree	23	.879	.474
	absence	29	−.778	−.488
Background:	hill	28	.223	.188
	hill and building	19	.156	.003
	absence	28	−.329	−.190

Table 5. Weight of each sub category of the model-scale scene according to the Quantification Theory 1 analysis

Variable	Sub-category	Number	The feeling of greenery	The total
Street tree:	presence	11	.667	.769
	absence	79	−.093	−.106
Fence or hedge:	hedges (prominent)	7	.625	.702
	block fences (prominent)	19	.018	.132
	hedges and block fences	11	.264	.238
	neither fences nor hedges	24	−.089	−.116
	the others	29	−.189	−.250
Trees in housing lot:	continuous low trees	8	.118	.074
	continuous high trees	12	1.260	.815
	scattered low trees	21	−.989	−.565
	scattered high trees	7	.367	−0.27
	continuous high and low trees	20	.775	.574
	scattered high and low trees	12	−.443	−.397
	absence	10	−.805	−.505
Background:	absence	40	.074	.072
	hill (not prominent)	12	−.153	−.253
	hill (prominent)	7	−.199	−.005
	buildings	21	−.171	−.165
	trees	10	.386	.364
Width of street surface:	narrow	27	.012	−.147
	medium	50	.090	.155
	wide	13	−.370	−.292
Ground cover vegetation:	presence	47	.110	.080
	absence	43	−.120	−.088
Area of sky in photo:	0-under 8%*	(1)	(−.091)	(−.766)
	8–16	16	.132	.004
	16–24	32	.224	.049
	24–32	32	−.319	−.085
	32 and over	9	.112	.204

* Sample is too small.

difference is not so clear.

Although, the proportion of sky in the photographs had a strong effect on preference of people or assessment in some previous papers,[12,18] the effect was not so clear in this study. The reason may be due to the photographs themselves which were taken in mainly individual housing areas.

The low effect of the ground cover vegetation may be due to the subjects' feeling that the street or housing lots with weeds were not well-kept. In this context, Nasar (1983)[20] reported that "well-kept vegetation" was one of important variables for preference of street scenes.

4. Summary and Conclusion

In summary, based on the color slides of the real streets our present study indicated that a visual green minimum for residential streets was about 20% and as an attainable goal, 30% was necessary. But the result based on the color slides of scale-model indicate that each standards was about half of these figures. Although the reason is not so clear, the ordered green arangement of street trees hedges, well-kept greenery and good spacious lots that are attributed in the models may be related to the differences. It is noteworthy that remote greenery which can provide the "eye-stop" effect is important.

We can point out that these results are useful for planning and landscaping of residential areas. Although further studies are needed to develop simulation method techniques, we can show the usefulness of scale-models for this purpose.

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