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DIFFERENT EFFECTS OF CERTAIN KINDS OF GREENERY ON THE ASSESSMENTS BY PEOPLE IN URBAN RESIDENTIAL AREAS

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Introduction

The past decade has seen a growth in the research related to urban greenery in Japan because of the increasing demand of citizens. One of the predominant concerns of these works has been to examine the relationship between the satisfaction of residents with greenery and quantity of greenery.

Some studies have showed the importance of tree-covered area[1,2,3], vegetation-covered area[4], natural surface[5] and open space area per capita[6]. Furthermore, a few papers indicated the different effect of the tree-covered area, grass-covered area and other greenery from some functional viewpoints[7,8]. For example, a lower effect of grass-covered ratio on satisfaction with greenery and on many functional assessments than the effect of the tree-covered ratio except for a few functional assessments was found.

Certain other papers showed that some kinds of greenery which were clasified according to land use where greenery exist are more effective for the satisfaction of people than others[9,10,11,12]. For example Aoki showed the importance of greenery in housing lots, greenery in parks and street trees[9] and he proposed an estimation method[13]. And also Hirano[14] tried to evaluate greenery environment using the different effect of land use.

However, a closer relationship between visual greenery and satisfaction of people has been suggested[11,15,16], but the measurement is difficult and the method is not confirmed and it is difficult to use the indices to evaluate many functions of greenery and green spaces.

Although these studies are usefull, work in this area is insufficent and there have been few studies which tried to combine many indices. We examined the importance of some indices in detail which were measured on a plane using aerial photos and attempted to find simple and effective indices for greenery planning in urban residential areas.

Method

Three questionnare surveys were analysed. The first one was carried out in August 1979 in fifteen typical residential areas in Sapporo. The size of each study area, which is surrounded by main streets or some other natural boundaries, covers an area of about 300 m × 300 m. About 200 samples of households in each area were drawn from a map which shows each family name and the location of each home. The effective responses were 2345.

The second one was carried out in August 1981 in the other fifteen residential areas in Sapporo. Although the survey method was similar to the first one, the survey areas were chosen with varying distances from three neighborhood parks. The effective responses were 2622.

The third survey was done from September to October in 1980 in five typical residential areas in Hirosaki. This city was selected for comparison with Sapporo, it is located in a snowy area such as Sapporo, but is different in its historical and cultural background. The efficent response was 908.

Some results of these surveys were reported in a previous paper[17].

In the questionnaire surveys, residents were asked to rate their satisfaction with greenery in their neighborhood on a five point scale; extremely satisfied, satisfied, neutral, unsatisfied, and extremely unsatisfied, and also asked to assess the functionality of their neighborhood open spaces on a scale of five: extremely good, good, neutral, bad, and extremely bad. At the same time the residents were asked to rate the quantities of greenery on a scale of six: extrmely abundant, abundant, neutral, sparse, deficient, and no greenery.

Using aerial photos taken in 1976 and 1981, the amount of the following greenery in the thirty survey areas of the first and second questionnare surveys was measured respectively.

The following signs were used to save space.

(1) Satisfaction with greenery

SGN; Satisfaction with neighghorhood greenery

PSGN; Percentage of people who responded saying that they were satisfied with neighborhood greenery

SGO; Satisfaction with overall greenery

PSON; Percentage of people who responded saying that they were satisfied with overall greenery

(2) Functional assessment of open spaces by residents

FARS; Resting or strolling

FAOE; Outside exercises

FAPL; Children's play ground

FANA; Contact with nature

FALA; Improves landscape

FASA ; Protection from fire or safety spaces
FAAI ; Air purification

(3) Perceived quantity of greenery
FGH ; Feeling of greenery in housing lots
FGS ; Feeling of greenery in streets
FGP ; Feeling of greenery in parks
FGF ; Feeling of greenery at certain sites of some facilities
FGV ; Feeling of greenery in vacant lots under development
FGN ; Feeling of greenery in natural spaces (e. g., hills or mountains which can be seen from their living areas, forest vegetations etc.)

(4) Physical attributes of survey areas in Sapporo
PHS ; Housing lot ratio of each survey area (%)
PPS ; Park space ratio of each survey area (%)
PFS ; Facility site ratio of each survey area (%)
POS ; The other site ratio of each survey area (%), (e. g., vacant land, natural spaces etc.)
PHV ; Coverage of housing lot vegetation (%)
PST ; Street tree crown coverage (%)
PPV ; Coverage of park vegetation (%)
PFV ; Coverage of facility sites vegetation (%)
POV ; Coverage of vegetation in the other sites (%)

Results and Discussion

1. Effects of the perceived quantity of greenery

Using data of individual respondents, we examined the relationships between the two scales of satisfaction with greenery (SGN, SGO) and the seven functional assessments (FARS, FAOE, FAPL, FANA, FALA, FASA, FAAI) and the cognition of quantity of greenery (FGH, FGS, FGP, FGF, FGV, FGN). Table 1 shows the standadized coefficients of the multiple regression analysis by the step wise method.

If we compare the differences of the three surveys, many higher R^2s were found in the first survey. This may be due to the fact that the survey areas of it were selected to include a large variety of greenery. These reasons for some different effects among the kinds of greenery by the three surveys, may be the same. For example, higher coefficents of FGN of the first survey in most cases may depend on including some survey areas with many natural areas or located next to mountains.

In spite of these differences, we can find some common results in the three surveys and the results show that different effects of the classified greenery on the satisfaction which people feel with greenery and the functional assessments. Namely, FGH had the greatest effects on SGO, and FGH and FGP had great

TABLE 1. Effects of the kinds of perceived greenery on the satisfaction with greenery and the functional assessments of greenery based on data of individual respondents

Satisfaction & assessment		Perceived greenery FGH	FGS	FGP	FGF	FGV	FGN	R^2
SGN	Survey 1	.27	.14	.21	.09	—	.16	.39
	Survey 2	.19	.14	.27	.06	—	.06	.27
	Survey 3	.33	—	.15	.10	—	.09	.21
SGO	Survey 1	.37	.11	.14	.08	—	.18	.41
	Survey 2	.32	.12	.17	.05	—	.09	.28
	Survey 3	.43	—	.15	—	—	.10	.27
FARS	Survey 1	.13	.08	.37	.05	—	.30	.50
	Survey 2	.11	.08	.32	.08	.08	.16	.31
	Survey 3	.17	.13	.31	—	—	.17	.28
FAOE	Survey 1	—	.10	.37	.06	—	.18	.32
	Survey 2	.10	—	.27	.05	.12	.09	.20
	Survey 3	.11	.18	.29	—	—	.17	.26
FAPL	Survey 1	.14	—	.43	.04	—	.15	.37
	Survey 2	.12	—	.36	—	.11	.05	.24
	Survey 3	.13	.20	.28	—	.18	—	.27
FANA	Survey 1	.16	—	.28	.04	—	.43	.50
	Survey 2	.10	.08	.22	.07	.10	.27	.32
	Survey 3	.22	—	.29	—	—	.21	.24
FALA	Survey 1	.15	.09	.27	—	—	.42	.50
	Survey 2	.14	.10	.19	.09	.08	.26	.33
	Survey 3	.22	.18	.30	—	—	.17	.34
FASA	Survey 1	.12	—	.24	.06	.06	.22	.27
	Survey 2	.08	.08	.23	.06	.10	—	.15
	Survey 3	.17	—	.21	—	.09	.12	.16
FAAI	Survey 1	.19	.07	.23	—	.09	.34	.45
	Survey 2	.14	.09	.18	.10	.14	.18	.29
	Survey 3	.20	.17	.26	.08	—	.19	.30

Standardized regression coefficients with significant level at $p<.05$.

effect on SGN. In this case, the relatively lower effect of FGH on SGN than on SGO is suggested that some respondents excluded their own gardens when they rate the SGN[17].

Meanwhile, FGP had the greatest effect on the assessments of FARS, FAOE, FAPL and FASA which were assessed based on behavioral use of spaces. Without the third survey, FGN had the greatest effect on the assessment of landscape and natural environment (FALA and FANA) and the 2nd most important variable was FGP. For, FGP or FGN had the largest effect on FAAI. The reasons for the relatively low effect of FGS, and low coefficent of FGF and FGV may be different respectively. In other words, we can find enough street trees only in a few survey areas, and kinds of facilities in FGF were different according

to the survey areas (some might be effective and some not) and this variable had significant relation to FGH. A large part of the greenery in FGV might be weed which people do not have a good image of.

Next, using means of the individual data of the survey areas of the surveys 1 and 2, we examined the same relationships. As shown in Table 2, higher R^2s. relatively higher coefficents and clear relationships which were similar to the results mentioned previously were found because of excluding individual errors.

From these results, it is noteworthy that parks are very important in many functional points, and the natural greenery in and around the neighborhood is important from the landscaping view point.

TABLE 2. *Effects of the kinds of perceived greenery on the satisfaction with greenery and the functional assessments based on the survey areas*

Satisfaction & assessment	Perceived greenery FGH	FGS	FGP	FGF	FGV	FGN	R^2
SGN	.27 (.77)	.21 (.67)	.41 (.88)	— (.78)	— (.25)	.25 (.81)	.91
SGO	.47 (.86)	.15 (.63)	.32 (.84)	— (.72)	— (.29)	.22 (.82)	.94
FARS	— (.65)	— (.59)	.70 (.94)	— (.74)	— (.27)	.32 (.84)	.92
FAOE	−.40 (.21)	— (.48)	1.10 (.88)	— (.55)	— (.11)	— (.53)	.88
FAPL	— (.51)	— (.43)	1.15 (.91)	−.31 (.56)	— (.34)	— (.68)	.88
FANA	— (.70)	— (.47)	.36 (.85)	— (.66)	— (.39)	.66 (.93)	.92
FALA	— (.68)	.12 (.51)	.26 (.86)	— (.69)	— (.29)	.70 (.94)	.94
FASA	— (.54)	— (.50)	.86 (.86)	— (.62)	— (.28)	— (.70)	.74
FAAI	.26 (.78)	— (.44)	.30 (.81)	— (.63)	.18 (.50)	.43 (.90)	.92

Standardized regression coefficients with significant level at $p<.05$. Each ( )shows a simple correlation coefficient.

2. Relationship between the perceived greenery and physical attributes of sites

If we examined the relationships between the perceived greenery and space features in each land uses, using Pearson's correlation coefficients (Table 3), the following results were found.

TABLE 3. Correlation coefficients between the perceived greenery and space features in each land use

Perceived greenery	Space features* Tree	Grass	Bare	Tree & grass	Space**
FGH	.51	.58	−.61	.70	.48
FGS	.76	—	—	—	—
FGP	.44	.34	.29	.41	.41
FGF	−.15	.09	−.23	−.02	−.19
FGV	.40	.83	.12	.81	.77
FGN	.42	.35	.11	.38	.37

* The features were measured according to corresponded land use as the percentage of each survey area. For example, .51 was calculated between FGH and tree- covered ratio which was measured as a divided total tree -covered area in all housing lots in respective survey areas.

** Ratio of total space of each land use in a survey area. For example, the ratio of public park space was compared to the total space of the survey area.

(1) The ratios of tree-covered and grass-covered areas in the total housing lots of each survey area had relatively great positive effect on the FGH. Both coefficients had almost the same values, thus we can suggest that both types of greenery are important.
(2) The street tree-covered ratio of the survey area was very small in most survey areas except for a few areas due to the fact that street trees are planted only in streets with wide sidewalks, but the ratio had a high correlation with FGS. This may be due to the one or two survey areas which have an abundance of street trees.
(3) Althought the coefficients were not so high, the tree-covered and grass-covered ratios had a positive effect on the FGP.
(4) The tree-covered and grass-covered ratios of the facility sites did not have any significant effect on the perceived greenery (FGF).
(5) Although tree-covered ratio in vacant land did not have a significant effect, grass-covered ratio had a great influence on FGV.

Furthermore, as shown in the same table, if we add the tree-covered ratio and grass-covered ratio, the variable (vegetation-covered ratio) had higher correlation coefficient in the case of FGH.

TABLE 4. Effects of physical greenery attributes on the satisfacton with greenery and the functional assessments

Satisfaction & assessment	Physical greenery attributes PHV	PST	PPV	PFV	POV	Constant	R^2
SGN	.021 (.46)	.368 (.43)	.054 (.43)	—	.024 (.44)	2.514	.52
SGO	.024 (.53)	.304 (.36)	.047 (.37)	—	.024 (.43)	2.289	.51
FARS	.021 (.32)	.469 (.38)	.086 (.47)	—	.034 (.41)	1.982	.43
FANA	.021* (.31)	.371* (.30)	.056* (.31)	—	.040 (.49)	1.842	.35
FALA	—	.444 (.34)	—	—	.036* (.42)	2.155	.19
FAAI	.025 (.40)	.327* (.29)	.053 (.32)	—	.042 (.57)	1.439	.46

Regression coefficients with significant level at $p<.05$ except *($p<.10$).
( ): Standardized coefficients.

TABLE 5. Effects of physical attributes of greenery on a few functional assessments

Assessment	Physical attributes PHS	PST	PPS	PFS	POS	Constant	R^2
FAOE	.016* (.26)	.286* (.26)	.091 (.74)	—	—	1.817	.54
FAPL	.026 (.49)	—	.084 (.77)	—	.077 (.30)	1.912	.53
FASA	.017 (.37)	.230* (.27)	.067 (.69)	—	.020 (.39)	2.130	.46

Regression coefficients with significant level at $p<.05$ except *($p<.10$).
( ): Standardized coefficients.

3. Effect of the physical attributes on the satifaction with greenery and the functional assessmets

Based on the previous results, we examied the effect of the vegetation-covered ratios (PHV, PPV, PFV, POV), site space ratios (PHS,PPS, PFS, POS) and street tree crown coverage (PST) on the satisfaction scales and the assessments as independent variables of regression analysis.

Except for three functional assessments shown in Table 5, all the models accounted for more variance in the case of using the vegetation covered ratios. As shown in Tables 4 and 5, PST has the largest regression coefficient in all cases

except FAPL. And in many cases PPV has great influence. Although, this means that PST per unit has a great effect on the satisfaction scales and assessments, and planting street trees is effective for them, it is not so stable because the variances thereof were relatively large. If we compare the standardized coefficients, the highest value was PHV in the cases of SGN and SGO ; PPV in the case of FARS ; PPS in the cases of FAOE, FAPL and FASA ; POV in the cases of FANA, FALA and FAAI. Furthermore the effect of PFV was not significant in all cases and PHV was not significant in the cases of FALA. The models in Table 5 show the importance of space itself, especially public park space.

Although a large part of these results corresponded to the results mentioned earlier using perceived greenery, it is worthy of note that the relatively higher coefficient of PST in many cases and POV in some assessments which did not have enough effects in the models using perceived greenery were found. The former reason may be due to a strong effect of a few survey areas which were mentioned earlier. Although, the latter reason is not so clear, it is interesting that FGV did not have a significant effect on the satisfaction scales and the functional assessments because of bad image of "vacant land", but people evaluated POV in which are included much of the greenery in vacant land.

Although, the variance accounted for in most models were not so large, those in the models of SGN and SGO are near to the ratio which Anderson and Schroeder[18] pointed out (physical attributes in the survey areas account for 50-60% of the total variance in many cases).

Using Tables 4 and 5, we can show the relative importance of some kinds of greenery. If we know to what extent each kind of space can be used for greening in a planning area, we can make greening plans effectively.

In a previous paper[2], we showed the importance of tree-covered ratio and building coverage (or non built-up area ratio) for predicting people's satisfaction with greenery. Thus we examined these effects and the effect of grass-covered ratio based on the data of thirty survey areas.

As shown in Table 6, all models except FAOE and FAPL accounted for a larger variance than that of the models in Table 4 and 5. It is suggested that the best or second good predictors of all except FAOE and FASA were building coverage and tree-covered ratio. But the tree-covered ratio did not have a positive effect on FAPL. From these results, we can point out that building coverage which had a negative effect is very important to predict the satisfaction with greenery and the assessments. As the R^2 of FAOE in this case was too small, PPS or PPV instead of the tree-covered ratio is necessary.

If we examined the grass-covered ratio, we could not find a significant effect in all cases except FAOE and FASA and we found a minus effect in these cases. The reason may be due to relatively high correlation to the building coverage and the ratio that included weeds showed as image of bad maintenance. Because of

TABLE 6. Effects of the tree-covered and grass-covered ratios on the satisfaction with greenery and the functional assessments

Satisfaction & assessment	Building coverage (%)	Tree-covered ratio (%)	Grass-covered ratio (%)	Constant	R^2
SGN	−.030 (−.50)	.031 (.49)	—	3.850	.64
SGO	−.031 (−.52)	.032 (.50)	—	3.651	.68
FARS	−.044 (−.50)	.360 (.39)	—	3.832	.52
FAOE	−.088 (−1.15)	—	−.043 (−.87)	6.145	.34
FAPL	−.082 (−1.21)	−.031 (−.70)	—	6.128	.48
FANA	−.046 (−.52)	.032 (.34)	—	3.693	.49
FALA	−.042 (−.47)	.039 (.40)	—	3.218	.49
FASA	−.074 (−1.24)	—	−.027 (−.71)	5.816	.53
FAAI	−.048 (−.60)	.031 (.36)	—	3.426	.62
PSGN	−1.212 (−.52)	1.114 (.44)	—	80.544	.60
PSGO	−1.179 (−.52)	1.198 (.49)		69.551	.68

Regression coefficients with significant level at $p<.05$.
Each( )shows a standardized coefficient.

lower R^2s of FAOE, FAPL, FANA and FALA, it is necessary to find more effective variables. For example if we use the building coverage and PPV, higher R^2 will be found.

As mentioned earlier, the higher regression coefficents of the perceived greenery variables as compared with the physical attributes showed that it is important to study how people recognize greenery from the view points of human behavior and cognition[19,20]. Especially it is necessary to find new physical variables which indicate the FGP and FGN better than PPS and PFV. For example, we can get better variables if we include outside greenery (e. g., hill, mountain, parks etc.) which should be weighted by distance and quality of greenery as well as quantity.

To compare, we show two models using satisfaction ratios of residents as dependent variable in the same Table. Although the model is similar to the model in a previous paper, the effect of bulding coverage is larger and if we caluculate

the tree-covered ratio which satisfies the same rate of residents at the same building coverage, smaller tree-covered area is needed than the previous model[2]. Although the reason is not so clear, because the site of the each survey area is small, as mentioned above the satisfaction ratios may be influenced by outside greenery of the survey area, especially, greenery in parks and natural spaces.

If the models are improved, we can set greenery planning standards in detail correspond to satisfaction with greenery of people and some models related to the amenity of neighborhood may be used as one of the methods to set the planning standards for amenity. Meanwhile standards of the other green space function, for example "protection from fire or safety space" and "air purification" should be mesured by the other objective methods instead of the assessment by people, but the results of this study which showed what types of greenery residents recognize and evaluate are usefull for effective planning. Improving the models by further studies, we can evaluate many sides of the greenery environment of residential areas.

Summary

To examine the effects of some kinds of greenery on the scales of satisfaction of people with greenery and the functional assessments of green spaces, the questionnare surveys and the physical attributes of the survey areas were analysed. The examination concentrated on the following relationships; 1) between ratings of the satisfaction scales and the functional assessments, and amounts of greenery which residents feel. 2) between ratings of the satisfaction scales and the functional assessments, and some indices which show the physical attributes.

Multiple regression analysis of the first case showed that park greenery and greenery in housing lots had a great effect on the overall satisfaction with greeney. The park greenery had the largest effect on some functional assessments (resting or strolling, outside exercises, children's play ground and protection from fire or safety spaces), and the greenery in natural spaces had the largest effect on the other few functional assessments (contact with nature and improves landscape).

The second analysis showed that, in many cases, the models using building coverage and tree-covered ratio of the survey area accounted for a larger variance than the models using some indicess which measured different kinds of greenery. This result suggest that the two indices are important for greenery planning of residential areas and further studies are necessary to improve the measurements of the kinds of greenery.

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