Tree biodiversity in USU green space: Exotic plant and its risk to native species

A Susilowati¹,³, H H Rachmat², A B Rangkuti¹,³, A H Iswanto¹,³, D Elfiati¹,³, R Rambey¹,³, I M Ginting¹ and S H Larekeng⁴

¹Faculty of Forestry, Universitas Sumatera Utara, Jl. Tridharma Ujung No.1, USU Campus-Medan 20155, Indonesia
²Forest Research and Development Center, Ministry of Environment and Forestry. Jl Raya Gunung Batu Bogor, 16118, Indonesia
³ JATI-Sumatran Forestry Analysis Study Center, Universitas Sumatera Utara. Jl. Tridharma Ujung No.1, Kampus USU Medan 20155, Indonesia
⁴Biotechnology and Tree Breeding Lab., Faculty of Forestry, Hasanuddin University, Makassar, Indonesia

E-mail: arida.susilowati@usu.ac.id

Abstract. Globally, urban ecosystems provide important green spaces for biodiversity conservation. Many exotic species are grown in tropical urban ecosystems, and their harmful effects on native species and pollinator communities have been widely documented. Therefore, the purpose of this research is to determine the origin (native or exotic to Indonesia, sexual and reproductive system) of tree species on the University of Sumatera's (USU) campus. Field inventory methods were used in this study for observed tree species on the USU campus. All tree species were observed, their flowering observed if any. According to our research, the USU green area comprises a collection of 121 tree species. Seventy species (57.85 %) are native to Indonesia, while 51 species (42.15 %) are exotic from other tropical regions. In terms of individual abundance, these values are 37.28% native and 62.72% exotic. The exotic trees on the USU campus show monoecious and dioecious flower sexuality; 19 species are hermaphrodite, two species have self-incompatibility characters, seven species are dioecious, and 23 species are monoecious. Together with the results from the few other experimental studies, it concluded that the increase of exotic species plantation in USU campus might indicate risk for animal interactions (e.g., pollination; dispersal), threaten reproduction of native plant species, pollination specialization, habitat, and other life-history properties. Therefore, the use of these exotic species needs special attention for stakeholders at USU.

1. Introduction
The existence of green open space is a new hope to get ecological, social, economic, and relaxation functions for urban residents [1]. In various contexts, green space is considered a new ecosystem that can combine native and exotic species [2]. The choice of plants for green spaces, especially which types of plants are best used to increase biodiversity, is still an early topic [3]. As in the broader conservation context, the classification of species as native or exotic has important consequences for activities and policies, community and ecosystem perceptions.

Native species are considered to have better adaptability to the local environment [4]. Its means that
they are assumed to be able to grow better and be efficient in treatment. However, urbanization inevitably changes local habitat conditions and makes urban habitats unsuitable for this species. Furthermore, the assumption of the superiority of native plant species to provide habitat is still a matter of debate because both native and exotic species contribute to the habitat. Replacement of native species with exotic ornamental plants can disrupt the urban food chain [5]. The existence of green space composed of native species supports higher insect diversity as well as insectivorous birds. Another study showed the use of native species significantly increased the density and diversity of caterpillars and the abundance of insectivorous birds, and the number of breeding pairs. Similarly, using native plants in the yard usually increases pollinator abundance and diversity [6].

On the contrary, the introduction of exotic species in urban areas is considered a threat for various reasons. The exotic species are considered to harm ecosystem services in urban communities [7]. This species can also damage various ecosystems by acting like animals, causing toxicity and allergic reactions or vectors of fires in urban forests. On the other hand, many exotic species also increase diversity, especially in permanently regulated areas but retain essential ecosystem functions [8]. The University of Sumatera Utara (USU) Campus, located in Medan city, is a university green space with many functions. Previous research conducted by Susilowati et al., (2021) found 121 species belong 37 families on USU campus [9]. The species have many functions: food, wood, fiber producer, medicine source, bio-herbicide, and pollutant absorber. Specific research on the existence of native and exotic species in USU is still determined yet. Therefore, our study determined the origin (native or exotic to Indonesia, sexual and reproduction system) of tree species on the University of Sumatera Utara (USU) campus.

2. Material and methods
2.1. Research location
This research was conducted on the University of Sumatera Utara campus (3.330 N and 98.390 E), located in Padang Bulan, Medan, with 120 hectares [10]. The Padang Bulan campus is located in the city of Medan with an altitude of 2.5-37.5 m above sea level with a range of 23.2°C-33.2°C. The average air humidity in the city of Medan is between 84-85%, and the average wind speed is 0.48 m/s, and the soil type is inceptisol.

2.2. Data collection
The field inventory method was adopted for tree data collection at 120 hectares campus area. Each species was observed and measured for morphological characters, diameters, heights, and flowering conditions. Identification of tree species is made with the help of a tree book. Local names are also used to identify species. Specimens that are still ambiguous are taken from the leaves for making herbarium. Furthermore, the samples were further identified in the Botany and Taxonomy laboratories, FORDIA (Forest Research and Innovation Agency), the Ministry of Environment, and Forestry-Bogor. The following types are found based on their origin. Exotic species were observed for their flowering conditions. For species not in the flowering period, flowering conditions were obtained by the existing literature.

3. Result and discussion
3.1. Diversity of native and exotic species in USU campus
The tree composition in green space is an important aspect of biodiversity conservation. Humans have a tendency to plant new species and distribute them to different new areas [11]. This causes the dominance of exotic species in urban areas, which previously did not exist. Humans generally plant exotic species because of several reasons, one of which is profit reasons, whereas some species actually have a negative impact on urban ecosystems due to increased pest and disease attacks. The issue that is still being debated in the biodiversity of tree species in urban areas is the proportion of native and exotic species. The Millenium Ecosystem Assessment (2005) describes the distribution of exotic species as a strong driver of biodiversity loss across key ecosystem types such as grasslands, forests, or mountains.
on a local to global scale [12]. Some evidence regarding the negative ecological and economic impacts of exotic species has also been presented. However, the basic understanding that needs to be considered is that not all introduced species are invasive. In addition, the advantages of the existence of exotic species have also been reported.

Exotic species in this study are defined as species introduced to an area where the species does not naturally spread in that location. Of the 121 tree species found on the USU campus, 70 species (57.85%) are native species, while 51 species (42.15%) are exotic species from other tropical areas. The proportion of exotic species includes 25 species from the Asian continent, 22 species from the Americas, 2 species from the African continent, and 2 species from the African continent. Based on an individual number, the number of the native was 2734 trees (37.28%), whereas the exotics were 4599 trees (62.72%). The high individual number of exotic than native need more attention, especially for campus authority. Based on the family number, the exotic can be classified into 23 families. The high proportion of exotic species in urban green space were a common condition in many cities in the world [2]. In Indonesia, this condition is also found in many cities. Research conducted by Arifin and Nakagoshi (2011) reported among 19 species in urban area Jakarta, only nine species were native [13]. Another condition also found in Karawang city, Kediri City Park, and Kupang city green space [14–16]. The common species were aesthetic trees such as Cassia siamea and Polyalthia longifolia.

| Family         | Number of species | Origin and number | Native | Individual | Exotic | Individual |
|----------------|-------------------|-------------------|--------|------------|--------|------------|
| Anacardiaceae  | 4                 |                   |        | 274        | 2      | 4          |
| Annonaceae     | 6                 |                   | 2      | 4          | 4      | 657        |
| Apocynaceae    | 5                 |                   | 2      | 69         | 3      | 33         |
| Araucariaceae  | 2                 |                   | 1      | 60         | 1      | 77         |
| Bignoniaceae   | 2                 |                   | -      | -          | 2      | 36         |
| Bombacaceae    | 1                 |                   | 1      | 2          | -      | -          |
| Callophyllanaceae | 1          |                   | 1      | 5          | -      | -          |
| Casuarinaceae  | 3                 |                   | 2      | 168        | 1      | 248        |
| Clusiaceae     | 3                 |                   | 3      | 52         | -      | -          |
| Combretaceae   | 2                 |                   | 1      | 147        | 1      | 44         |
| Cupressaceae   | 1                 |                   | 1      | 77         | -      | -          |
| Dipterocarpaceae | 4              |                   | 4      | 72         | -      | -          |
| Ebenaceae      | 2                 |                   | 1      | 2          | 1      | 4          |
| Elaocarpaceae  | 2                 |                   | 1      | 1          | 1      | 38         |
| Euphorbiaceae  | 4                 |                   | 2      | 50         | 2      | 64         |
| Fabaceae       | 18                |                   | 10     | 389        | 8      | 807        |
| Gnetinaceae    | 2                 |                   | 2      | 31         | -      | -          |
| Lamiaceae      | 1                 |                   | 1      | 5          | -      | -          |
| Lauraceae      | 3                 |                   | 2      | 9          | 1      | 17         |
| Lecytidaceae   | 1                 |                   | -      | -          | 1      | 30         |
| Lythraceae     | 1                 |                   | 1      | 9          | -      | -          |
| Malvaceae      | 5                 |                   | 3      | 82         | 2      | 6          |
| Magnoliaceae   | 1                 |                   | 1      | -          | 1      | 4          |
| Meliaceae      | 5                 |                   | 1      | 13         | 4      | 1572       |
| Moraceae       | 11                |                   | 8      | 143        | 3      | 134        |
| Moringaceae    | 1                 |                   | -      | 1          | 1      | -          |
| Myrtaceae      | 7                 |                   | 4      | 119        | 3      | 400        |
| Myristicaceae  | 1                 |                   | 1      | 6          | -      | -          |
| Phyllantaceae  | 3                 |                   | 3      | 26         | -      | -          |
| Pinaceae       | 1                 |                   | 1      | 8          | -      | -          |
| Podocarpaceae  | 1                 |                   | 1      | 2          | -      | -          |
| Rubiaceae      | 2                 |                   | 2      | 13         | -      | -          |
| Salicaceae     | 2                 |                   | -      | -          | 2      | 9          |
| Sapindaceae    | 8                 |                   | 5      | 938        | 3      | 253        |
3.2. Sexual system of exotic species

Important arguments for and against managing invasive species in urban areas increasingly hinge on their contributions to the delivery of ecosystem services and disservices. Exotic tree species are considered to be one of the most serious threats to native ecosystems [17]. Due to species-specific effects on light availability and nutrient cycling, exotic tree species significantly alter the functioning of invaded ecosystems. As a consequence, exotic tree species influence dependent native organisms: soil microbes, invertebrates, fungi, bryophytes, and vascular plants. Some studies on exotic species also found the potential risk of exotic tree reproductive system to animal interactions (e.g., pollination; dispersal), threaten reproduction of native plant species, increase the risk of biological invasion, and interfere with the maintenance of biodiversity [7].

The risk of the existence of exotic trees is related to their reproductive ability. It is known that most types of flowering trees are hermaphrodites with pistils and stamens on the same flower [18]. The individual number of exotic trees covers 62.72% of the total tree on the USU campus. *Swietenia macrophylla* is the highest abundant exotic tree on the USU campus, followed by *Polyalthia longifolia* and *Syzygium paniculatum* (Table 2). Based on our observation, flower sexuality of the exotic trees on the USU campus can be classified into monoecious and dioecious; 19 species are hermaphrodite, two species have self-incompatibility characters, seven species are dioecious, and 23 species are monoecious with stamen and pistils in different flower.

Table 2. Ten highest abundance Exotic tree and the reproductive system.

| No. | Scientific name     | Family       | Flower sexuality           |
|-----|---------------------|--------------|----------------------------|
| 1   | *Swietenia Macrophylla* | Meliaceae    | Monoecious                 |
| 2   | *Polyalthia Longifolia* | Annonaceae   | Monoecious/Hermaprodite    |
| 3   | *Syzygium Paniculatum* | Myrtaceae    | Monoecious                 |
| 4   | *Tamarindus Indica*   | Fabaceae     | Monoecious/Hermaprodite    |
| 5   | *Pterocarpus Indicus*  | Fabaceae     | Monoecious/Hermaprodite    |
| 6   | *Ficidium Decipiens*  | Sapindaceae  | Monoecious                 |
| 7   | *Swietenia Mahagoni*  | Meliaceae    | Monoecious                 |
| 8   | *Samanea Saman*       | Fabaceae     | Monoecious/Hermaprodite    |
| 9   | *Artocarpus Heterophylla* | Moraceae | Monoecious                 |
| 10  | *Tectona Grandis*     | Verbenaceae  | Monoecious/Hermaprodite    |

The interaction between plants and pollinating agents is very important in determining the diversity and composition of species in an ecosystem. The existence of both supports the creation of genetic diversity of a plant population and produces new combinations of traits that are intended to support the life of the species. Flowering plants provide essential nutrients for the animals involved. Although it may be very important, the introduction of exotic species into a deep ecosystem is thought to affect the increase in pollinators and the reproductive success of natives [19]. A positive interaction between the two species occurs if the presence of one species (e.g., exotic) increases pollinator visits to another (e.g., native) because the presence of one species attracts so many pollinators to the heterospecific patch that the rate of visits to the other species (e.g., native) increases. Such a facilitative interaction is often referred to as the magnetic species effect. A negative interaction for pollinator services could be that the presence of one species (e.g., exotic) reduces pollinator visits to another (e.g., native) because the species previously dominated the available potential pollinator pool. This reduces the number of pollinator visits [20]. In addition, plants of different species can reduce the success of pollinating each other through heterospecific pollination, resulting in a decrease in pollination quality.
3.3. Maintaining strategy
Our results from our study and a review of the literature on the effects of exotic invasions on pollination and reproduction in native populations show that the magnitude of the impact caused by species varies greatly by species; ability depends on the mating system, pollination specialization, habitat, and life history. Native vegetation has an advantage over exotic species in ameliorating urban heat effects and their ability to withstand heat stress. Therefore, native plants should be the main choice in tropical urban ecosystems. The use of native species for reforestation programs has been suggested because of the tendency of native species to have a high adaptation success rate, low maintenance due to their high suitability to local biophysical conditions, and preservation of genetic resources. The high abundance of exotic species on the USU Campus needs more attention from USU stakeholders for the above reasons. However, further studies regarding the potential of the threat of exotic species in detail still need to be carried out.

4. Conclusion
Our research found that of 121 tree species in USU Campus, 70 species (57.85%) are native to Indonesia, and 51 species (42.15%) are exotic from other tropical regions. In terms of individual abundance, these values are 37.28% native and 62.72% exotic. Some of the exotics are hermaphrodite and self-incompatible. Together with the results from the few other experimental studies, exotic species plantation in USU campus may indicate risk for animal interactions such as a pollinator, therefore maintaining strategy still needed for this species.

References
[1] Gulwadi G B, Mishchenko E D, Hallowell G, Alves S and Kennedy M 2019 The restorative potential of a university campus: Objective greenness and student perceptions in Turkey and the United States Landsc. Urban Plan. 187 36–46
[2] Riley C B, Herms D A and Gardiner M M 2018 Exotic trees contribute to urban forest diversity and ecosystem services in inner-city Cleveland, OH Urban For. Urban Green. 29 367–76
[3] Tudorie C A-M, Vallés-Planells M, Gielen E, Arroyo R and Galiana F 2020 Towards a greener university: Perceptions of landscape services in campus open space Sustainability 12 6047
[4] Berthon K, Thomas F and Bekessy S 2021 The role of ‘nativeness’ in urban greening to support animal biodiversity Landsc. Urban Plan. 205 103959
[5] Ksiazek-Mikenas K, Herrmann J, Menke S B and Köhler M 2018 If you build it, will they come? plant and arthropod diversity on urban green roofs over time Urban Nat. 1 52–72
[6] Sjöman H, Morgenroth J, Sjöman J D, Sæbø A and Kowarik I 2016 Diversification of the urban forest—can we afford to exclude exotic tree species? Urban For. Urban Green. 18 237–41
[7] Shackleton C 2016 Do indigenous street trees promote more biodiversity than alien ones? Evidence using mistletoes and birds in South Africa Forests 7 134
[8] French K, Major R and Hely K 2005 Use of native and exotic garden plants by suburban nectarivorous birds Biol. Conserv. 121 545–59
[9] Susilowati A, Rangkuti A B, Rachmat H H, Iswanto A H, Harahap M M, Elfati D, Slamet B and Gontong I M 2021 Maintaining tree biodiversity in urban communities on the university campus Biodiversitas J. Biol. Divers. 22
[10] Susilowati A, Ahmad A G, Rangkuti A B, Harahap M M and Ginting I M 2021 The health status of saga tree (Adenanthera pavonina) in campus area of Universitas Sumatera Utara (USU) IOP Conference Series: Earth and Environmental Science vol 782 (IOP Publishing) p 42029
[11] Wardle D A, Bardgett R D, Klironomos J N, Setälä H, Van Der Putten W H and Wall D H 2004 Ecological linkages between aboveground and belowground biota Science (80-. ). 304 1629–33
[12] Millennium Ecosystem Assessment 2005 Ecosystems and human well-being vol 5 (Washington, DC: Island press United States of America)
[13] Arifin H S and Nakagoshi N 2011 Landscape ecology and urban biodiversity in tropical Indonesian cities Landsc. Ecol. Eng. 7 33–43
[14] Heriyanto N M and Samsoedin I 2019 Struktur tegakan dan stok karbon di ruang terbuka hijau PT Toyota motor manufacturing di Sunter dan Karawang *Bul. Kebun Raya* **22** 59–66
[15] Sulistiyowati T I 2019 Jenis-jenis pohon peneduh di Taman Kota Kediri *J. Biol. dan Pembelajarannya* **6** 13–7
[16] Lestari I, Yanuwiadi B and Soemarno S 2013 Analisis Kesesuaian Vegetasi Lokal Untuk Ruang Terbuka Hijau (RTH) Jalur Jalan Di Pusat Kota Kupang *Indones. J. Environ. Sustain. Dev.* **4**
[17] Ikin K, Knight E, Lindenmayer D B, Fischer J and Manning A D 2013 The influence of native versus exotic streetscape vegetation on the spatial distribution of birds in suburbs and reserves *Divers. Distrib.* **19** 294–306
[18] Gleditsch J M and Carlo T A 2011 Fruit quantity of invasive shrubs predicts the abundance of common native avian frugivores in central Pennsylvania *Divers. Distrib.* **17** 244–53
[19] Hanley M E, Awbi A J and Franco M 2014 Going native? Flower use by bumblebees in English urban gardens *Ann. Bot.* **113** 799–806
[20] Lerman S B and Milam J 2016 Bee fauna and floral abundance within lawn-dominated suburban yards in Springfield, MA *Ann. Entomol. Soc. Am.* **109** 713–23