Pertanika J. Trop. Agric. Sci. **35 (1)**: 27 - 32 (2012)
ISSN: 1511-3701

Urban Trees Diversity in Kuching North City and UNIMAS, Kota Samarahan, Sarawak

Zainudin, S. R.*, Mustafa, K. A., Austin, D., Helmy, J. and Lingkeu, D. A.
Department of Plant Science and Environmental Ecology,
Faculty of Resource Science and Technology,
Universiti Malaysia Sarawak,
94300 Kota Samarahan, Sarawak, Malaysia
**E-mail: zsrubiah@frst.unimas.my*

ABSTRACT

Tree species composition often varies widely amongst cities, depending to their geographical locations, urban history, land area or population. The objective of the study was to identify the species diversity of urban trees planted along the roadsides of Kuching North city and Universiti Malaysia Sarawak (UNIMAS), Kota Samarahan. A total of 31,181 trees representing 186 species were sampled. The roadside trees of Kuching North city were more diverse with 176 species of trees while 28 species were recorded from UNIMAS. Inverse of Simpson Index of diversity of the roadside trees in Kuching North city and UNIMAS was 21.0 and 10.7, respectively. In particular, five common species dominated the whole study area with indigenous species dominating UNIMAS, while exotic species exceed indigenous species at roadsides in Kuching North city. Five popular species accounted for one third of the total trees planted with *Mimusops elengi* as the dominant species planted at both sites. All the species recorded from both the study areas were less than 10 % and they complied with the urban forest health status guideline, whereby a diverse tree population might slow or prevent the spread of insects or diseases, and in the event that such pests should become established, the impact on a diverse tree population may be less severe. Data on species floristic composition will assist the local authorities in the planting, maintaining and planning for future replanting activities.

Key words: Urban environment, urban trees, species diversity, *Mimusops elengi*

INTRODUCTION

Landscape planting has been widely regarded as an indispensable urban infrastructure in the attempts to ameliorate stresses arising from artificial covers and to furnish a broad range of environmental benefits (Grey & Deneke, 1986; Miller, 1997). Trees in urban settings play an important role in improving urban life by reducing runoff, air pollution and energy use, and improving human health and emotional well being (Schroeder & Cannon, 1983; Ulrich, 1985; Heisler, 1986; Dwyer *et al*., 1992; Nowak & Crane, 2000; Nowak & Crane, 2002; Xiao & McPherson, 2002). The increasing size and proportion of the human population living in towns and cities has also resulted in greater emphasis on the maintenance and improvement of trees within these settings. An understanding of urban floristic composition can help the municipal in managing their resources sustainably. Biological diversity within populations is important in order to minimize plant maintenance needs and disease tolerance of urban tree populations (Richards, 1993; Graves, 1998). Low species diversity may leave the tree population more vulnerable to the new stress environments; both abiotic and

*Corresponding Author

biotic (Graves, 1998). Urban forestry literature generally recommends that not more than 10% of the trees be from any one species and the concern underlying this recommendation is with the possibility of a species-specific pest or disease sweeping through the area damaging or destroying a large segment of the trees (Graves, 1998).

The diversity of the tree population at the level of the genus, species or genotype is an important consideration in terms of the ability of the urban forest to withstand stress (Wen, 1992). A diverse tree population may slow or prevent the spread of insects or diseases, and in the event that such pests should become established, the impact on a diverse tree population may be less severe. Perhaps, one of the most obvious examples is that of the American Elm (*Ulmus americana*), whereby its attractive form and suitability for urban growing conditions resulted in the widespread planting throughout North American cities (Wen, 1992). These cases, and also others like them, have shown that the most serious pests or problems are specific to certain families, genera, or species of plants. Pauleit *et al*. (2002) showed that throughout Europe, there existed a poor diversity of tree genera and species planted in urban areas, especially as street trees. In Finland, for example, there is a trend to use smaller trees as the building density increases. However, in many places, large tree species are still planted, in spite of the complaints that they have too little space for both roots and crown. In Denmark, different cities listed different species as “the most used species”. This may reflect adverse growing conditions, but the choice may also be the “footprint” and personal preferences of the city planners. The species choice for street trees (Pauleit *et al*., 2002) shows that the number of species used increases towards the south of the European region and reflects the more amenable climatic conditions. However, it is rare to find places with such poor species choice as within the two largest Norwegian cities, where 70% of the street trees planted were of one clone, i.e., *Tilia x euopaea* ‘Pallida’. The limited number of species planted in the urban areas is often a result of the use of well-tested cultivars that have been proven to be the most resistant and aesthetically-pleasing, and are also easily propagated and cultivated. Although planners in the Central and North-Western European countries use a relatively broad range of species, only three to four genera predominate in the urban areas, namely *Platanus, Aesculus, Acer* and *Tilia* (Pauleit *et al*., 2002).

Kuching North city and Kota Samarahan have transformed enormously over the past ten years with many developments, such as office buildings, universities, schools, houses and roads to cater the needs of the ever-growing population. In spite of the fast phase of development, greening of the city is not forgotten. Like any other city in the world, benefits of trees in the urban environment have been greatly emphasized and recognized. This study evaluated the species diversity of the trees in Kuching North city and UNIMAS, Kota Samarahan, Sarawak. The data collected would provide information on the diversity of trees planted and assist the local authorities in their planting, maintaining and future replanting activities.

Study Area

The study area, i.e. Kuching North city, is located in the north of the equator line of South East Asia and Kota Samarahan (*Fig. 1*). Kuching North city, which is also the main capital of Sarawak, accommodates a population of over 500 000 in 370 km^2 of land. The climate of Kuching North city and Kota Samarahan is equatorial, with the daytime temperature between 28 to 34°C. The average rainfall is between 330 cm and 460 cm, and the average humidity is 70%. The two study areas represent a range of development history and land use patterns; aggressive tree planting was carried out around residential areas and roadsides in the recent years in line with the recognition of Kuching as a garden city. Issues of landscaping are very important as one of the factors that could promote the city as liveable and environmentally healthy. Kota Samarahan is considered as a university city as two main universities in Sarawak, namely Universiti

Malaysia Sarawak (UNIMAS) and Universiti Technologi MARA (UiTM), are located here. In this study, only UNIMAS was selected as the study site.

MATERIALS AND METHODS

In order to evaluate the patterns and combinations of the planted trees, one or more roads in each of the study areas was/were selected and the trees were measured and analyzed according to the procedures described by Jaenson *et al.* (1992). An accurate street map, with a scale ranging between 1" = 400' and 1"= 900', was taken and the cities were stratified by relatively dividing them into homogeneous zone segments of three zone types known as Rectilinear Residential (RR), Curvilinear Residential (CR), and Downtown (DT). In each RR and DT zone segment, every block is given a number. Stratified random sampling was done within each zone segment to ensure that every block has an equal probability of being selected. For each zone segment, the tree density or the number of trees per street unit was counted. A list of the roads surveyed in Kuching North city and UNIMAS is given in Table 1. The trees were identified up to species level and their diameters at breast height (dbh) were measured and recorded. Data analysis was aided by Microsoft Excel 2007 and SPSS/PC 9.0. The Shannon-Weiner diversity, Inverse of Simpson's Index of diversity, Maximum equitability and Equitability species indices were calculated using the standard formulae (Greig-Smith, 1983; Mueller-Dombois, 1974) listed in the footnote of Table 2. Shannon-Wiener's and Simpson's inverse diversity indices are derived from the aggregation of relative proportions of individual species, and they provide a synoptic summary of the diversity of species in a given flora. Maximum equitability is derived directly from species richness. Equitability is a ratio between Shannon-Wiener and Maximum equitability indices depicting the relationship between species diversity and richness, and a high value denotes that the constituent species are more evenly represented.

RESULTS AND DISCUSSION

A total of 31,181 trees, represented by 204 species, from both the study sites were sampled (Table 2). The roadside trees of Kuching North city were more diverse with 176 species of trees, while 28 species were recorded from UNIMAS. For an area of 14,578 ha, the number of species recorded at the roadside in Kuching North city was 176 and this is considered as high compared with temperate-latitude cities (Kunick, 1987; Richards, 1983; Whitney, 1985). Similar results were reported by Jim (2002) for the city of Guangzhou in China, whereby for an area of 5519 ha, species richness was 246, and

TABLE 1
Name of roads surveyed and their distance in Kuching North city and UNIMAS

No	Name of road	Distance (km)
1	Tun Abang Haji Openg	5
2	Tunku Abdul Rahman Yaakub	10
3	Tun Zaidi Adruce	5.5
4	Sultan Tengah	5
5	Nanas	2
6	Bako	25
7	Rubber	2.5
8	Kampung Malaysia	3.0
9	Kampung Tunku	2.5
10	Santubong Damai	57.5
11	UNIMAS	9.0

TABLE 2
Basic and derived quantitative attributes of the two forest types in Kuching North city (roadsides) and UNIMAS, Kota Samarahan, Sarawak.

Quantitative attributes	Roadsides	UNIMAS	Whole Study Area
Basic statistics			
Tree Frequency, N	25819	5362	31181
No. of Species	176	28	204
Area, A(ha)	14,578	110	14,688
Road length, L (km)	118 km	9 km	127 km
Tree statistics			
Indigenous tree,%	44.4%	71.4 %	63.2%
Tree density (area),N/A (tree/ha)	1.8	48.7	50.5
Tree density (road length), N/L(tree/km)	218.8	595.8	
Species indices			
Shannon-Weiner diversity, H	20.3	1.07	21.1
Inverse of Simpson diversity index, D	21.0	10.7	23.1
Maximum equitability, H_{max}	7.46	4.81	7.53
Equitability, E	2.72	0.22	2.90

Shannon-Wiener diversity, $H = -\sum pi \log_2 pi$
Inverse of Simpson diversity index, $D = \sum p^2 i$
Maximum equitability, $H = \log_2 S$
Equitability, $E = H/H$max.

Hong Kong with 149 species at roadside (Jim, 2000). Inverse of Simpson Index of diversity of roadside trees in Kuching North city and UNIMAS was 21.0 and 10.7, respectively, and these are also considered as high compared to other Asian countries, such as Hong Kong and Fujian, China, with the values of 12.7 and 6.0, respectively (Jim, 1992, 1999). Similarly, the Shannon-Weiner diversity index of roadsides trees in Kuching North city and UNIMAS was 20.3 and 1.07, respectively. Meanwhile, equitability value (E) was 2.72 and 0.22 for Kuching North city and UNIMAS, respectively. A high equitability value denotes that the constituent species represented roadsides trees in Kuching North city more evenly as compared to those in UNIMAS. The length of the roads in Kuching North city is 10 times longer than those in UNIMAS and they can account for the high values of the calculated parameters. Another contributing factor could be the fact that UNIMAS new campus was established in 2003 compared to the aggressive tree planting in Kuching North city. Data on species diversity and composition would serve as a guide for the local authorities and UNIMAS in planting, maintaining and planning for future replanting activities.

For the whole study area, a small number of popular species dominate the tree population, with the remainder making limited contributions (Table 3). The top five popular species planted along the roadsides accounted for one third of the total trees planted, while 16.4% of the said roadsides were dominated by the family Leguminoseae. The five most popular species were *Mimusops elengi, Cinnamomum iners, Tabebuia pentaphylla, Samanea saman* and *Andira surinamensis.* For UNIMAS, the top five species accounted for 32.1% of the trees planted. Leguminoseae is the main family dominating the two planting zones (Table 3). Meanwhile, five common species dominated the whole study area, with indigenous species dominating the area in UNIMAS, while exotic species exceed the natives at roadsides in Kuching North city**.** Ten species were found to be unique to UNIMAS as they have not been planted along the roadsides of Kuching North city, and these included *Araucaria excelsa, Casuaurina nobile,*

TABLE 3
Five most common tree species planted in Kuching North city and UNIMAS

Kuching North city			UNIMAS		
Species Name	Family	% of trees planted	Species Name	Family	% of trees planted
Mimusops elengi	Sapotaceae	8.8	*Filicium decipiens*	Leguminoseae	9.2
Cinnamomum iners	Lauraceae	8.5	*Syzygium polyantha*	Myrtaceae	6.8
Tabebuia pentaphylla	Leguminoseae	6.6	*Roystonea regia*	Palmae	6.2
Samanea saman	Leguminoseae	5.2	*Cinnamomum iners*	Lauraceae	5.1
Andira surinamensis	Leguminoseae	4.6	*Mimusops elengi*	Sapotaceae	4.8

Hopea odorata, Salix babylonica, Dacrydium araucarioides, Dyera costulata, Gmnostema nobille, Plumeria rubra, Plumeria obtuse and Parkia angulatum. Roadside trees of Kuching North city have similar frequency distributions that are pronouncedly skewed towards the popular species. Similar results were also reported by Jim (2002) for Guanghzou China whereby the popular species included *Ficus virens*, *Bauhinia purpurea*, *Aleurites moluccana*, *Bauhinia variegata* and *Ficus microcarpa*. The selection of the species planted in Kuching North city was made by the officials in the municipals; however, due to restrictive habitat conditions, the selection tended to favour heavy planting of popular species. Roadside amenity strips and associated sites have been heavily filled by trees. On the basis of species selection in both study sites, Leguminoseae dominate the planting stocks. This is probably due to the fact that most of the legume trees have been proven to be successful in urban habitats, and also the existence of the nitrogen–fixing bacteria, *Rhizobium*, in nodules associated with the roots (Wee, 1989). *Mimusops elengi* and *Filicium decipiens* were the most popular species planted in Kuching North city and UNIMAS. *Cinnamomum iners* from the family Lauraceae has striking pinkish leaves and its attractive shape contributes significantly to the aesthetic values of urban trees. *Samanea saman* is among the most common tree species planted in Kuching North city and this is probably due to its dense and wide-spreading foliage suitable for shading.

CONCLUSIONS

As an artificial plant community, roadside trees in Kuching North city and UNIMAS have been planted to meet human's demands such as beautifying the area and for environmental benefits. A total of 31,181 trees were sampled from both the study sites. The roadside trees of Kuching North city were found to be more diverse with 176 species of trees, while 28 species were recorded from UNIMAS. Inverse of Simpson Index of diversity of roadside trees in Kuching North city and UNIMAS were 21.0 and 10.7, respectively. The five common species dominated the whole study area with indigenous species dominating UNIMAS, while exotic exceeds indigenous species at roadsides in Kuching North city. As indicated earlier on, five popular species accounted for one third of the total trees planted, with *Mimusops elengi* and *Filicium decipiens* as the most popular species planted in Kuching North city and UNIMAS.

ACKNOWLEDGEMENTS

The authors would like to thank Kuching North Municipal Council, Sarawak, for funding this study.

REFERENCES

Dwyer, J. F., McPherson, E. G., Schroeder, H.W., & Rowntree, R. A. (1992). Assessing the benefits and costs of the urban forest. *J. Aboric., 18*(5), 227–234.

Grey,G. W. and Deneke, F. J. (1986). *Urban Forestry* (2nd Ed.). New York: Wiley.

Graves, W. R. (1998). Drought resistance on trees: An overview of mechanisms and new research with Iowa Black Maple. *Metropolitan Tree Improvement All*iance *(METRIA*), *5,* 1-5.

Greig-Smith, P. (1983). *Quantitative Plant Ecology* (3rd Ed.). Oxford: Blackwell.

Heisler, G. M. (1986). Energy savings with trees. *J. Aboric., 12*(5), 113–125.

Jaeson, R., Bassuk, N., Schawer, S., & Headley, D. (1992). A statistical method for the accurate and rapid sampling of urban tree populations. *J. Arboric*., *18*(4), 171-183.

Jim, C. Y. (1992). Provenance of amenity-tree species in Hong Kong. *J. Aboric., 16*, 11-23.

Jim, C. Y. (1999). A planning strategy to augment the diversity and biomass of roadside trees in urban Hong Kong. *Landscape Urban Planning, 44*, 13-32.

Jim, C. Y. (2000). The urban forestry programme in the heavily built-up milieu of Hong Kong, Cities. *J. Aboric., 4*, 271–283.

Jim, C. Y. (2002). Heterogeneity and differentiation of the tree flora in three major land uses in Guangzhou City, China. *Ann. For. Sci*., *59*, 107-118.

Krebs, C. J. (1994). Ecology: The Experimental Analysis of Distribution and Abundance (4^{th} ed.). New York: Harper Collins.

Kunick, W. (1987). Woody vegetation in settlements. *Landscape Urban Planning*, *14*, 57–78.

Miller, R.W. (1997). *Urban Forestry-Planning and Managing Urban Greenspaces (2^{nd} Ed.)*. New York: Prentice-Hall.

Mueller-Dombois, D., & Ellenberg, H. (1985). *Aims and Methods of Vegetation Ecology.* New York: John Wiley & Sons.

Nowak, D. J., & Dwyer, J. F. (2000). Understanding the Benefits and Costs of Urban Forest Ecosystems. In J. E. Kuser (Ed.), *Handbook of Urban and Community Forestry in the Ecosystems.*

Nowak, D. J., Civerolo, K. L., Rao, S.T., Sistla, G., Luley, C. J., & Crane, D. E. (2000). A modeling study of the impact of urban trees on ozone. *Atmospheric Environment, 34*, 1601–1613.

Nowak, D. J. & Crane, D. E. (2002). Carbon storage and sequestration by urban trees in the USA. *Environmental Pollution, 116*, 381–389.

Pauleit, S., Jones, N., Garcia-Martin, G., Garcia-Valdecantos, J. L., Riviere, L. M., Vidal-Beaudet, L., Bodson, M., & Randrup, T.B. (2002). Tree establishment practise in towns and cities -Results from a European survey. *Urban For. & Urban Greening, 1*(2), 83–96.

Richards, N. A. (1993). Optimum stocking of urban trees. *J. Aboric*., *18*, 64-68.

Richards, N. A. (1983). Diversity and stability in a street tree population. *Urban Ecology, 7*, 159–171.

Schroeder, H. W., & Cannon, W. N. (1983). The esthetic contribution of trees to residential streets in Ohio towns. *J. Aboric., 9*(9), 237–243.

Ulrich, R. S. (1985). Human responses to vegetation and landscapes. *Landscape and Urban Planning, 13*, 29–44.

Wee, Y. C. (1989). *A Guide to the Wayside Trees of Singapore. Singapore Science Center, Singapore*. 160 pp.

Wen, Q. S. (1992). Quantifying species diversity of streetside trees in our cities. *J. Aboric., 18*(2), 91-93.

Whitney, G. G. (1985). A quantitative analysis of the flora and plant communities of a representative midwestern U.S. town. *Urban Ecology, 9*, 143–160.

Xiao, Q., & McPherson, E. G. (2002). Rainfall interception by Santa Monica's municipal urban forest. *Urban Ecosystems, 6,* 291–302.