BIODIVERSITAS
Volume 19, Number 5, September 2018
Pages: 1615-1621

ISSN: 1412-033X
E-ISSN: 2085-4722
DOI: 10.13057/biodiv/d190503

Short Communication: The species diversity and composition of roadside trees in five cities in Sumatra, Indonesia

WIRYONO♥, YANSEN♥♥, ADITYA, DAVID JUARA LAMHOT, JURIAH HUTAHAEAN
Department of Forestry, Faculty of Agriculture, Universitas Bengkulu. Jl. WR Supratman, Bengkulu, Indonesia. Tel./fax.: +62-736-21170.
♥email: wiryonogood@unib.ac.id, wiryonogood@yahoo.com, ♥♥ yansen@unib.ac.id

Manuscript received: 7 Juli 2018. Revision accepted: 5 August 2018.

Abstract. *Wiryono, Yansen, Aditya, Lamhot DJ, Hutahaean J. 2018. Short Communication: The species diversity and composition of roadside trees in five cities in Sumatra, Indonesia. Biodiversitas 19: 1615-1621.* Roadside trees make living in a city more enjoyable due to their aesthetic values and ecosystem services. The ecological benefits of roadside trees may be enhanced by increasing the species diversity and the proportion of native species. The objective of this study was to know the species diversity and composition of roadside trees in the cities of Palembang, Bengkulu, Curup, Pematang Siantar and Argamakmur, in Sumatra Island, Indonesia, varying in size and altitude. Data of trees were collected from selected streets and analyzed to determine the species richness (S), Shannon-Wiener index of diversity (H′) and Ellenberg index of community similarity (IS_E). The results showed that the species richness in a city ranged from 7 to 26, with the diversity index between 1.05 and 2.08. The large and medium cities had higher S and H′. More introduced species were found, both in number of species and number of individuals, than the native ones. The similarity among cities in species composition ranged from 47 to 82%. Overall, *Swietenia macrophylla*, an introduced species, was the most abundant species. The S and H′ values of all cities were considered low and the composition of tree species did not support the conservation of native species. It is, therefore, essential to increase the species diversity of street trees, especially by planting native species.

Keywords: Biodiversity, Indonesia, Sumatran cities, urban forest

INTRODUCTION

Urban trees, including roadside trees, not only make a city beautiful, but also provide many ecosystem services beneficial to urban community, such as sequestering carbon (Zhao and Sander 2015) and other pollutants (Jim and Chen 2008), ameliorating temperature (Fan et al. 2015), and controlling stormwater (McPherson et al. 2005). Living in cities with trees is enjoyable because people experience positive thinking from direct contact with nature (Chiesura 2004), so the presence of trees managed beautifully in a city can increase the rental price of apartment and office in that city (Laverne and Wilson-Geideman 2003; Donovan and Butry 2011)

To get the maximum benefits from road trees, city planners must consider many things when selecting trees for streets. The ability of a tree to cope with harsh environment of the street may be the most important criterion (Sjöman and Nielsen 2010), but they also need to consider the aesthetic value of the tree, the landscaping objective, and the health of the urban street tree population, the seedling availability, the site condition, the planting techniques, and the maintenance management (Li et al. 2011). Some arboriculturist proposed that many species must be selected for roadside trees, so they proposed the maximum percentage of a single species planted in streets for a city. Barker (1975) proposed that any single species of trees categorized as liberal use should not exceed 5% of the total trees in streets, while Miller and Miller (1991) increased the limit of liberal use to 10%. Richards (1993), however, argued that this simple numerical limits had no scientific basis and he believed that species equity was a poor standard for selecting street trees.

Although there may be no scientific basis for setting maximum percentage of a given species to be planted in streets, there have been concerns that street trees as well urban parks must be used for promoting diversity because many natural ecosystems have been degraded (Alvey 2006; Nielsen et al. 2014). This concern is relevant to the situation of Sumatra, the second largest island in Indonesia which used to have extensive natural tropical rainforest harboring a great variety of tree species. However, in the last five decades, much of the natural forest in Sumatra has gone due to logging industries, conversion into oil palm plantation, mining and illegal clearing (FWI 2011; Saxon and Roquemore 2011; Abood et al. 2015). Increasing species diversity in roadside trees in Sumatra will help conserve the biodiversity on this island. Also, studies show that increasing biodiversity in urban ecosystems can have a positive impact on the quality of life (Chivian and Bernstein 2004; Fuller et al. 2007).

Not only for promoting diversity, street trees may also be used for conserving native species. So far, more exotic species than the native ones are found in streets and urban parks in many cities in the world, such as in Brazil (Moro and Castro 2015), in Santiago, Chile (Figueroa et al. 2016), in Bangalore, India (Nagendra and Gopal 2010), in ten Nordic cities (Sjöman et al. 2012), and in Halifax, Canada

(Turner et al. 2005). The presence of exotic species may bring deleterious effects to the local ones. The exotic chestnut imported from Japan to the US in the 19th century almost brought the native American chestnut (*Castanea dentata*) to extinction due to chestnut blight (*Cryphonectria parasitica*) which came with the exotic species (The American Chestnut Foundation 2017). The use of native species for roadside trees not only help conserve the species but also help introduce local people to the local plant species (Savard et al. 2000). The rare presence of native species in roadside trees will alienate people of their local species and may reduce local botanical knowledge and support biodiversity conservation (McKinney 2006; Dearborn and Kark 2010).

The objective of this paper was to report the results of four independent studies to know species diversity and species composition of roadside trees in the cities of Palembang, Bengkulu, Curup, Argamakmur and Pematang Siantar in Sumatra Island, Indonesia. As a whole, this is considered a preliminary study, because the number of streets sampled was low. To get a more comprehensive results, bigger samplings need to be done.

MATERIALS AND METHODS

Study area

This study reported four independent studies. The first one was conducted in Palembang City, South Sumatra Province, the second one in Bengkulu City, Bengkulu Province, the third one in Curup and Argamakmur Cities, Bengkulu Province, and the fourth one in Pematang Siantar, North Sumatra Province. Bengkulu City is located at the west coast of Sumatra (3° 47' 59" S/102° 16' 1" E), with altitudes of 0-20 m, Palembang at the east coast of Sumatra (2° 55' 0" S/104° 44' 45" E) with altitudes of 0-20 m. The other three sites are inland cities with higher elevation. Argamakmur lies at 3° 25' 24" S/102° 11' 21" E, with altitudes of 200-250 m, Pematang Siantar at 2° 57' 34" N/99° 4' 7" E, with altitudes of 400-500 m, and Curup at 3° 28' 13" S/102° 31' 15" E with altitudes mostly between 500 m to above 1000 m.

Palembang is the capital city of South Sumatra Province, a large city, with an area of about 400 km², and a population of about 1.6 million (Central Bureau of Statistics of Palembang City 2017). Bengkulu is the capital

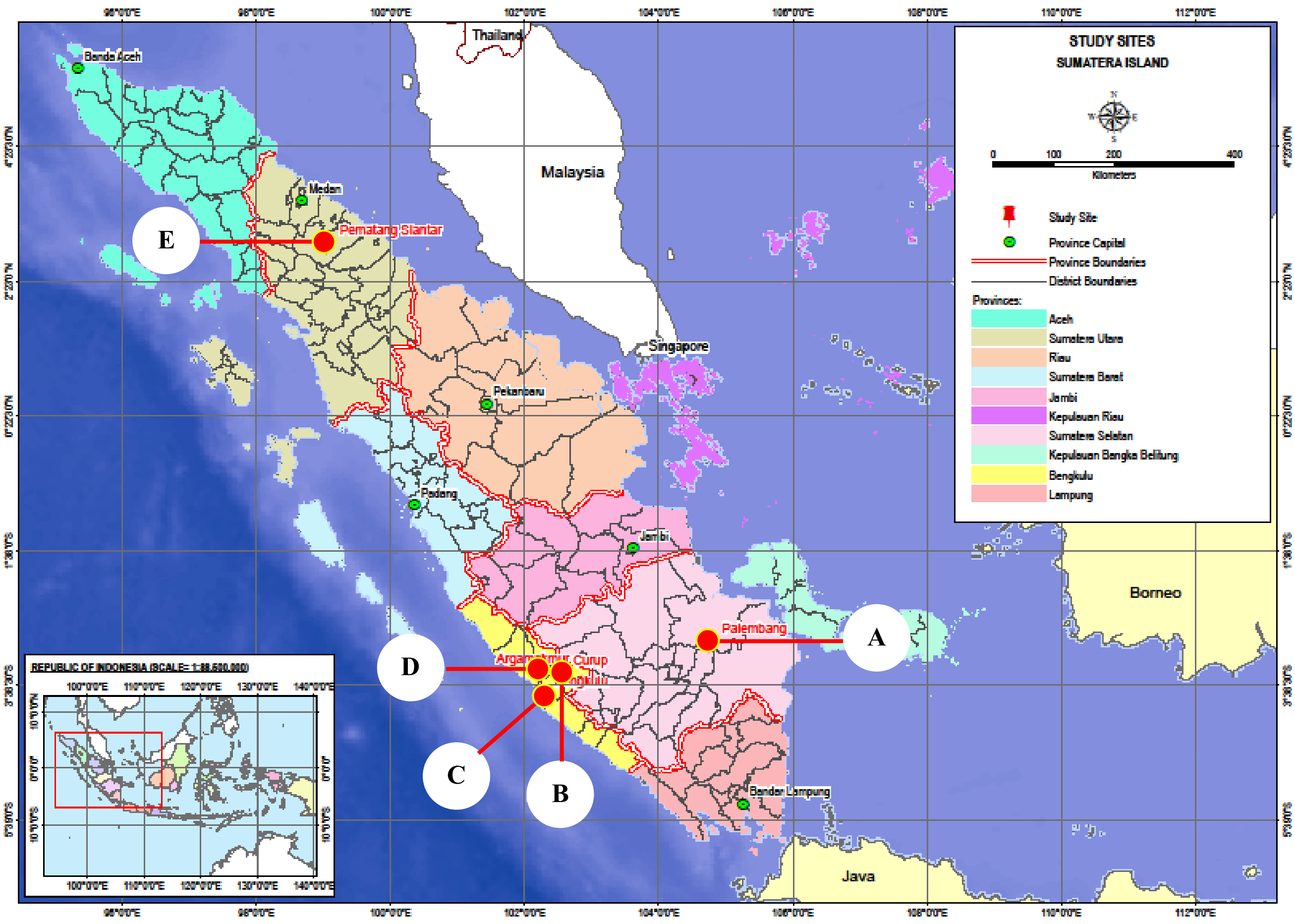

Figure 1. Study sites in five cities of Sumatra, Indonesia, i.e., A. Palembang, B. Curup, C. Bengkulu, D. Argamakmur, and D. Pematang Siantar

city of Bengkulu Province, a medium-size city, 144.5 km² in area, with a population of about 350 thousand (Central Bureau of Statistics of Bengkulu City 2017). Pematang Siantar is a small-medium city, about 80 km² in area with a population of 249 thousand (Central Bureau of Statistics of Pematang Siantar 2017). On the other hand, Curup City (about 3.95 km² area) and Argamakmur City (about 32 km² area) are small cities with about 29 thousand and 42 thousand inhabitants respectively (Central Bureau of Statistics of Rejang Lebong 2017; Central Bureau of Statistics of North Bengkulu 2017).

All five locations fall into *Af* climate classification according to Köppen dan Geiger, which is a tropical rainforest climate. Coastal cities, i.e. Bengkulu and Palembang, have slightly higher air temperature than inland cities. In general, all cities have high rate of rainfall (https: //id.climate-data.org).

Tree sampling

Each researcher conducted an independent study with sampling intensity based on the species diversity of each street and available time. In Palembang, 12 streets were selected, and trees in those streets were recorded with 100% sampling intensity (SI); in Bengkulu 20 streets with 10% SI; in Curup and in Argamakmur, 8 streets with 50% SI respectively, and in Pematang Siantar 8 streets with 10% SI. This inequality of sampling intensity was one of the weaknesses of this article. For a better result, the same sampling intensity should have been done for every city.

Data analyses

The species, number, and percentage of trees in each location were tabulated to show the species composition. The species were categorized into native and introduced. Native species are those whose natural distribution includes Sumatra Island, and so, those which do not meet this criterion were classified as introduced. The natural distribution of species was searched from the literature on the internet.

The diversity of tree species in each city was determined by calculating the number of species of species richness (S) and the Shannon-Wiener diversity index (H′). The distribution of individuals among species was determined using species evenness index (E), and the similarity in species composition among cities were determined using Ellenberg. The formulas for these indexes were taken from Mueller-Dombois and Ellenberg (1974).

Shannon-Wiener index:

$$H' = -\sum_{i=1}^{s} (pi)(\ln pi)$$

Where:
H′ : Species diversity index
s : Total species
pi : Proportion of species i = ni/N = (total individual of species i/total species).

Species evenness index (E) = H'/H'_{max}

H'_{max} = Ln S, where S is the number species

The similarity of species composition between two locations was determined using Ellenberg index. Ellenberg is a modification of Jaccard index, with the integration of species abundance in the equation. While Sørensen and Jaccard index treats every species equally, Ellenberg index gives more weight for species having higher abundance. For community having low evenness index, Ellenberg is more appropriate than index of Sørensen or Jaccard.

$$IS_E = \frac{Mc:2}{Ma + Mb + (Mc:2)} \text{ x } 100\ \%$$

Where:
Mc: Biomass or other quantitative measures of common species;
Ma: Biomass or other quantitative measures of species found only in the first community;
Mb: Biomass or other quantitative measures of species found only in the second community

The similarity of species composition in street trees was also compared with that of natural forest from literature (Kusumo et al. 2016).

RESULTS AND DISCUSSION

Species diversity

The species diversity of road trees in five sites was low, as indicated by the low species richness (S) and diversity index (H′), while the evenness index was considered medium (Table 1). The largest number of trees was found in Palembang and Bengkulu, which was only 26. These two cities also had the highest H′. In term of diversity, the roadside trees in five urban areas in this study did not represent the natural vegetation of Sumatra which has very high diversity (Whitten et al. 1984; Laumonier 1997). In other cities of Sumatra, the total species of roadside trees was also low, such as in Medan, the capital of North Sumatra Province, which was only 33 species (Purwasih et al. 2013) and in Pekanbaru, the capital of Riau Province, which was only 13 species (Nursal et al. 2005).

The species diversity in this study was affected by the size of the city (Table 1). Palembang and Bengkulu, a large and a medium-sized cities, had more species and higher species diversity index than the three smaller cities, Curup, Argamakmur and Pematang Siantar. In general, the diversity of roadside size increases with increasing size of the city. The number of street tree species in Medan (Purwasih et al. 2013), the largest city in Sumatra, was higher than that in five cities in this study and that in Pekanbaru (Nursal et al. 2005), while Jakarta, the largest city in Indonesia, had 119 tree species along the roadside (Nasrullah and Suryowati 2009).

Unlike the natural forest in Sumatra which has no single dominant species, the roadside trees in three cities in this study, namely Bengkulu, Curup and Pematang Siantar, was dominated by *Swietenia macrophylla*, constituting more than 40% of the total roadside trees in each city, while the roadside trees in Argamakmur was dominated by *Polyalthia* *longifolia,* constituting more than 65% of the total trees. In every city in this study, only six or fewer species constituted more than 80% of all the trees, and in Argamakmur, 88.5% of the trees was composed only by two species, namely *P. longifolia* and *Mimusops elengi* (Table 2). In Medan, five species constituted 90% of all the trees (Purwasih et al. 2013), while in Jakarta, 10 species comprised 79% of all the trees (Nasrullah and Suryowati 2009).

Some experts have set a limit on the maximum percentage of a single species planted on roadside. Barker (1975) proposed that any single species of trees categorized as liberal use should not exceed 5% of the total trees in streets, while for trees categorized as limited use, the maximum number was 3%, and for those categorized as candidate use the maximum number was 2%. Miller and Miller (1991) increased the limit of liberal use to 10%. Richards (1993), however, said that this simple numerical limits had no scientific basis and he believed that species equity was a poor standard for selecting street trees. Instead, he stated that Street tree diversity should relate to

While there are no scientific or legal bases for setting the limit of single species proportion in street tree population, or the ideal value of species richness or species diversity index for a city park, it is believed that high diversity of species and genera in urban forest is essential for the health and sustainability of urban trees (Raupp et al. 2006). In addition, with the continuing decline of natural forest, urban forest, including roadside trees, should be utilized to promote species diversity (Alvey 2006; Nielsen et al. 2014). It is, therefore, important to increase the diversity of street tree species, especially for Sumatra nbIsland, where much of its natural forest has been converted into single-species plantation, mainly oil palm (Saxon and Roquemore 2011), and even conservation forest areas have also been illegally cleared (FWI 2011). Increasing species diversity in roadside trees in Sumatra will help conserve the biodiversity on this island. Also, studies show that increasing biodiversity in urban ecosystems can have a positive impact on the quality of life (Chivian and Bernstein 2004; Fuller et al. 2007).

Species composition

Of the 44 species found in 5 cities, 27 were introduced, and only 17 were native, and the top five dominant species were all introduced (Table 4). The species composition of roadside trees in all sites had zero similarity with natural forest in Sumatra (Kusumo et al. 2016). Among the sites, however, the similarities in species composition were high, with scores between 57%-82% using Ellenberg index, despite differences in altitude (Table 3). Argamakmur which is located in lowland had 82% similarity with Curup and Pematang Siantar which are located in high altitude. Likewise, Palembang a lowland city had 72% similarity with Pematang Siantar. High similarity among five cities despite differences in altitude confirms the statement of McKinney (2006) that urbanization homogenizes the ecosystems.

Among 44 species, *S. macrophylla*, an introduced species, had the highest percentage in this study. The same species was also found the most dominant in Jakarta (Nasrullah and Suryowati 2009) and the second most dominant in Pekan Baru (Nursal et al. 2005). The next four most dominant species in this study were *Mimusops elengi, Polyalthia longifolia, Roystonea regia* and *Samanea saman*, all of which are introduced. Only in Bengkulu, a native species *Casuarina equisetifolia* had a large percentage (10.6%), because one of the streets studied was located along the natural beach forest dominated by *C equisetifolia*.

Table 1. Species richness (S), index of species diversity (H′) and evenness (E)

City	S	H'	E
Palembang	26	2.03	0.62
Bengkulu	26	2.08	0.64
Curup	19	1.80	0.61
Pematang Siantar	10	1.46	0.63
Argamakmur	7	1.05	0.54

Table 2. The dominant species of roadside trees in three small cities, a medium-size city, and a large city

Species	Abundance (%)
Small city	
Curup	
Swietenia macrophylla	47
Mimusops elengi	22
Samanea saman	7
Hura crepitans	5
Total	81
Argamakmur	
Polyalthia longifolia	65
Mimusops elengi	24
Total	89
Pematang Siantar	
Swietenia macrophylla	45
Mimusops elengi	25
Roystonea regia	11
Samanea saman	9
Total	90
Medium-size city	
Bengkulu	
Swietenia macrophylla	43
Casuaria equisetifolia	10.6
Diallum indum	10.4
Tectona grandis	8.8
Polyalthia longifolia	5.2
Angsana	4.8
Total	82
Large city	
Palembang	
Mimusops elengi	24
Pterocarpus indicus	21
Swietenia macrophylla	18
Roystonea regia	15
Samanea saman	10
Total	88

Table 3. The list of species, its family, abundance and origin

Species	Family	Abundance (%)						Origin
		Palembang	Bengkulu	Curup	Arga-makmur	Pematang Siantar	Average	
Swietenia macrophylla King	Meliaceae	18.15	43	46.76	45.40	2.80	31.22	Introduced
Mimusops elengi L.	Sapotaceae	24.20	3.2	22.25	24.69	23.50	19.57	Introduced
Polyalthia longifolia Sonn	Annonaceae	1.99	5.2	1.13	6.56	65.00	15.98	Introduced
Roystonea regia (Kunth) O.F.Cook	Arecaceae	14.88	2.4	2.54	10.62	1.40	6.37	Introduced
Samanea saman (Jack) Merr.	Fabaceae	10.03		7.32	9.37		5.34	Introduced
Pterocarpus indicus Wild	Fabaceae	20.83	4.8				5.13	Native
Casuarina equisetifolia L.	Casuarinaceae	0.02	10.6			0.70	2.26	Native
Hura crepitans L.	Euphorbiaceae	1.28	0.6	4.51		0.60	1.40	Introduced
Elaeis guineensis Jack	Arecaceae	1.89				4.50	1.28	Introduced
Terminallia catappa L.	Combretaceae	0.32	3.4		0.62		0.87	Native
Cerbera odollam Gaerth	Apocynaceae	1.21	0.6	0.28			0.42	Native
Delonix regia (Boj. ex Huff.) Raf.	Fabaceae	1.77	0.2				0.39	Introduced
Cocos nucifera L.	Arecaceae	0.02	1.8			0.10	0.38	Native
Syzygium polyanthum (Wight) Walp.	Myrtaceae	0.69	0.8				0.30	Native
Juniperus chinensis L.	Cupressaceae	0.15				1.30	0.29	Introduced
Tabebuia aurea (Silva Manso) Benth. & Hook.f. ex S.Moore	Bignoniaceae	1.13					0.23	Introduced
Ficus benjamina L.	Moraceae	0.05	0.2	0.28		0.10	0.13	Native
Artocarpus heterophyllus Lam.	Moraceae	0.66	0.4				0.08	Introduced
Acacia mangium Willd.	Fabaceae	0.15	0.2				0.07	Introduced
Melaleuca cajuputi Powell	Myrtaceae	0.10					0.02	Native
Terminallia mantally H.Perrier.	Combretaceae	0.12					0.02	Introduced
Artocarpus altilis (Parkison) Forsberg.	Moraceae	0.12					0.02	Introduced
Erythrina crista-galli L	Fabaceae	0.05					0.01	Introduced
Acacia auriculiformis A. Cunn. ex Benth.	Fabaceae	0.05					0.01	Introduced
Syzygium aqueum (Burm f.) Alston	Myrtaceae	0.05					0.01	Native
Dialium indum L	Fabaceae		10.4				2.08	Native
Mangifera indica L.	Anacardiaceae		0.8				0.16	Introduced
Leucaena leucochepala (Lam) de Wit.	Fabaceae		0.6				0.12	Introduced
Averrhoa carambola L	Oxalidaceae		0.4				0.08	Native
Maesopsis eminii Engl.	Rhamnaceae		0.2				0.04	Introduced
Durio zibethinus L	Malvaceae		0.2				0.04	Native
Lagerstroemia floribunda Jack 1820	Lythraceae		0.2				0.04	Introduced
Lannea coromandelica (Houtt.) Merr.	Anacardiaceae		0.4				0.08	Introduced
Muntingia calabura L.	Muntingiaceae		0.4				0.08	Introduced
Tectona grandis L.f.	Lamiaceae		8.8	0.28			1.82	Introduced
Felicium decipiens (Wight & Arn.) Thwaites ex Hook.f.	Sapindaceae		0.2	2.54			0.55	Introduced
Duranta erecta L.	Verbenaceae			2.54			0.51	Introduced
Pinus merkusii Jungh. & de Vriese	Pinaceae			2.25			0.45	Native
Cinnamomum burmannii (Nees & T.Nees) Blum	Lauraceae			2.82			0.56	Native
Alstonia scholaris L. R. Br.	Apocynaceae			1.69			0.34	Native
Psidium guajava L.	Myrtaceae			0.85			0.17	Introduced
Nephelium lappaceum L.	Sapindaceae			0.56			0.11	Native
Areca catechu L.	Arecaceae			0.56			0.11	Native
Annona muricata L.	Annonaceae			0.56	2.18		0.55	Introduced

Table 4. Similarity in species composition among locations (using Ellenberg index)

	Similarity index (%)				
	Palembang	Bengkulu	Curup	Arga makmur	Pematang Siantar
Palembang	100				
Bengkulu	70	100			
Curup	62	47	100		
Argamakmur	58	66	77	100	
Pematang Siantar	72	57	82	82	100
Primary forest	0	0	0	0	0

The top five introduced species have characteristics that make them suitable to be planted along roadsides. *Swietenia macrophylla* has an umbrella-shaped crown, makes it suitable for a shade tree. In addition, this species can tolerate a wide range of soil and environmental conditions (Krisnawati et al. 2011). Like *S. macrophylla, S. saman* has an umbrella-shaped crown. It thrives in tropical and subtropical climate regimes, ranging from wet to seasonal dry climate and can adapt to a wide range of soil types and pH (Staples and Elevitch 2006). *Mimusops elengi* ,in addition to having medicinal value, also has an elegant shape and fragrant flowers (Gami et al. 2012) *Polyalthia longifolia* var *pendula* with its columnar-shaped crown can be used to frame the view and the structure of a landscape (Mitra et al. 2013). *Roystonea regia* a native of Cuba is valued as an ornamental palm and has fragrant flowers (Connor 2002).

The higher number of introduced or exotic species in roadside trees and in urban ecosystem, in general, was also found in many parts of the world. Exotic species constituted 72% of roadside trees in Fortaliza, Brazil (Moro and Castro 2015), 85.1% of vegetation in public places in Santiago, Chile (Figueroa et al. 2016), and 77% of urban parks in Bangalore, India 77% (Nagendra and Gopal 2010). More exotic species were also found in ten Nordic cities (Sjöman et al. 2012), in Halifax, Canada (Turner et al. 2005). In Beijing, however, the percentage of exotic species was only 53%, slightly higher than the native ones (Zhao et al. 2010). The focus on ornamental value is one of the reasons why exotic species dominate urban vegetation (Turner et al. 2005).

For biodiversity conservationists, the presence of exotic species is undesirable because the exotic species may bring deleterious impacts on native species through competition and introduction of pest and diseases. The exotic chestnut imported from Japan to the US in the 19th century almost brought the native American chestnut (*Castanea dentata*) to extinction due to chestnut blight which came with the exotic species (Jordan 2008). In Oregon, exotic grass species caused the decline of plant community diversity and abundance of native grass species (Davies 2011). To prevent the detrimental effect of exotic species, many parties have advocated for increasing native plant species in urban ecosystems (Wilde et al. 2015). The use of native species for roadside trees not only help conserve the species but also help introduce local people to the local plant species (Savard et al. 2000). The rare presence of native species in roadside trees will alienate people of their local species and may reduce local botanical knowledge and support biodiversity conservation (McKinney 2006; Dearborn and Kark 2010).

Increasing native species and conserving biodiversity can be done simultaneously if every city plants mostly its native species. However, the city planner should also consider the aesthetic value of the tree, the landscaping objective, and the health of the urban street tree population, the seedling availability, the site condition, the planting techniques, and the maintenance management (Li et al. 2011). These desired traits for roadside trees may be conflicting with each other (Wilde et al. 2015), so it will be hard to find a single species having those traits. The most important criterion for a road tree species may be its ability to cope with harsh environment of street (Sjöman and Nielsen 2010), because the trees must survive first before they can provide ecosystem services. Pioneer native species may be good choices, since they are able to live in harsh condition, so they do not need intensive care. To get mass seedlings of pioneer native species, plant tissue culture can be used.

In conclusions, the roadside trees in five cities of Sumatra Island, Indonesia, had relatively low diversity. More introduced species than the native ones were found, both in number of species and number of individuals. The diversity and composition of species did not represent the native forest of Sumatra. Therefore, a great variety of native species should be planted for roadside trees.

ACKNOWLEDGEMENTS

We gratefully acknowledge the comments of reviewers for the improvement of this paper. We also thank M. Fajrin Hidayat for making the map of study sites.

REFERENCES

Abood SA, Lee JSH, Burivalova Z, Garcia-Ulloa J, Koh LP. 2015. Relative contribution of the logging, fiber, oil palm and mining industries to forest loss in Indonesia. Conserv Lett 8 (1): 58-67.

Alvey AA. 2006. Promoting and preserving biodiversity in the urban forest. Urban Forestry & Urban Greening 5 (4): 195-215.

Barker P. 1975. Ordinance control of street trees. J Arboricult 11: 212-215.

Central Bureau of Statistics of Bengkulu City. 2017. Bengkulu City in Figures 2016. Central Bureau of Statistics of Bengkulu City, Bengkulu.

Central Bureau of Statistics of North Bengkulu District. 2017. North Bengkulu District in Figures 2016. Central Bureau of Statistics of North Bengkulu District, Argamakmur.

Central Bureau of Statistics of Palembang City. 2017. Palembang City in Figures 2016. Central Bureau of Statistics of Palembang City, Palembang.

Central Bureau of Statistics of Pematang Siantar City. 2017. Pematang Siantar City in Figures 2016. Central Bureau of Statistics of Pematang Siantar City, Pematang Siantar.

Central Bureau of Statistics of Rejang Lebong District. 2017. Rejang Lebong District in Figures 2016. Central Bureau of Statistics of Rejang Lebong District, Curup.

Chiesura A. 2004. The role of urban parks for the sustainable city. Landsc Urban Plann 68: 129-138.

Chivian E, Bernstein AS. 2004. Embedded in nature: human health and biodiversity. Environ Health Perspect 112 (1): 12-13

Connor KF. 2002. *Roystonea regia* (Kunth) O.F. Cook. In: Vozzo JA (ed.).. Tropical Tree Seed Manual. USDA Forest Service Agriculture Handbook 721, Washington, DC.

Davies KW. 2011. Plant community diversity and native plant abundance decline with increasing abundance of an exotic annual grass. Oecologia 167: 481-491.

Dearborn DC, Kark S2010. Motivations for conserving urban biodiversity. Conserv Biol 24: 432-440.

Donovan GH, Butry DT. 2011. The effect of urban trees on the rental price of single-family homes in Portland, Oregon. Urban Forestry & Urban Greening10 (3): 163-168.

Fan C, Myintand SW, Zheng B. 2015. Measuring the spatial arrangement of urban vegetation and its impacts on seasonal surface temperatures. Progress in Physical Geography 39 (2): 199-219.

Figueroa JA, Teillier S, Guerrero-Leiva N, Ray-Bobadilla C, Rivano S, Saavedra D, Castro SA. 2016 Vascular flora in public spaces of Santiago, Chileco de Santiago, Chile. Gayana Bot. 73 (1): 85-103 .

Fuller RA, Irvine KN, Devine-Wright P, Warren PH, Gaston KJ. 2007. Psychological benefits of green space increase with biodiversity. Biol Lett 3: 390-394.

FWI. 2011. The Portrait of Indonesian forest 2000-2009. Forest Watch Indonesia, Jakarta

Gami B, Pathak S, Parabia M. 2012. Ethnobotanical, phytochemical and pharmacological review of *Mimusops elengi* Linn. Asian Pac J Trop Biomed. 2(9): 743–748. doi: 10.1016/S2221-1691(12)60221-4

Jim CY, Chen CY. 2008. Assessing the ecosystem service of air pollutant removal by urban trees in Guangzhou (China). J Environ Manag 88 (4): 665-676.

Jordan M. 2008. The American chestnut. A legacy to come. Compass 11:3-5. USDA Forest Service.
Krisnawati H, Kallio M, Kanninen M. 2011 *Swietenia macrophylla* King: Ecology, Silviculture and Productivity. CIFOR, Bogor.
Kusumo A, Bambang AN, Izzati M. 2016. Struktur vegetasi kawasan hutan alam dan hutan rerdegradasi di Taman Nasional Tesso Nilo. Jurnal Ilmu Lingkungan 14 (1): 19-26. [Indonesian]
Laumonier Y. 1997. The vegetation and physiography of Sumatra. Kluver Academic Press, Doordrecht.
Laverne RJ, Winson-Geideman K. 2003. The influence of trees and landscaping on rental rates at office buildings. J Arboric 29 (5): 281-290
Li YY, Wang XR, Huang CL. 2011.Key street tree species selection in urban areas. African J Agric Res 6 (15): 3539-3550.
McKinney ML. 2006. Urbanization as a major cause of biotic homogenization**.** Biol Conserv 127 (3): 247-260.
McPherson EG, Simpson JR, Peper PJ, Maco SE, Xiao Q. 2005. Municipal forest benefits and costs in five US cities. J For 103: 411-416.
Miller RH, Miller RW. 1991. Planting survival of selected street tree taxa. J Arboricult 17: 185-191.
Mitra S, Choudari IG, Seem SK. 2013. A handbook of landscape- a guide. Directorate General of Central Public Work Department. New Delhi.
Moro MF, Castro ASF. 2015. A checklist of plant species in the urban forestry of Fortaleza, Brazil: where are the native species in the country of megadiversity? Urban Ecosyst 18: 47-71.
Mueller-Dombois D, Ellenberg H. 1974. Aims and Methods in Vegetation Ecology. John Willey & Sons, New York.
Nagendra H, Gopal D. 2010. Tree diversity, distribution, history and change in urban parks: studies in Bangalore, India. Urban Ecosyst. DOI 10.1007/s11252-010-0148-1
Nasrullah N, Suryowati C. 2009. The diversity of trees in roadside greenbelts in Jakarta. In: Proceedings of the Green City International Symposium. Department of Landscape Architecture, Bogor Agricultural University, Bogor.
Nielsen AB. van den Bosch M, Maruthaveeran S, van den Bosch CK. 2014. Species richness in urban parks and its drivers: A review of empirical evidence. Urban Ecosyst 17: 305-327
Nursal Y, Fauziah, Zam. 2005 SI. Keragaman jenis pohon pelindung jalan pada jalur hijau kota pekanbaru. Jurnal Pilar Sains 4 (1) 56-62. [Indonesian]
Purwasih H, Latifah S, Sukmana A. 2013. Identifikasi Jenis Tanaman di Beberapa Jalur Hijau Jalan Kota Medan. Peronema For Sci J 2 (2): 108-116. [Indonesian]
Raupp MJ, Cumming MJ, Raupp EC. 2006. Street tree diversity in eastern North America and its potential for tree loss to exotic borers. Arboricult Urban For 32 (6): 297-304.
Richards AN. 1993. Reasonable guidelines for street tree diversity. J Arboricult 19 (6): 344-350.
Savard JP, Clergeau P, Mennechez G. 2000. Biodiversity concepts and urban ecosystems. Landsc Urban Plan 48: 131-142.
Saxon E, Roquemore S. 2111. Palm Oil. In: Boucher D, Elias P, Lininger K, et al. (eds.). The Root of the Problem. What is the driving force of tropical deforestation today? Tropical Forest and Climate Initiative. Union of Concerned Scientists. Carnegie Council, New York.
Sjöman H, Nielsen AB. 2010. Selecting trees for urban paved sites in Scandinavia - A review of information on stress tolerance and its relation to the requirements of tree planners. Urban For Urban Green 9: 281-293
Sjöman H, Östberg J, Bühler O. 2012. Diversity and distribution of the urban tree population in ten major Nordic cities. Urban For Urban Green. 11 (1): 31-39.
Staples GW, Elevitch CR. 2006. Samanea saman (rain tree) ver. 2.1. in Elevitch CR (ed.). Special Profile for Pacific Island Agroforestry. Permanent Agricultural Resources (PAR), Holualoa, Hawaii.
Turner K, Lefler L, Freedman B. 2005. Plant communities of selected urbanized areas of Halifax, Nova Scotia, Canada. Landsc Urban Plan 71: 191-206.
Whitten AJ, Damanik SJ, Anwar J, Hisyam N. 1984. The ecology of Sumatra. Gadjah Mada University Press, Yogyakarta.
Wilde HD, Gandhi KJK, Colson G. 2015. State of the science and challenges of breeding landscape plants with ecological function. Hortic Res 2: 14069. DOI: 10.1038/hortres.2014.69.
Zhao C, Sander HA. 2015. Quantifying and mapping the supply of and demand for carbon storage and sequestration service from urban. trees. PLoS ONE 10 (8): e0136392. DOI: 10.1371/journal.pone.0136392.
Zhao J Z. Ouyang, Zheng H, Zhou W, Wang X, Xu W, Ni Y. 2010.Plant species composition in green spaces within the built-up areas of Beijing, China. Plant Ecol 209: 189-204.