

Maintaining tree biodiversity in urban communities on the university campus

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Abstract. *Susilowati A, Rangkuti AB, Rachmat HH, Iswanto AH, Harahap MM, Elfiati D, Slamet B, Ginting IM. 2021. Maintaining tree biodiversity in urban communities on the university campus. Biodiversitas 22: 2839-2847.* Many universities worldwide have green spaces (GS) as an integral part of their campuses because of significant benefits for ecological function and urban communities. University of Sumatera Utara (USU) campus is located in urban area of Medan city, Indonesia, with a total area of 120 hectares. The campus offers various outdoor spaces for resting, sports, playgrounds and other psychological benefits. The campus also offers vital benefits for its surrounding environment, such as improving air quality and ensuring pleasant climatic conditions and biodiversity. One of the important functions of USU GS is to become an area for preserving tree diversity in urban communities, which in busy urban communities is sometimes a little overlooked. This research aimed to identify the species diversity, abundance, utilization, and conservation status of trees across 120 hectares of USU Campus using the field inventory method. Results revealed a total of 7333 individual trees of 121 species from 37 families. The most common tree species is *Swietenia macrophylla* (18.37%), while the dominant families are Fabaceae. Margalef index and the Shannon-Wiener diversity index reaching 13.48 (good) and 3.41 (high). Based on the utilization status, 55.43% of the tree species were wood producers, 45.34% were pollutant absorbers, while the lowest percentage functioned as latex producers (0.12%). About 70 species (57.85%) were native species, while 51 species (42.15%) were exotic. According to the International Union for Conservation of Nature (IUCN), 50 species (41.33%) were listed as the least concern status, 8 species (6.61%) with a vulnerable status, 4 species (3.30%) with a near-threatened status and 2 species (1.66%) with and endangered status. The result from this study also showed that GS at USU not only performed its main function as a shade or an oxygen producer (environment services) but also maintained the tree biodiversity and a means of ex-situ conservation for many trees species. Trees threatened by anthropogenic activities, particularly tree felling for infrastructural developments were still found in the campus area. Therefore, sustainable conservation efforts should be geared towards ensuring the continued existence of the trees to maintain their ecological functions.

Keywords: Campus, diversity, green space, the conservation efforts, utilization

INTRODUCTION

The university campus green spaces (GS) have recently received more attention as urban green areas than in the past (Rahnema et al. 2019). Many universities are currently trying to design their campuses and create features such as urban ecosystems' function (Tudorie et al. 2020). They also apply environmentally friendly principles to the well-being of the university communities, the cities, and the natural environment (Speake et al. 2013). As a part of urban green area in the city, the university campus does not only focus on building and academic facilities but also on a suitable place for absorbing heat, reducing the noise from the surrounding streets, reducing dust, delivering aesthetics, and forming a habitat for various types of birds or other animals (Gulwadi et al. 2019). Campus open space can also serve as protection from direct sunlight, heavy rain, wind, bad views, as well as aesthetic appeal. In this way, the open space can be made as a place of recreation and relaxation

and can function as a natural laboratory for education and research (Hanan 2013).

Cooper and Wischemann (1990) and Abu-Ghazzeh et al. (1999) proposed that the outdoor area of campus should be an element associated with different activities and uses. They also suggested that a campus provide outdoor spaces that can primarily be used to study, socialize, and meet areas. Campus should be peaceful, relaxing, tranquil, serene, comfortable and green, which is needed to reduce stress and maintain mental health. Moreover, Scholl et al. (2015) stated that a university campus should be promoted as a model environment for sustainable development. In line with this concept, choosing the correct types of plants will determine the expected output of green space. As known, plants are elements of a landscape that play an important role in creating aesthetic and ecological functions (Poursafar 2016; Feng et al. 2019; Podhrazka et al. 2021). Aesthetically, plants must create a comfortable atmosphere for the surrounding environment, with the right composition and selection of plants (Lau et al. 2014). The

aesthetic value of the plants is obtained from a combination of the color of the constituent organs (leaves, stems, flowers), the physical form of the plant (stems, branches, canopy), plant texture, and plant composition (MacKenzie and Gibbons 2019). Functionally, the selected plants must improve the environmental conditions through their ability to absorb pollutants, creating a suitable microclimate for the surrounding community and a physically comfortable atmosphere (Ives et al. 2016). The plants also function as physical barriers, climate control, visual control, erosion control, habitat for wildlife, and aesthetic values (Sivarajah et al. 2018).

The University of Sumatera Utara (USU) campus is one of the green spaces in urban area of Medan city covering an area of 120 hectares (Susilowati et al. 2017). In December 2020, USU was ranked at 11th place by the University of Indonesia (UI) Green Metric, an institution established by the UI to assess universities' commitment and actions towards greening and environmental sustainability. USU's commitment to caring for the campus environment is exhibited through regular tree planting activities every year. As part of urban green space, the campus area has an outstanding contribution to biodiversity conservation to enhance socio-ecological systems' resilience (Le Roux 2014). The tree community in university campuses can become special defining feature (Zhao et al. 2010). Trees define the landscape by their presence and beauty (Lau et al. 2014). Long-lived tree species, in particular, can endure periodic reproductive failures without direct negative demographic consequences (Stagoll et al. 2012). The higher number of tree species can increase the associated species number and ecological niches (Suratman 2012). Moreover, the existence of trees provides many ecosystem services such as species conservation, soil erosion prevention, and habitat preservation for plants and animals (Mincey et al. 2013). Therefore, information on the diversity, composition, and tree species communities is very important in biodiversity conservation efforts for planning and implementation (Suratman 2012).

The trees as the element of campus green space should have benefits that can be felt by campus residents and the surrounding community (Nero et al. 2017). In general, previous tree planting in green space was only for dietary needs, such as nuts and fruit (Carol et al. 2005), timber production (Webb 1999), wood and latex (Sudha and Ravindranath 2000) or firewood (Kuchelmeister 1998). Recently, selecting trees is based not only on human needs but also on the physiological, social, and cultural needs of urban dwellers (Dwyer et al. 1991). Trees play a social role in relieving tension and creating a calm environment that helps quiet residents' minds in urban environments (Rode et al. 2016). For people living in urban areas, the existence of campus green spaces brings many benefits, such as reduced household pollution material exposure (Nowak et al. 2014). Vegetation density in green spaces is associated with pollution mitigation (Selmi et al. 2016; Scholz et al. 2018). Bushes instead of trees may retain more pollution particles and reduce concentrations (Wania et al. 2012). Diversity of tree species of evergreen, conifer, and

deciduous tree species has complementary air-pollution barriers (Hernandez et al. 2017) and uptake patterns, and it provides maximum air-quality improvements (Chen et al. 2017). Knowledge of a community's tree vegetation will enable people to have positive relationships with trees and promote diversity and sustainable tree management. Therefore, this study aims to identify the species diversity, abundance, utilization, and conservation status of trees across 120 hectares of USU Campus.

MATERIALS AND METHODS

Research location

This study was conducted at the University of Sumatera Utara campus (3.33°N and 98.39°E) in Padang Bulan, Medan, Indonesia, with 120 hectares (Figure 1). The university Padang Bulan campus is located in Medan City with 2.5-37.5 m asl. The minimum temperature ranges from 23.2°C-24.3°C, and the maximum temperatures range from 30.8°C-33.2°C. The average air humidity in Medan City ranges from 84-85%. The average wind speed is 0.48 m/sec, while the total evaporation rate per month is 104.3 mm, and the soil type is inceptisol (BPS Medan 2020). At the beginning of the USU campus establishment in 1952, the land on the campus was rice fields and swamps (Rauf A, personal communication 10st January 2021). And since the campus development, USU has continued to carry out tree planting activities until today.

Data collection and analysis

Data and material collection were conducted with research permit number 1125.UN5.1.15/KRK/2020. Field inventory methods were adopted for tree data collection. Through this field inventory, all the tree species encountered within a 120-hectare area of USU campus Padang Bulan. Each species were observed and measured its morphological characters, diameter, and height. The species also counted for its number, frequency, abundance, conservation status, and utilization. Tree species identification was made with the aid of tree identification guidebooks. Local names were also used to identify taxonomic species. Specimens that were ambiguous and had not been identified were taken for further identification in the Botany and taxonomy laboratory, FORDIA (Forestry research and Innovation Agency) Ministry of Environment and Forestry-Bogor. Herbarium collections were made, and vouchers of trees collected were also deposited. All recorded species were measured for relative density (RD), richness (d), diversity (H'), and evenness (E).

Relative density of species (RD) is measured using formula:

$$\text{Relative density of species (RD)} = \frac{\text{Number of individual species}}{\text{Total number of trees}} \times 100\%$$

$$\text{Relative abundance of species (Pi)} = \frac{\text{Relative density of species}}{100}$$

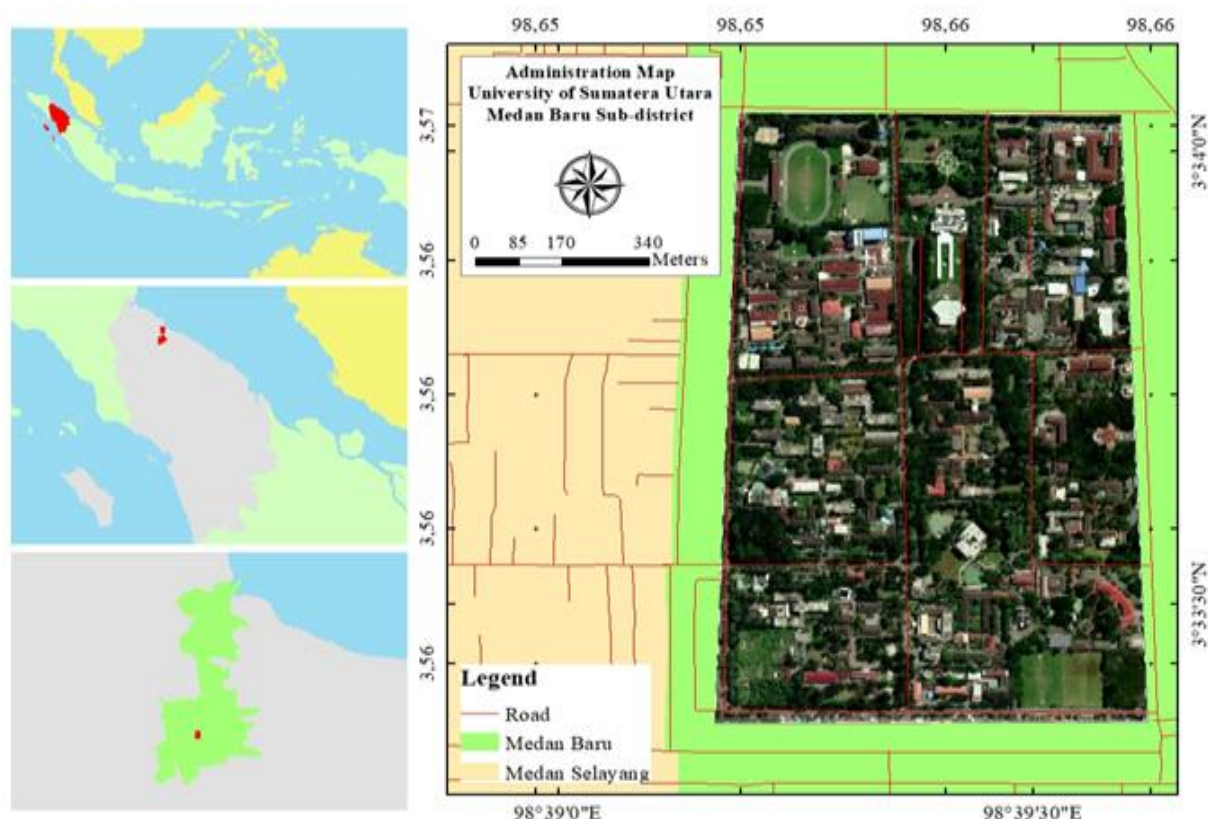


Figure 1. Research location in USU Campus, Medan, Indonesia

The various species were scored according to their relative densities (Ogwu et al. 2016), i.e., abundant ($RD \geq 5.00$), frequent ($4.00 \leq RD \leq 4.99$), occasional ($3.00 \leq RD \leq 3.99$), rare ($1.00 \leq RD \leq 2.99$) and threatened/endangered ($0.00 < RD \leq 1.00$).

From each site, diversity indices were determined using Magurran (2004) as the following:

Margalef species richness index (d) was used as a simple measure of species richness, according to Margalef (1958).

$$d = (S - 1) / \ln N$$

Where, S = total number of species; N = total number of individuals in the site; \ln = natural logarithm.

The species richness index (d) criteria as follows: $d \leq 2.5$: low; $2.5 < d \leq 4.0$: moderate; $d \geq 4.0$: high.

Shannon-Weiner index (H), which is the measure of diversity within site, was used according to Shannon and Wiener (1949).

$$H' = - \sum P_i \ln P_i$$

Where, $P_i = S / N$; S = number of individuals of one species; N = total number of all individuals in the site; \ln = logarithm to base e .

The diversity index criteria as follow: $H' \leq 1$: low diversity; $1 < H' \leq 3$: moderate diversity; $H' \geq 3$: high diversity.

Evenness index (E) is measured using the formula:

$$E = S / (\log n_i - \log n_s)$$

Where, S = number of species in observed plot; n_i , n_s = the density value of most and least important species, respectively.

The dispersion of a species is categorized based on Krebs (1989) as low uniformity if $0 < E < 0.5$ and high uniformity if $0.5 < E < 1$.

RESULTS AND DISCUSSION

Species composition and abundance

Information on tree composition, species diversity, and community wealth is very important in planning and conservation efforts for biodiversity (Suratman 2012). For exemplary conservation, understanding the composition of tree species and their constituent elements is needed (Farhadi et al. 2013). Monitoring the existence and the composition of vegetation is also required to maintain biodiversity and habitat (Attua and Pabi 2013). Results from the inventory conducted found that a total of 7333 trees were found in the campus area consisting of 121 different species, classified into 37 families. The species diversity and richness were also evaluated in this research. The value of each of the indices includes the Shannon Wiener Index, Simpson Diversity, and Species Evenness were 3.41, 13.43 and 0.71, respectively. *Swietenia*

macrophylla ranked the highest RD with 1347 individuals (18.37%), followed by *Mimusops elengi* with 707 individuals (9.64%). Table 1 revealed the ten highest ranks based on the diversity value of all trees on the USU Campus. Based on Table 1, *Swietenia macrophylla* had the highest relative density, relative abundance, species diversity, and species richness value, followed by *M. elengii* and *Polyanthia longifolia*. The high value of mahogany is due to the intensive planting activities carried out for this species. There is a particular block for mahogany, often referred to as the tri dharma forest with the number of individuals. *M. elengi* can be found along the campus road, with the number of individual trees reaching 707 individuals (9.64%).

Based on the family value, Meliaceae had the highest RD value (21.62%), followed by Fabaceae (16.31%) and Sapindaceae (16.19%). Based on the species diversity index, Fabaceae was the highest (17.89%). According to Magurran (2004), the diversity index value can range from 0-7, with the following criteria: 0-2 (low), 2-3 (moderate), and > 3 (high). Based on these criteria, the diversity of tree species on the USU campus was high. The species diversity index contains important information about a tree community. The larger the sample area and the more species found; the species diversity index value would tend to be higher. Relatively low diversity index values were generally found in tree communities that reached climax. Based on the diversity index value (Table 2), it could be

seen that the diversity of species within the family for trees was low because it had a value of less than 2 for all families. This showed the need for enrichment activities so that each family would have a variety of species. The evenness index value on the USU campus was 0.71 and was classified as high, which means that the trees community classified as stable (Krebs 1989).

According to Wilsey and Potvin (2000), sometimes species richness is positively correlated with species diversity. However, environmental conditions throughout the study area were heterogeneous so that an increase in diversity could result in a decrease in species richness. This condition was possible because the number of individuals at each station varied greatly. Evenness will be maximum and homogeneous if all species have the same number of individuals at each observation location. This phenomenon is scarce because each species can adapt to and tolerate a different life history pattern. In addition, environmental conditions in nature are very complex and varied. At the micro-level (microsites), the environment may be homogeneous, but at the macro-level (macrosites), it consists of heterogeneous microsites. The same individual will adapt relatively to the same microsites. This phenomenon can be identified by detecting the distribution and the association patterns of species in a community, which usually produce most of the species with group distribution and association patterns that tend to be positive (Tilman et al. 2014; Daly et al. 2018).

Table 1. The ten species with highest Relative density (RD), Relative abundance (Pi), Species diversity (d), and Species richness (H')

Species	RD	Pi	d	H'
<i>Swietenia macrophylla</i>	18.37 ± 2.54	0.18 ± 0.01	1346.89 ± 0.00	0.31 ± 0.08
<i>Mimusops elengi</i>	9.64 ± 0.64	0.09 ± 0.01	706.89 ± 0.00	0.22 ± 0.08
<i>Polyalthia longifolia</i>	8.52 ± 0.49	0.08 ± 0.01	624.89 ± 0.00	0.21 ± 0.09
<i>Syzygium paniculatum</i>	4.55 ± 0.11	0.04 ± 0.01	333.89 ± 0.00	0.14 ± 0.09
<i>Tamarindus indica</i>	4.16 ± 0.09	0.04 ± 0.01	304.89 ± 0.00	0.13 ± 0.09
<i>Pterocarpus indicus</i>	3.94 ± 0.08	0.04 ± 0.01	288.89 ± 0.00	0.13 ± 0.09
<i>Mangifera indica</i>	3.71 ± 0.07	0.03 ± 0.01	271.89 ± 0.00	0.12 ± 0.09
<i>Adhenaanthera pavonina</i>	3.39 ± 0.05	0.03 ± 0.01	248.89 ± 0.00	0.11 ± 0.09
<i>Casuarina equisetifolia</i>	3.38 ± 0.05	0.03 ± 0.01	247.89 ± 0.00	0.11 ± 0.09
<i>Filicium decipiens</i>	3.31 ± 0.05	0.03 ± 0.01	242.89 ± 0.00	0.11 ± 0.09

Table 2. The ten families with the highest Relative density (RD), Relative abundance (Pi), Species diversity (d), and Species Richness (H')

Family	RD	Pi	d	H'
Meliaceae	21.62 ± 7.11	0.21 ± 0.07	4.89 ± 0.08	0.33 ± 0.11
Fabaceae	16.31 ± 1.39	0.16 ± 0.01	17.89 ± 5.86	0.29 ± 0.04
Sapindaceae	16.19 ± 3.05	0.16 ± 0.02	7.89 ± 0.60	0.29 ± 0.07
Annonaceae	9.01 ± 3.14	0.09 ± 0.03	5.89 ± 0.20	0.22 ± 0.08
Myristicaceae	7.05 ± 0.00	0.07 ± 0.00	6.89 ± 0.38	0.19 ± 0.09
Casuarinaceae	5.67 ± 1.40	0.05 ± 0.01	2.89 ± 0.01	0.16 ± 0.04
Anacardiaceae	3.79 ± 1.60	0.03 ± 0.01	3.89 ± 0.00	0.12 ± 0.06
Moraceae	3.78 ± 0.48	0.03 ± 0.00	10.89 ± 1.61	0.12 ± 0.02
Combretaceae	2.6 ± 0.70	0.02 ± 0.00	1.89 ± 0.04	0.09 ± 0.02
Araucariaceae	1.87 ± 0.16	0.01 ± 0.00	1.89 ± 0.04	0.07 ± 0.00

Woody species utilization, conservation status

The green space is associated with heat stress (Park et al. 2012), urban heat islands (Nowak et al. 2014), air pollution reductions (Ulmer et al. 2016). It is critical for protecting wildlife, watersheds, meads vegetation; provides air quality for a dense urban environment and recreational activities (Hernandez et al. 2017). The tree combination in green space also reduces dust (Tiwary et al. 2014), delivers aesthetics (Czaja et al. 2020), forms a habitat for various types of birds or other animals (Gulwadi et al. 2019), provides human need (Carol et al. 2005; Webb 1999) and serves as pollutant absorber (Gratani et al. 2016). The tree species on USU campus had various functions (Figure 2). Table 3 showed that the species on the campus functioned as a source of food and fruit (38.01%), wood (33.88%), energy (2.46%), medicine (42.15%), a source of fiber (2.47%), aesthetics (5.79%) and pollutants absorber (16.53%). Several species were known as food producers (*Mangifera indica*, *Persea americana*, *Durio zibethinus*, *Artocarpus artilis*, *Syzygium aqueum*, and *Averrhoa carambola*), wood producers (*Shorea leprosula*, *Intsia bijuga*, *Diospyros celebica*, *Tectona grandis*), biodiesel producers (*Sterculia foetida* and *Calophyllum inophyllum*), fiber producers (*Eucalyptus urophylla*, *Acacia mangium* and *Hibiscus tiliaceus*), medicine sources (*Prema corymbosa*, *Mimusops elengi*, *Schleichera oleosa*, *Moringa oleifera*, *Aquilaria malaccensis* and *Guazulma ulmifolia*), biopesticide producers (*Melia azedarach*, *Cerbera manghas*) and aesthetic trees (*Delonix regia*, *Casuarina equisetifolia* and *Bauhinia purpurea*).

Apart from these benefits, 16.53% of species on USU campus also served as important pollutant absorbers. This pollutant absorption function was closely related to the campus function as a green space. *Agathis dammara*, *Swietenia macrophylla*, *Myristica fragrans*, *Pithecellobium dulce*, *Cassia siamea*, *Polyalthia longifolia*, *Barringtonia asiatica*, *tanjung Mimosops elengi* are classified as lead absorber according to Rahayu (1995). *Acacia mangium*, *Cinnamomum verum*, and *Bauhinia purpurea* were also found in this location. These species were known to have a function to increase rainwater pH (Endes 2011). *Agathis dammara*, *Bauhinia purpurea*, *Leucaena leucocephala*, *Acacia mangium* and *Ficus benjamina* were known as good

CO₂ gas absorbers and oxygen producers (Dachlan 2011). *Lagerstroemia speciosa*, *Michelia champaca*, *Caesalpinia pulcherrima*, *Mimusops elengi*, *Bauhinia purpurea*, and *Spathodea campanulata* were known as effective carbon monoxide (CO) absorbers (Kusminingrum 2008). *Delonix regia*, *Mimusops elengi*, *Pterocarpus indicus*, *Cinnamomum verum*, *Swietenia macrophylla*, *Lagerstroemia speciosa*, and *Gmelina arborea* have also known as nitrogen dioxide (NO₂) absorbers (Sulistijorini 2009).

Besides its various benefits in supporting human needs and ecosystem function, USU campus also has an important role in conserving endangered tree species. Table 4 showed that 54.55% of the species in USU campus were listed in several categories based on International Union for Conservation of Nature (IUCN) Redlist. About 41.33% species were listed as least concerned status (*Schleichera oleosa*, *Magnolia champaca*), 6.61% as vulnerable (*Intsia bijuga*, *Podocarpus polystachyus*), 3.30% as near-threatened (*Dimocarpus longan*, *Swietenia mahagoni*), 1.66% as endangered (*Shorea parvifolia*, *Pterocarpus indicus*), and 0.82% as critical endangered (*Aquilaria malaccensis*), while 0.82% were listed into data deficient (*Myristica fragrans*). Only 55 species (45.46%) were not listed in IUCN. Based on these data, it could be concluded that USU campus is important for conserving tree species.

Table 3. The number of species based on its utilization

Utilization	Number of species	Number of individuals	Percentage (%)
Food	46	1392	38.01
Medicine	51	3048	42.15
Wood	41	4065	33.88
Biopesticide	2	4	1.65
Aesthetic	7	676	5.79
Energy	3	416	2.48
Cosmetic	4	34	3.30
Biodiesel	3	18	2.47
Fiber	3	19	2.47
Latex	1	9	0.82
Pollutant absorber	20	3325	16.53

Table 4. The number of species based on the conservation status and the origin

Conservation status	Number of species	Number of individuals	Percentage (%)	Origin of species				
				Exotic				Native
				Asia	America	Australia	Africa	
Critical endangered (CR)	1	4	0.82	-	-	-	-	1
Endangered (EN)	2	290	1.66	-	-	-	-	2
Vulnerable (VU)	8	1499	6.61	-	1	1	-	6
Near threatened (NT)	4	336	3.30	1	1	-	-	2
Least concern (LC)	50	2859	41.33	7	9	1	2	31
Data deficient (DD)	1	6	0.82	-	-	-	-	1
Not included	55	2339	45.46	17	11	-	-	27
Total	121	7333	100	25	22	2	2	70



Figure 2. Some green space spots in USU Campus. Trees for aesthetics, pollutants absorber and another function planted along the street in campus

Among the 121 species, 70 were native species, 51 were exotic species from another tropical region. Exotic tree species are defined as species introduced to an area where they do not occur naturally. The proportion of exotic tree species from other continents consisted of introduced species from other parts of Asia (25 species), America (22 species), Australia (2 species) and Africa (2 species). The exotic tree planting was also found in Kediri City Park (Sulistiyowati and Yuantika 2019), Kupang city green space (Lestari et al. 2013), Mataram Merah Park (Simangunsong et al. 2021) and Karawang city (Heriyanto and Samsudin 2019). Another study conducted by Arifin and Nakagoshi (2011) found that among 19 species found in urban areas in several regions in Jakarta, only nine species were native to Indonesia. The species such as *Cassia siamea*, *Polyalthia longifolia*, *Plumeria rubra*, *Swietenia macrophylla* and *Spathodea campanulata* were commonly planted in Indonesian green space. Taxa originating from America and Asia also dominated the flora in Patras green space (Chronopoulos and Christodoulakis 2000), the Mediterranean green space (Quezel et al. 1990), and the central European region green space (Pysek et al. 1995). According to Riley et al. (2018) and Aronson et al. (2015), exotic tree species are common in many cities, and may influence the ecological and economic value of urban forests. Every exotic tree species is known for its good ability to adapt to harsh urban

environments, which is even more important in the face of climate change (Chalker-Scott 2015). Despite this, the negative impacts of exotic species have also been widely documented (Simberloff 2005; Rejmánek and Richardson 2013). Humans tend to like many of the same non-native species, and they tend to transport the same species to different settlements (Mack and Lonsdale 2001). Therefore, the dominance of certain species in urban areas may result in an intensive selection of species by humans that are benefit-oriented. Some of these species' dominance can adversely affect urban forests due to the potentially damaging effects of pest and disease attacks (Alvey 2006).

Tree species conservation action, management, and maintenance

Trees in urban areas should be resistant to pollutants, high temperatures due to the heat island effect, have limited root space, and be able to adapt to less water availability in compacted soils (Song et al. 2020). Thus, different tree attributes play an important role in plant selection (Ferini et al. 2020). Trees with dense and wide canopies produce more oxygen with high aesthetic value, while trees with dense foliage allow removal of air pollutants and provide shade (Leung et al. 2011; Ferini et al. 2020), leading to improved temperature (Buyadi et al. 2015; Threlfall et al. 2017). Hence, species selection is an important aspect of urban greening. The correct selection of species can

significantly improve the urban environment and increase the benefits derived from urban green open spaces (Lopucki et al. 2015; Lahoti et al. 2020). On USU campus, the vegetation consisted of native and exotic species with a mixture of broadleaf and conifer. The most common native species on the campus was *Mimusops elengi* with a high tolerance and fast growth rate. The highly abundant introduced species recorded was *Swietenia macrophylla*, which was mainly planted in the Tri dharma forest. Among the ornamental trees, *Delonix regia*, *Cassia siamea*, *Peltophorum petrocarpum*, and *Bauhinia purpurea* were obvious choices due to the species flowering characteristics, the fast growth rate, and the shady canopy.

This study documented the taxonomy, the diversity, the benefits, the conservation status, and the relevance of trees existence as green space elements on the USU campus. The existence of green spaces, trees, and forests around our environment plays an important role in promoting sustainable development in our communities. As an important component of green infrastructure, trees can provide several social, communal, psychological, economic, and environmental benefits (Jansson 2014). Trees also contribute significantly to the health of green infrastructure components and work in the environment. Considering the important contribution of tree in green space and benefit for urban community, the planting should not be done based on aesthetic bases only, but also based on its potential contribution to the environment such as nature conservation (Kowarik 2013), biodiversity wildlife (Oliver et al. 2011; Qiu et al. 2013), urban climate (Feyisa et al. 2014; Song and Park 2014), air quality (Setala et al. 2013), noise reduction (Veisten et al. 2012; Watts et al. 2013), cleaning up contaminant (Wong et al. 2012). Furthermore, Ferini et al. (2020) stated that the paramount important consideration for planting trees was the effectiveness of the trees to reduce the global climate change impact, the planting area condition, the species selection (native or exotic), the biodiversity importance, the species utilization (i.e., climate mitigation, pollution reduction, hide visuals, etc.), the planting techniques (i.e., concentrated massive plantations, scattered or widespread planting with the creation of ecological corridors and stepping stones), and the party in charge of planting and managing green areas (i.e., public institutions, volunteers, private owners, etc.). These choices should be based on parameters such as the proportion of pollutants removed, the daily emission of volatile organic compounds, the production of pollen and allergens, the effects on the mitigation of the urban heat island and on the energy efficiency in the neighboring area.

All trees in USU campus area were terrestrial trees due to climatic conditions. The unfavorable conditions experienced by some species in this study were probably caused by anthropogenic activities in the study area. Wardle et al. (2004) also noted anthropogenic activities could cause some species' unfavorable conditions, and the study area had a relative density of less than 1.00 and, as such, could be considered threatened or endangered. These species were endangered and would soon be extinct from the campus if sustainable management practices were not

adopted, which included massive replanting exercises and instituting a committee to oversee tree management. Many plant species' disappearance due to anthropogenic activities is depleting the world's genetic resources and is putting man's heritage of biodiversity under serious threat. Threatened and endangered tree species on campus must be adequately protected to maintain urban tree diversity and prevent logging due to the development of academic facilities. There is also a need for a tree preference survey by campus residents when planning tree protection and tree planting programs. Considering that native fauna prefers native tree species, native plant conservation is also appropriate for USU campus. It is suggested that revegetation efforts should emphasize native plant species.

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