Distribution and structure of urban green spaces in Metro Manila

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ABSTRACT

We studied the distribution and structure of urban green spaces in Metro Manila, the Philippines, one of the most rapidly growing prime cities in Southeast Asia. Our field vegetation survey focused on the vertical structure and composition of species in urban green spaces.

We selected 35 sample sites from 6 different land use types: high-density residential, low-density residential, business and commercial, industrial, park and urban-rural mixture areas. We identified plant species and their heights at each sample site. In addition, we calculated the green cover ratio at each sample site from aerial photographs.

The results showed that the green cover ratios were high in low-density residential areas and parks, but low in high-density residential, business and commercial, industrial and urban-rural mixture areas. Species richness was marked in low-density residential areas, but poor in business and commercial and industrial areas. While, on average, trees were relatively tall in low-density residential areas, business and commercial areas and parks, the trees in high-density residential areas and urban-rural mixture areas were relatively short. We observed distinct differences in species composition, depending on the major use of the trees: fruit and ornamental species predominated in both types of residential areas; shade and ornamental species predominated in business and commercial areas and parks; and fruit species predominated in urban-rural mixture areas.

We consider that our results will be useful in future green space planning to improve the urban environment of Metro Manila.

Keywords : urban vegetation , urban green spaces, vegetation survey, species composition

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1. Introduction

In most prime cities of East and Southeast Asia, intense urban agglomeration has led to expansion of urbanized areas. In the course of this rapid urbanization, much of the existing green spaces inside and around cities are diminishing, thus contributing to serious environmental degradation. The establishment of efficient policies to promote the conservation and creation of urban green spaces through an understanding of the urbanization process is becoming an ever more urgent issue in the field of urban planning. In this context, we performed this study to determine the distribution and structure of urban green spaces in Metro Manila, the Philippines, one of the most rapidly growing prime cities in Southeast Asia.

In a previous study, we analyzed the relationships between urbanization and the distribution of urban green spaces in Metro Manila from satellite images and geographic information system (GIS) data (Murakami *et al.* 1999). We used a quantitative analysis of land use / cover mixture to categorize the distribution of green spaces. In the current study, we performed a field vegetation survey, focusing on vertical structure and species composition in order to gain a deeper understanding of the characteristics of urban green spaces.

2. Study Area

Metro Manila (officially called the National Capital Region, NCR), the capital of the Philippines, is located in the lowlands of south-western Luzon Island (Fig. 1). It stretches between Manila Bay and Laguna de Bay, and covers approximately 15 × 40 km. Three types of landforms are distributed around Metro Manila in a north-south direction: the eastern lowlands along Manila Bay, the central plateau and the western lowlands along the Marikina river basin and Laguna de Bay. Pasig River, the main water transportation route in Metro Manila, runs through these 3 landforms from east to west, to reach Manila Bay.

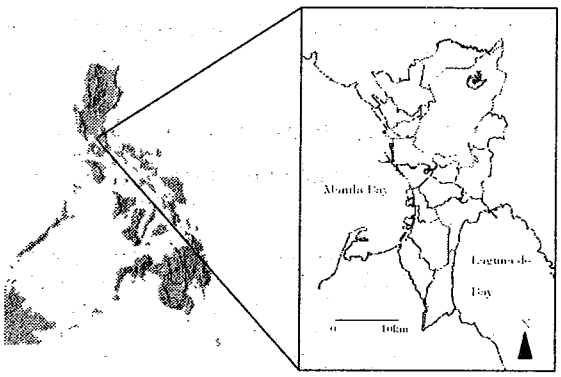

Fig. 1 Location of Metro Manila

Metro Manila consists of 8 contiguous cities, including the City of Manila, and 9 other municipalities. Although the total land area of Metro Manila is 638 km^2 and it occupies only 0.2% of the total national land area, a census showed that about 9.45 million, more than 13% of the national populace, was concentrated in this area in 1995. While the average annual population growth rate is only 3.3% in Metro Manila, there are some suburbs of Metro Manila and surrounding areas where rapid population growth and urbanization is occurring, with an average annual population growth rate of 5.0 %- 10.0 % (NSO 1996).

3. Study methods

(1) Selection of sample sites

With the aid of previously reported studies, such as that of Rowntree (1984), who examined the urban green cover of different land use types in entire cities, we analyzed the characteristics of urban green spaces in Metro Manila based on land use type. By overlaying the land use GIS data and the land cover data obtained from the land cover classification of satellite images, we calculated the average green cover pixel ratio for each major land use type (Table 1). We observed significant differences in green cover pixel ratio among land use types, indicating the importance of land use type as the major determinant of urban green space distribution in Metro Manila.

In order to select more detailed land use classification for examination, we used land use GIS data to calculate the land use composition of Metro Manila (Fig. 2). First, we selected residential areas, business and commercial areas and industrial areas as target land use types. Parks, which constitute important urban green spaces, were also included, and the residential areas were divided into high-density residential areas and low-density residential areas according to their population densities. For each of the 5 land use types described above, areas largely with homogeneous land use were selected as sample sites. In addition, considering the accessibility, we selected sample sites in urban-rural mixture areas where urbanization was in progress.

From the 6 land use types described above we selected 35 sample sites (Fig. 3); 8 sites in high-density residential areas; 7 in low-density residential areas; 5 in business and commercial areas; 5 in industrial areas; 5 in parks; 5 in urban-rural mixture areas located in different directions from the city center. (Cultivated agricultural land was found at 3 of the sites, but the agricultural land at the other 2 sites had already been abandoned and had become vacant land.)

Table 1 Relationship between land use type and green cover pixel ratio

Land Use Type	Green Cover Pixel Ratio (%)
Residential area	37.9
Business and commercial	23.2
Industrial area	27.7
Agricultural area	62.6
Forest	66.9

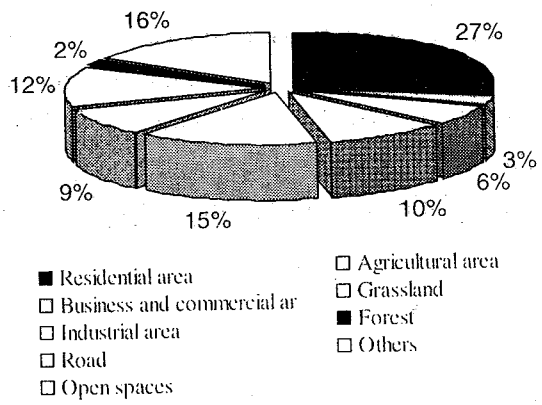

Fig. 2 Major land use types in Metro Manila

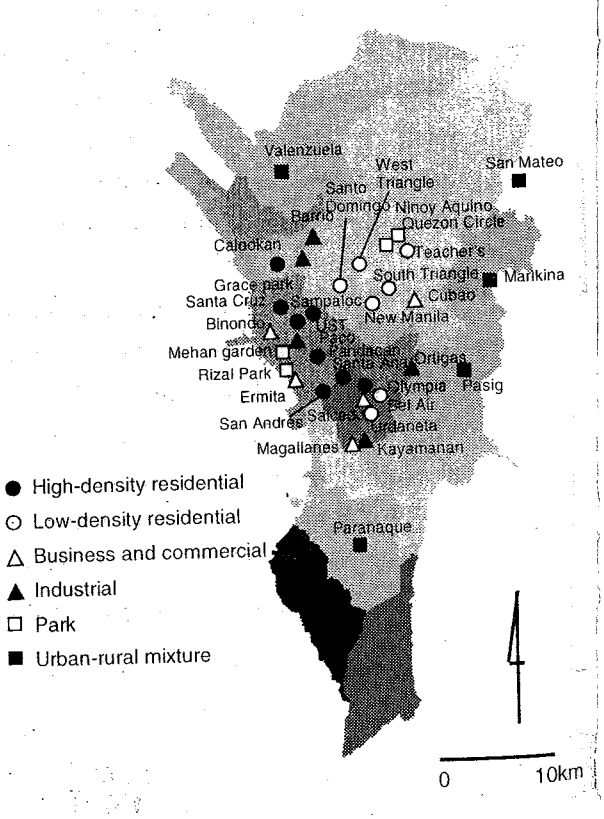

Fig. 3 Location of sample sites

(2) Field survey

The area of each sample site was fixed at a 250 × 250 m quadrat or its equivalent area; we considered that this was the smallest area that could be used while still excluding significant bias. For each sample site we identified the species and heights of trees 5.0 m or taller, as they could be observed from outside of the residential plots in Metro Manila. Shrubs 5.0 m or taller were included, but vines were excluded because of the difficulty in determining their heights. Bamboos were also excluded because it was difficult to identify them. Tree heights were estimated to the closest 0.5 m with a measuring pole. The field survey was conducted between August and November 1999, and between February and March 2000 and lasted for a total of 26 days.

We also calculated the green cover ratio of each sample site from aerial photographs in order to do a quantitative analysis of the green space distribution. The photographs we analyzed were black and white with a scale of 1:12,500, and had been taken in October 1996. As it is difficult to distinguish grassland from bare land in black and white photographs, we used tree crown cover as the green cover in our study.

(3) Data analysis

First, we calculated the number of trees, the number of species, and the average tree height at each sample site. Second, as the sample-site areas were uniform, we compared the average values of all sites in order to characterize the qualitative aspects of the vegetation in each land use type. Third, we classified the species we had observed into 4 categories by their major use, with the aim of determining the species composition in each land use type. The categories were: fruit species (including those with other practical uses, such as vegetable and dyeing); ornamental species; naturally occurring species (not planted, and distributed by means other than human actions); and shade species.

The green cover ratio was defined as the ratio of the total tree crown cover area to the total area of the individual sample site. The value calculated for each site was compared with the average value for all sites.

4. Results

We recorded 13,711 trees and 201 species over the entire survey. The number of trees at each site ranged from 18 - 1,156, the number of species from 6 - 91, and the green cover ratio from 0.1% - 56.4% (Table 2).

(1) Green cover ratio

The green cover ratio, an indicator of spatial quantity of greenery, exhibited 2 tendencies (Fig. 4). The ratio exceeded 20% in most of the sample sites in low-density residential areas and parks, indicating that the green cover area was relatively large in these land use types. However, the ratio was less than 10% in high-density residential areas, business and commercial areas, industrial areas and urban-rural mixture areas; this figure was below average, indicating that the green cover area was small in these land use types.

(2) Number of trees

Low-density residential areas and parks had the largest numbers of trees, exceeding the average at most sites (Fig. 5). The values at all the sample sites in high-density residential areas, business and commercial areas and industrial areas were well below average. At sample sites in urban-rural

mixture areas they were somewhat below average.

Although the number of trees was not a satisfactory quantitative indicator, because the crown size and volume differed among species and among individual trees, our results for tree numbers showed the same trend as those for green cover ratio.

Table 2 Results of field survey and estimation of green cover ratio

Land use types	Sites	Green Cover Ratio (%)	Number of trees	Number of species	Mean height (m)
High-density residential	Caloocan	5.2	331	60	6.4
	Olympia	2.8	205	40	6.6
	Pandacan	4.7	302	51	6.6
	Sampaloc	2.3	244	44	6.4
	San Andres	3.8	196	42	6.3
	Santa Ana	4.1	283	55	6.5
	Santa Cruz	2.7	118	36	6.0
	UST	3.8	143	37	6.4
Low-density residential	Bel Air	32.0	770	79	6.9
	New Manila	28.9	739	89	7.8
	Santo Domingo	14.3	547	77	7.3
	South Triangle	16.8	466	73	7.2
	Teacher's Village	26.0	908	81	7.3
	Urdaneta	37.5	1156	78	7.3
	West Triangle	23.8	651	67	7.8
Business and commercial	Binondo	0.1	18	6	6.0
	Cubao	9.2	114	6	9.1
	Ermita	8.3	194	39	7.3
	Magallanes	7.5	117	24	7.9
	Salcedo	4.5	156	29	7.0
Industrial	Barrio	2.5	131	35	7.0
	Grace Park	1.2	86	28	6.3
	Kayamanan	2.9	139	17	7.1
	Ortigas	3.7	160	31	7.2
	Paco	2.0	71	17	7.0
Park	Quezon Circle	33.8	749	38	8.2
	Rizal Park	29.7	372	50	8.4
	Manila Zoo	52.8	1141	91	8.9
	Mehan Garden	33.2	676	66	7.4
	Ninoy Aquino Park	56.4	1130	66	8.2
Urban - rural mixture	Marikina	9.7	569	50	6.6
	Paranaque	4.4	184	30	6.1
	Pasig	0.8	89	18	5.8
	San Mateo	3.5	213	37	6.4
	Valenzuela	7.4	343	46	6.2
Average		13.8	392	47	7.4

(3) Number of species

There were many more species than average in low-density residential areas, suggesting that the species diversity was quite rich in these areas (Fig.6). Although the values in parks, high-density residential areas and urban-rural mixture areas varied, they tended to be higher than average in parks, around the average in high-density residential areas, and relatively low in urban-rural mixture areas. Species numbers were below average at all sample sites in the business and commercial areas and industrial areas, indicating that species diversity was poor in these land use types.

(4) Average tree height

We sorted average tree heights over land use type and compared the results with the average value over all sites (Fig. 7). The average value over all sites was quite high (7.4 m). This was because sample sites with a large number of trees tended to have high average tree heights. Another reason could be that the minimum tree height was fixed at 5.0 m. The tree-height distribution in parks was much higher than average, which suggests that the green space was spread vertically in these areas. The average tree height in business and commercial areas was higher than the average height over all sites, but in low-density residential areas it was around the overall average, and in industrial areas it was relatively low. In high-density residential areas and urban-rural mixture areas, the average tree height was much lower than the overall average.

(5) Species composition analysis by tree use

The species composition analysis revealed significant differences among land use types (Fig 8). Fruit and ornamental species predominated in both types of residential areas. While, in high-density residential areas, fruit species made up over 35% of the total and predominated at all sample sites, in low-density residential areas ornamental species made up over 45% of the total and

predominated at all but 2 sample sites. In parks and business and commercial areas, ornamental and shade species were the predominant species, and the proportion of fruit species tended to be quite small. Shade species were predominant at 4 out of 5 sites in both of these land use types. Although in industrial areas the results were varied and unclear, the proportion of shade species was relatively large as compared with other land use types. In urban-rural mixture areas fruit species overwhelmingly predominated, making up over 55% of the total at all the sample sites; ornamental and shade species made up only a very small proportion of the total number of trees - less than 25%.

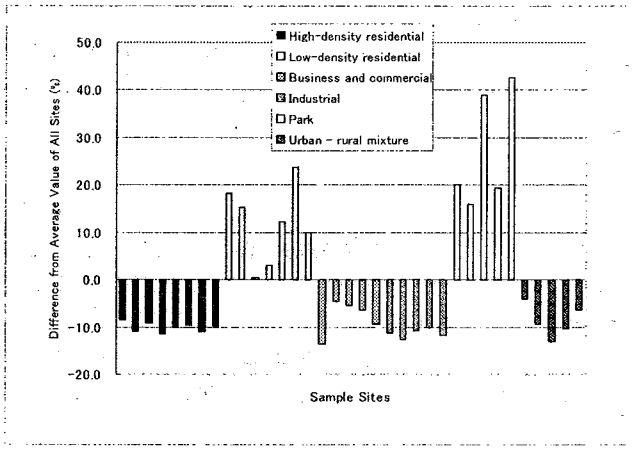

Fig.4 Range of green cover ratio at each sample site

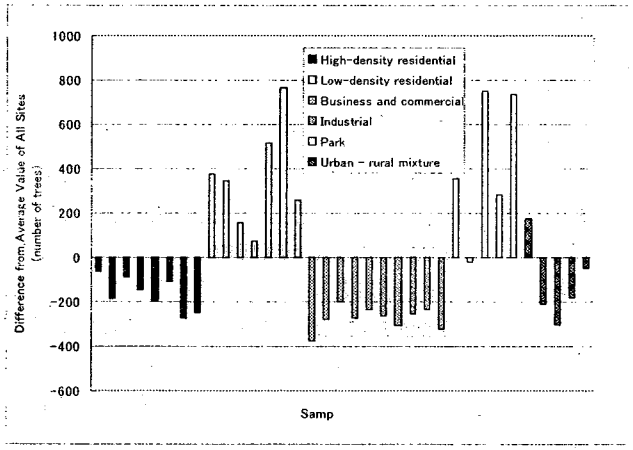

Fig.5 Range of number of trees at each sample site

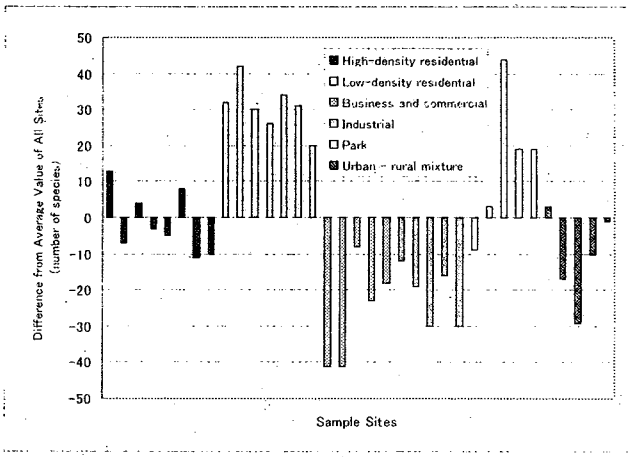

Fig.6 Range of number of species at each sample site

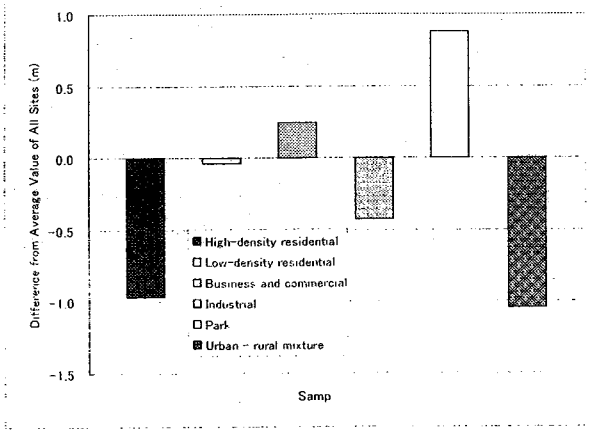

Fig.7 Range of average tree height for each land use type

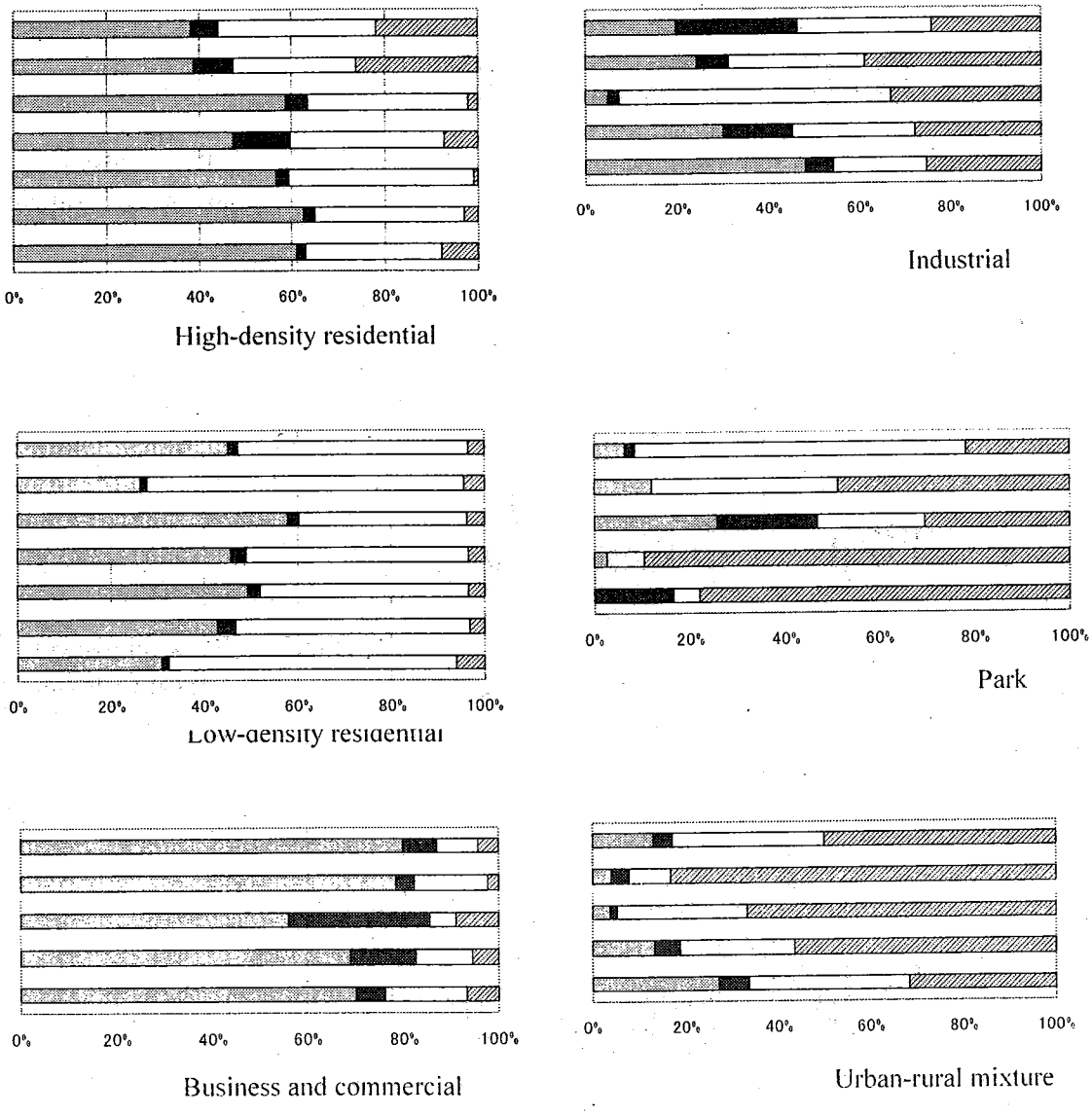

Fig.8 Species composition at each land use type

5. Discussion

(1) High-density residential areas

The low green cover ratio in high-density residential areas indicated that the green cover area was quite small. The number of trees was small, the species diversity was average, and the tree height was below average. The species diversity was found to be relatively high when the number of trees was taken into account. This could be because tree planting was not uniform, and trees had been planted largely according to the preferences of the residents. Fruit species were predominant in the species composition; this reflects the practical importance of urban green spaces. The relatively high proportion of shade species seen at some sample sites was probably a result of roadside tree planting by local government.

(2) Low-density residential areas

In low-density residential areas, the fairly high green cover ratio suggested that the green cover area was quite large. In one study of green spaces in residential areas in Japan, the tree crown cover ratio was calculated as 26.0% in Seijo, Setagaya Ward, Tokyo, a category I exclusive residential district. Since this ratio was exceeded at 4 sites out of 7 in low-density residential areas in this survey, it was apparent that a residential environment with extremely abundant greenery existed in Metro Manila, even though the sample sites covered only a limited area.

In low-residential areas, the number of trees and the species diversity were far above averages, and the tree height was about the overall average. These results suggest that the green spaces in low-density residential areas are very diverse. Fruit and ornamental species made up a large part of the appeared trees, as in high-density residential areas, but ornamental species predominated in these areas. This might be because the larger lot sizes gave more planting space, and the residents were affluent enough to buy expensive species, such as imported ornamentals.

(3) Business and commercial areas

The green cover area in business and commercial areas was small, since the green cover ratio was generally small. However, more than half the sample sites (3 of 5) had a higher green cover ratio than that found in the high-density residential areas. This indicates that there had been active tree planting in certain places. While the number of trees was significantly small and the number of species was also small, the mean tree height was relatively high. Ornamental species – and shade species in particular - predominated. These results suggest that in these areas only a small number of trees of limited species existed, mainly on the roadside, for the purposes of shade and landscaping.

(4) Industrial areas

In industrial areas the green cover ratio was extremely low (less than 4%), indicating that the green cover area was very small. The number of trees was lower than average at only about 200, the species diversity was poor, and the trees were shorter than the overall average. The species composition varied among sample sites, but there was a tendency for fruit, ornamental and shade species to exist in equal proportions; shade species, in particular, made up a relatively high proportion as compared with other land use types. As the total number of trees was small, trees growing in very small portions of residential or vacant areas that sometimes existed within the sample sites might have affected the result. The green spaces in industrial areas tended to be small and poor in species diversity, presumably because the trees had been planted to screen, soundproof and landscape the factories.

(5) Parks

Parks had large green spaces, with green cover ratios ranging from about 30% - 50%. While the number of trees was much larger than the average, the number of species varied from average to large. This could have been the result of uniform and systematic planting by a single planter, such as city council. Also, the tree were extremely high, and ornamental trees - and shade species in particular - predominated. Although the species diversity lagged behind that found in low-density residential areas, the green spaces in parks were large and spread vertically; this was efficient for shading and landscaping.

(6) Urban-rural mixture areas

The results varied significantly among urban-rural mixture areas. This could have been because there were differences in the land use composition at each sample site. (The sites were generally mixtures of agricultural, residential and vacant land.) However, we did observe some common characteristics. The green cover area was small, although taking into account the fact that we were assessing only tree crown cover in this study, it would have exceeded the average if grassland had been included. The number of trees and the number of species were smaller than average, and the trees were shorter than the overall average. Therefore, the green spaces were small and poor in species diversity in urban-rural mixture areas. This is because the agricultural land had few trees, and the trees in residential areas in new towns located within the urban-rural areas were still fairly young. The overwhelming predominance of fruit species was considered to reflect the rural characteristics of the environment.

Table 3 Characteristics of green spaces in different land use types in Metro Manila

Land use types	Green cover ratio	Number of trees	Number of Species	Mean height	Species composition
High-density residential	low	small	medium	low	fruit + ornamental
Low-density residential	high	large	large	medium	ornamental + fruit
Business and commercial	low	small	small	medium-high	shade + ornamental
Industrial	low	small	small	low-medium	(shade)
Park	high	large	medium-large	high	shade + ornamental
Urban-rural mixture	low	small	small	low	fruit

6. Conclusion

We determined the characteristics of urban green spaces in the major land use types of Metro Manila, not only the quantitative features, but also qualitative features such as species composition and vertical structure (summary: Table 3). These results are expected to contribute to our understanding of the functions and structures required in different types of urban green spaces.

They could also make a positive contribution to a greening program based on Metro Manila's local environment, which could be a unique exercise in urban planning.

According to statistical projections (NSCB 1997), the total population of Metro Manila is expected to grow continuously, and further spatial expansion of urbanized areas is expected. To cope with this situation, uniform landscape planning is inappropriate, and different planning policies need to be applied to well-planned urbanized areas developed under western planning systems - such as low-density residential areas - and unplanned Asian-type developing areas, such as urban-rural mixture areas. Therefore, environmental improvement needs to be promoted in built-up areas, and, at the same time, strategic landscape planning that takes into account the urbanization process is needed in areas that are still urbanizing. Some future planning tasks can be suggested from the study results. For example, maintaining the existing greenery by restricting lot fragmentation and conversion into multi-family housing would be the major task in low-density residential areas. Co-existence of urban and rural environment through the adoption of the rural aspects of greening in urban areas or through the adoption of appropriate land use arrangements would be a major aim in urban-rural mixture areas.

From the discussion above, we considered that the results of this study are useful for comprehensive landscape planning in relation to the urban green space distribution in Metro Manila.

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