Research article

Spatial Assessment of Cultural Ecosystem Services for Urban Forests based on a Multi-point Field Survey: Case in Nagoya City, Japan

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Abstract Urban forests including urban parks, secondary forests, and natural forests provide many benefits for citizens, such as recreational opportunities, scenic beauty, and cultural heritage value. Each has a different role in the provision of cultural ecosystem services (CESs) in a city. One issue with urban forests in Japan is the decrease of forests with the loss of CESs. The objective of this study was to develop a method to categorize the CESs of urban forests through multi-point field surveys as a case in Nagoya City, Japan. Then the equivalency and/or alternativeness of the forest CESs were examined. In total, 180 forests in the city were surveyed. The percentages of forests featuring aesthetic and daily recreation values were high. Using a hierarchical cluster analysis, the forests in the city were categorized into 9 types. Future issues include the idea that, in addition to CESs, other ESs should be considered as a part of a comprehensive ES assessment.

Keywords GIS, ecosystem service, cultural ecosystem service, forest, Japan

INTRODUCTION

Urban forests have many benefits for citizens, such as recreational opportunities, scenic beauty, and cultural heritage value. There are several types of forest: urban parks, secondary forests, natural forests, and more. Each has a different role in the provision of ecosystem services (ESs) (Millennium Ecosystem Assessment (MA), 2005). One issue with urban forests in Japan is their decrease over the past few decades due to the loss of forests. For example, in Nagoya, which is the third largest urban area in Japan, forest area has been decreasing. According to the Nagoya City government, the green coverage ratio of the city, including forests, grassland, agricultural land, and water bodies, was 22.0% in 2015 which was a decrease from 29.8% in 1990 (Nagoya City, 2015).

Cultural ESs (CESs) bring aesthetic value, recreation, education value, spiritual and religious values, inspiration, social relations, and cultural heritage value (MA, 2005). CESs are different from other ESs because they are assessed subjectively by individuals (Burkhard et al., 2012). Nahuelhual et al. (2013) summarized the approaches to the spatial mapping of CESs, such as recreation and ecotourism, into four types: visitors' expenditure; recreation areas; monetary benefits; and valuing by stakeholder assessment (Sieber, 2006; Sherrouse et al., 2011; van Riper et al., 2012; Hayashi et al., 2015). Nahuelhual et al. (2013) also developed a method to evaluate CESs using maps. Then, plenty of scholars have conducted economic evaluations of CESs (Costanza et al., 1997). By providing a city-scale assessment, several papers explored ES spatial assessments, including the CESs provided by urban forests (Dobbs et al., 2014; McPhearson et al., 2013). However, the scope of the CES items was limited. So, comprehensive and detailed assessments of CESs are needed to understand their provision and usage on a city scale.

Then it will be possible to discuss the equivalency and alternativeness of the CESs provided by urban forests. This is the focus of this study.

OBJECTIVES

The objective of this study is to develop a method to categorize forest CESs from the perspective of their provision and usage using multi-point field surveys. Then the equivalency and/or alternativeness of the CESs will be examined. The case study focused on urban forests in Nagoya City, Japan.

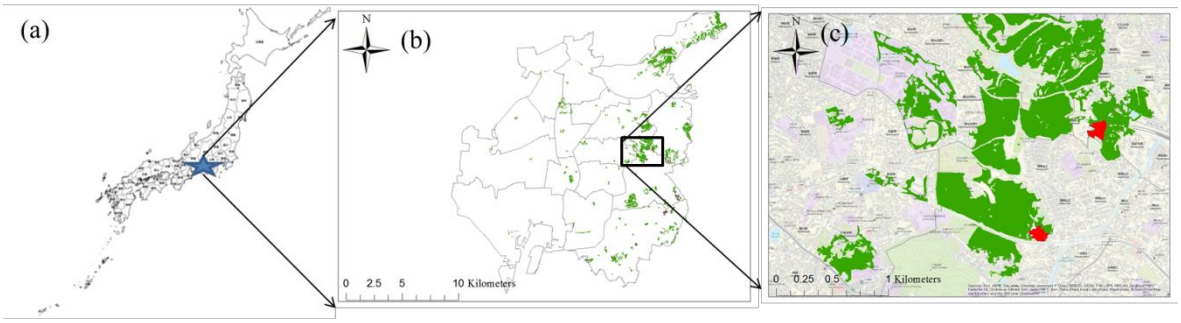

Fig. 1 Maps of the study area: (a) Japan with Nagoya City as a star symbol, (b) Nagoya City outlined in black with forests (≥1 ha) in green, (c) east-part of Nagoya City (as an example) with forests and bamboo forests in green and red, respectively

Source: Hayashi and Ooba (2015) and Hayashi (2017), forest and bamboo from Nagoya green coverage GIS provided by Nagoya City

METHODOLOGY

Nagoya City (city hall location: 35.181°N, 136.906°E) is the third largest city population-wise in Japan, with over 2 million residents. It is located in the geographical center of Japan (Fig. 1 (a)). The average annual temperature in 2015 was 16.6°C, and the average precipitation was 1803 mm (Japan Meteorological Agency, 2016). The city has an area of about 326 km^2 (Nagoya City, 2016b).

In this study, multi-point field surveys were employed to understand the provision and citizen usage of forest CESs. In the study, forests were defined as continuous tree crown areas with one ha or more of forest area. Based on the Nagoya green coverage geographic information system (GIS) data (provided by Nagoya City via personal communication), 180 forests (among around 240 total) with one ha or more of forest area were studied.

The field surveys were conducted in a similar style to Hayashi and Ooba (2015), which was as follows. First, one of the authors surveyed the entire forest area by foot. Then the forest usage of each CES was judged subjectively on the following five-point scale, tentatively: 1. "very frequently," 2. "frequently," 3. "sometimes," 4. "not so much," and 5. "rarely used," as well as "not enough information to make a decision," for both inside of the forest and the surrounding area. After conducting several visits to each forest site in various seasons from 2013 to 2016, the final scores were determined by the author subjectively with the opinions of field survey collaborators. The values were then put in the opposite order (e.g., 5. "very frequently" to 1. "rarely used") and then converting to 0 to 1 value. The CESs, which followed the categories of MA (2005) with some modifications, included in this study are listed in Table 1. However, based on several visits to each forest, "education value: school-related event," "inspiration," and "social relations: working or schooling in the forest" were slightly difficult to evaluate, so these items were excluded from the analysis. In total, 14 CES items (CES14) were used. Then seven new CES items were developed from the CES14 (Table 1). The maximum score of each CES14 value was selected for each CES7 value. Then, the following four data sets were used for the analysis: CES14 inside forest (CES14 in forest), CES14 inside forest with the surrounding area (CES14 in area), CES7 in forest, and CES7 in area. For example, let us imagine that there were children's play facilities in a park. If these were located inside a park forest, they would be classified as CES14 in forest and CES14 in area. However, if they were not inside a park forest but rather around the forest inside the park, they would be classified as only CES14 in area.

Table 1 CES14 and CES7 categories

CES14	Contents	CES7
subCES1	Aesthetic value	Aesthetic value (AE)
subCES2	Daily recreation: walking, etc.	Daily recreation (DRE)
subCES3	Daily recreation: play with children by play facilities	
subCES4	Daily recreation: play in forest (e.g. insect collecting)	
subCES5	Holiday recreation: holiday leisure, picnics, hiking, etc.	Holiday recreation (HRE)
subCES6	Holiday recreation: sports, etc.	
subCES7	Attraction facilities	Education value (ED)
*1	Education value: school-related event	-
subCES8	Education value: nature observation meetings/classes	Education value (ED)
subCES9	Spiritual value	Spiritual and religious values (SR)
*2	Inspiration	-
subCES10	Traditional festival	Spiritual and religious values (SR)
subCES11	Normal festival	Social relations (SO)
subCES12	Religious value	Spiritual and religious values (SR)
subCES13	Cultural heritage value	Cultural heritage value (CH)
*3	Social relations: working or schooling in the forest	-
subCES14	Social relations: volunteers	Social relations (SO)

*Note: *1, *2 and *3 were excluded.*

In addition, the basic parameters of the CESs were listed for each forest: "forest area," "in scenic districts designated by the city (S_D)" (Nagoya City, 2016a), "in shrine or temple (S_T)," and "in major attraction facilities listed by the city (A_F)" (Nagoya City, 2014).

Utilizing the CES14, statistical analyses including the Kolmogorov-Smirnov normality test and Spearman's Rank Correlation Coefficient among the CES14 items were conducted. Also, to investigate what percentage of Nagoya forest provided each CES, the total number of forests provided by each CES was summed up and divided by the total number of forests studied (N=180).

For the CES7 data sets, similar basic statistical analysis was conducted. Then, the differences among the CES7 in area items were tested with Friedman's test with pairwise comparisons. Also, a hierarchical cluster analysis (using Ward linkage) was conducted to categorize Nagoya City's forests into several types based on the CES7 in area with basic parameters: namely, forest area, S_D, S_T, and A_F after converting to the 0 to 1 scale.

Statistical analyses were conducted using SPSS ver. 22 (IBM). ArcGIS10.2.2 (ESRI) was used for GIS analyses.

RESULTS AND DISCUSSION

In total, 180 forests were studied. The total area of accumulated forest area studied was over 1,000 ha, which was around 30% of the total tree area in the city in 2015 (Nagoya City, 2015).

Table 2 Basic statistics for each subCES on a five-point scale

		subCES													
		1	2	3	4	5	6	7	8	9	10	11	12	13	14
CES14 in Forest	Mean	2.3	2.2	1.4	1.7	1.9	1.0	1.3	1.7	2.0	1.4	1.4	1.4	1.4	2.1
	Median	3	2	1	1	1	1	1	1	1	1	1	1	1	1
CES14 in Area	Mean	2.8	2.7	2.1	2.0	2.3	1.9	1.7	2.0	2.2	1.5	1.7	1.7	1.5	2.3
	Median	3	3	1	1	3	1	1	1	3	1	1	1	1	3

Table 2 shows the mean and median of each CES14 on a five-point scale for both the CES14 in forest and in area. SubCES1 (aesthetic value), subCES2 (daily recreation: walking, etc.), and

subCES5 (holiday recreation: holiday leisure, picnics, hiking, etc.) under CES14 in area showed relatively higher values than the other CESs.

Regarding the correlation coefficient among the CES14in area categories, subCES2-subCES3, subCES2-subCES9, subCES3-subCES4, and subCES7-subCES11 were relatively highly correlated, with coefficients over 0.7 (see Table 3).

Table 3 Correlation coefficients among CES14 in area

	subCES												
	2	3	4	5	6	7	8	9	10	11	12	13	14
subCES1	.623**	.514**	.454**	.685**	.252**	.491**	.616**	.625**	.185*	.532**	.076	.212**	.429**
subCES2		.737**	.667**	.540**	.428**	.171*	.575**	.741**	-.111	.261**	.093	-.060	.588**
subCES3			.888**	.466**	.572**	.077	.398**	.678**	-.104	.252**	.032	-.080	.416**
subCES4				.449**	.549**	.092	.429**	.616**	-.105	.272**	.009	-.066	.359**
subCES5					.265**	.478**	.550**	.596**	.016	.585**	-.094	.056	.554**
subCES6						.169*	.256**	.395**	-.254**	.253**	-.177*	-.161*	.127
subCES7							.386**	.315**	.152*	.720**	-.157*	.290**	.179*
subCES8								.660**	-.106	.454**	.002	.000	.549**
subCES9									-.115	.348**	.036	.057	.593**
subCES10										.129	.502**	.624**	-.096
subCES11											-.238**	.202**	.225**
subCES12												.376**	.033
subCES13													.029

*Note: statistical significance: **, <0.01; *, <0.05, N=180*

The results on the percentage of forest provided by each CES in area against the total number of forests are presented in Fig. 2. SubCES1 and subCES2 showed high percentages of nearly 80%. This means that nearly the 80% of the forests in Nagoya were used for subCES1 and subCES2 purposes. SubCES5, subCES9 and subCES14 were more than half. Conversely, the percentages of subCES7 (attraction facilities) and subCES10 (traditional festival) were relatively small, at around 20%. These kinds of CESs were found in a limited number of forests.

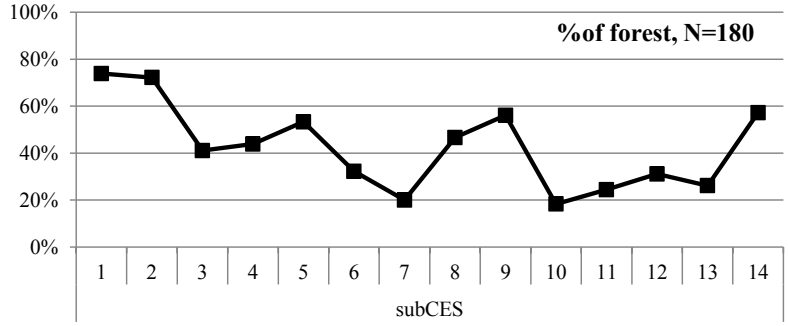

Fig. 2 Percentage of forests provided by each subCES in Nagoya

Regarding the analysis of the CES7 in area, the mean and median of each CES7 item are presented in Table 4. Here, the AE and DRE were high, but the CH was low. The results of Friedman's test showed that the differences among the several CES7 items were statistically significant, such as CH-ED and ED-HRE.

Table 4 Basic statistics for each CES7 on a five-point scale

		AE	DRE	HRE	ED	SR	CH	SO
CES7 in	Mean	2.8	2.8	2.6	2.3	2.7	1.5	2.6
Area	Median	3	3	3	2	3	1	3

*Note: Friedman's test with selected pairwise comparison; CH-ED:**, ED-SO: NS , ED-HRE:*, SO-SR: NS, HRE-SR: NS; SR-AE: NS, **, <0.01; *, <0.05, NS: not significant; N=180*

Table 5 Cluster analysis results for 9 forest categories (Using Ward linkage, total N=180)

	Category No and contents	N	Area(ha)
CES medium to high in S_D	1: in A_F	13	93
	2: in S_T	10	44
	3: other	43	529
CES low to medium	4: in S_T in S_D	15	44
	5: in S_T out side of S_D	12	24
	6: in S_D with low CESs	35	198
	7: outside of S_D, S_T and A_F with medium CESs	16	37
	8: outside of S_D, S_T and A_F with low to medium CESs	12	26
	9: outside of S_D, S_T and A_F with low CESs	24	41
Total		180	1,036

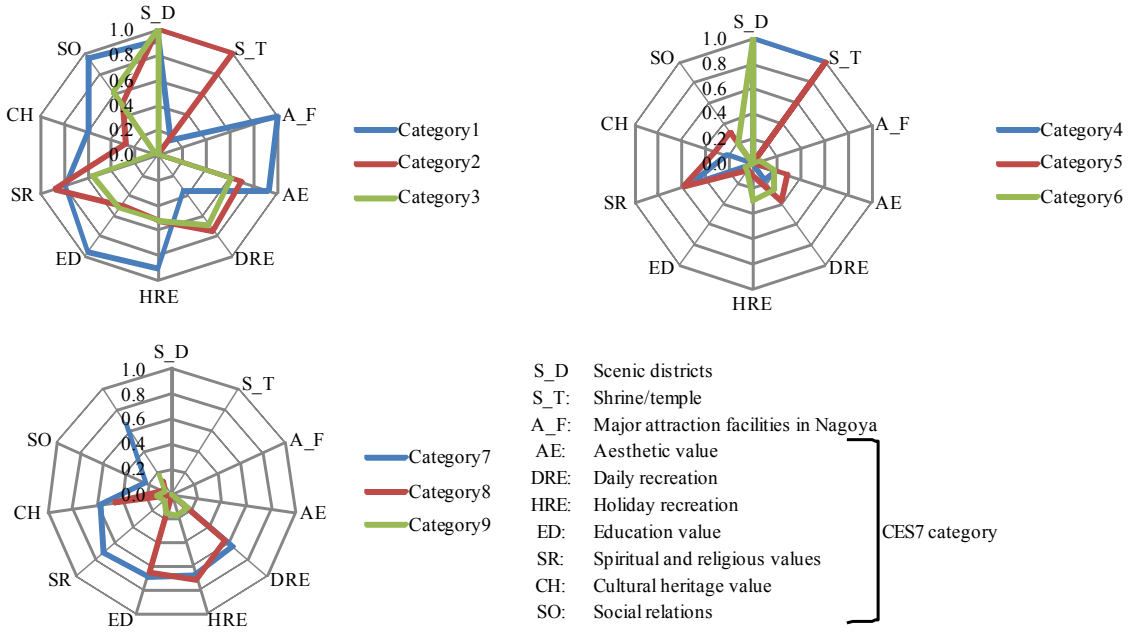

Fig. 3 Radar charts for each forest category after averaging values in each category

Using a hierarchical cluster analysis, we divided Nagoya's forests into 9 categories using the data sets of the CES7 in area with basic parameters. A basic description of the 9 categories can be found in Table 5, and the results of the radar charts for the categories are presented in Fig. 3. According to the results, the forests in category 1, including Atsuta Jingu shrine and Nagoya Castle, have relatively high values for most of the CES7 items within major attraction facilities (A_F), because these are major historical and cultural spots in Nagoya featuring nature areas. The forests, namely, Higashiyama Park, were also high in most of the CES7 items except for the CH, because a zoo and a botanical garden with nature areas can be found in these areas. Categories 2 showed relatively high values for most of the CES7 items in shrines or temples (S_T) including cemetery. The total number and area of forests in category 3 were 43 and 529 ha, respectively—higher than the other categories. On the other hand, categories 4 and 5 were located in shrines or temples (S_T) with low to medium CESs in which a lot of the natural forests were designated as conservation areas by the city or prefecture. The forests in category 9 were located outside of S_D, S_T, and A_F, with low CES7 items because they are located in a remote or low intervention area. So these are relatively low provisions for CES assessments.

Regarding the equivalency and/or alternativeness of the forest CESs, forests within the same category had similar roles in CES provision and usage by citizens, so their equivalency and/or alternativeness were relatively high. The number of forests in categories 1 and 2 with high CESs was small, so their alternativeness was relatively low.

An important point is that the forest category only included the CES contents and should be elaborated on; for example, the spatial distribution of the forest CESs and their future demands could be included. Also, the results were obtained by focusing on CES assessment without considering other ESs and habitats/species, except for basic parameters considered. Some forests were located in somewhat remote areas, even in a big city, so that there still remained natural forest with little human intervention. In this case, the use of cultural aspects of ESs were limited. These issues should be considered appropriately as part of a comprehensive ES assessment in the future.

CONCLUSION

In this study, based on multi-point field surveys, a method to categorize CESs was considered, taking into account their provision and usage as a case study in Nagoya City. Also, the equivalency and/or alternativeness of forests from the perspective of CESs were examined. The correlations among CESs were not very high, except among recreation values. The percentages of forests equipped with aesthetic and daily recreational values were high in the city. Via cluster analysis, the forests were categorized into 9 types by CES7 in area with forest area, S_D, S_T, and A_F. Then the equivalency and/or alternativeness of the forest CESs were discussed. This forest categorization could be used for a CES management planning and environmental assessment for development activities. Future issues include the fact that, in addition to CES assessment, other ESs and habitat/species assessment should be considered as part of a comprehensive ES assessment.

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