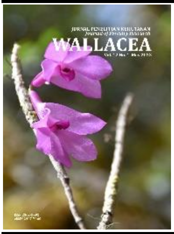

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Article

Spatial diversity patterns of understory shrub community in Srengseng urban forest, Jakarta

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Abstract

Urban forests are one of the natural ecosystems in urban environments. One of the most important components of the urban forest ecosystem is the understory shrubs. Therefore, this study aims to estimate the diversity of understory shrubs in the Srengseng Urban Forest in Jakarta City. The biodiversity of understory shrubs is calculated using the Shannon-Wiener diversity index (H') and mapped using the Geographic Information System (GIS). In this study, 24 plots measuring 2 m by 2 m each were placed to survey the understory shrubs. In total, there were 20 species of shrubs identified, which belong to 12 families with average values of H' is 0.671. The results show that almost 62.78% of the total Srengseng Urban Forest area has a H' diversity range of 1.001–1.500. In comparison, 8.62% of total urban forest area has an H' diversity range of 0.501-1.000. The area of urban forest with the lowest diversity in the H' diversity range of 0.000 to 0.500 reaches 28.58%. The eastern parts of the urban forest have the highest H' in comparison to the other parts of the forest. This study contributes to the conservation and forestry management of forest at an urban scale by identifying parts of the urban forest that should be conserved in the Srengseng. To conclude, the eastern parts of Srengseng Urban Forest sizing 64,765 m² should be prioritized for understory shrub conservation.

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INTRODUCTION

Urban areas are one of the fastest growing ecosystems on earth, with the development of cities influencing many aspects of the environment, including vegetation diversity (Theodorou et al., 2020). Urban area ecosystems are known to have different and vast vegetation diversities (Clemants & Moore, 2003). Urban ecosystems, such as parks, are extensively used for leisure and physical activity in urban settings, enhancing human health and well-being. Through the planning and management of urban ecosystems, including social, cultural, and economic elements, urban forests play a vital role in protecting world biodiversity.

Understory shrubs inventories and biological indices at urban forest are crucial for species conservation at the community (Jeschke et al., 2014) and ecosystem levels (Tobin, 2018). Understory shrubs (Chase et al., 2011) been widely utilized to assess and define community and ecosystem conservation status (Pysek et al., 2012), as well as to understand future responses to climate change (Foxcroft et al., 2017). These characteristics provide information regarding community dynamics, dispersion adaptation, and even the potential of understory shrubs to compete for establishment (Birch & Wachter, 2011). Understanding understory shrub spatial distribution patterns in urban forests through the application of biological indices include Shannon-Wiener diversity index (H') (Downey & Richardson, 2016) is critical for the creation and execution of understory shrub management and conservation plans (Guiaşu, 2016).

In Jakarta City, Srengseng Urban Forest is one of important urban ecosystems. Vegetation in here in particular tree diversity has been studied by Sari et al. (2022). In spite of tree assessments have been implemented, there is still a limited information about the understory shrub diversity and patterns in Srengseng Urban Forest. This study aims to estimate the diversity of understory shrubs in the Srengseng Urban Forest in Jakarta City. The novelty of this research lies in the use of geographic information to assess the spatial distribution patterns of understory shrubs. The results of these efforts, as mentioned by English et al. (2022), can aid urban forest managers in supporting urban forest conservation and the protection of biodiversity. Promoting understory shrub biodiversity in the Srengseng Urban Forest can be a potential conservation priority given the unique potential of the understory shrubs.

METHODS

The method used in this study is a combination of field survey and the use of geographic information system (GIS). Field survey activity aimed to collect and record the understory shrub species. While the use of GIS aiming to assess the understory shrub diversity and patterns.

Time and Study Locations

The study area was located at Srengseng Urban Forest in West Jakarta District, Jakarta City (Fig. 1). The geocoordinates for Srengseng Urban Forest was 106.76160 - 106.76640 east longitude and 6.20800 - 6.21360 south latitude. This forest sizing 104,461 m^2 around located at 7 m above sea level elevation. The monthly rainfall rate ranges were 35.8 – 604.4 mm^3. The study was implemented from October to November 2022.

Understory Shrub Survey

Methods for surveying understory shrub follows methods by Pourbabaei & Haghgooy (2012), Siregar et al. (2020), and Khan et al. (2021). An understory shrub survey at sampling locations was implemented using grids sized 2 m by 2 m as the understory shrub sampling points. Those sampling points were distributed randomly across the sampling locations, with a total of 24. Inside the sampling points, shrubs were observed, collected, and counted for the number of individuals. The geocoordinates of sampling points were recorded using a Global Positioning System (GPS) Garmin Etrex handheld. The recorded geocoordinate data was then tabulated in a GIS attribute table. The recorded data within the GIS included the geocoordinates of sampling points and the numbers of individuals of understory shrub species recorded.

Data Analysis

Data analysis includes the calculation of diversity using Shannon-Wiener index and analyzing spatial patterns of understory shrubs. Other quantifications data were presented as histogram graphics and tabular presentations.

Diversity Analysis

The diversity of understory shrub (Matius et al., 2018) within Srengseng was calculated with Shannon-Wiener index (Bhat et al., 2014) using the equation and formula as follows

$$H' = \sum (pi)\,(\ln_2 pi)$$

With: H': Shannon-Wiener index of diversity;
pi : proportion of the total sample belonging to i-th species

Spatial Pattern Analysis

Spatial pattern analysis was used to map and estimate the distribution and diversity pattern of understory shrub species. The analysis used the interpolation method (Hernandez-Stefanoni & Ponce-Hernandez, 2006), which was assisted by GIS and supported by ArcView 3.2. The interpolation method used sampling points representing previously recorded geocoordinates. As attribute data, those points were linked based on the number of individuals and diversity (H) values of understory shrubs. It is presumed that the connection and resemblance rate among contiguous sampling points is commensurate with the distance between sampling points. Each interpolated sampling point was calculated using numbers of individuals and H' values as a weight. Those weights were equal to the inverse of its distance from the point, and the place that was closest to the known sampling point had more weight than the far ones (Setianto et al., 2013; Bhunia et al., 2018). In the interpolation method, the unknown point value is estimated using the following equation (Al-Mamoori et al., 2021):

$$z(x0) = \frac{\sum_{i=1}^{n} \frac{xi}{\beta hij}}{\sum_{i=1}^{n} \frac{1}{\beta hij}}$$

With:
z : the interpolated value of H' of understory shrub species;
n : the values of total sample points;
xi : the i-th data value;
Hij : the separation distance between interpolated value and the sample point value;
ß : the weighting power.

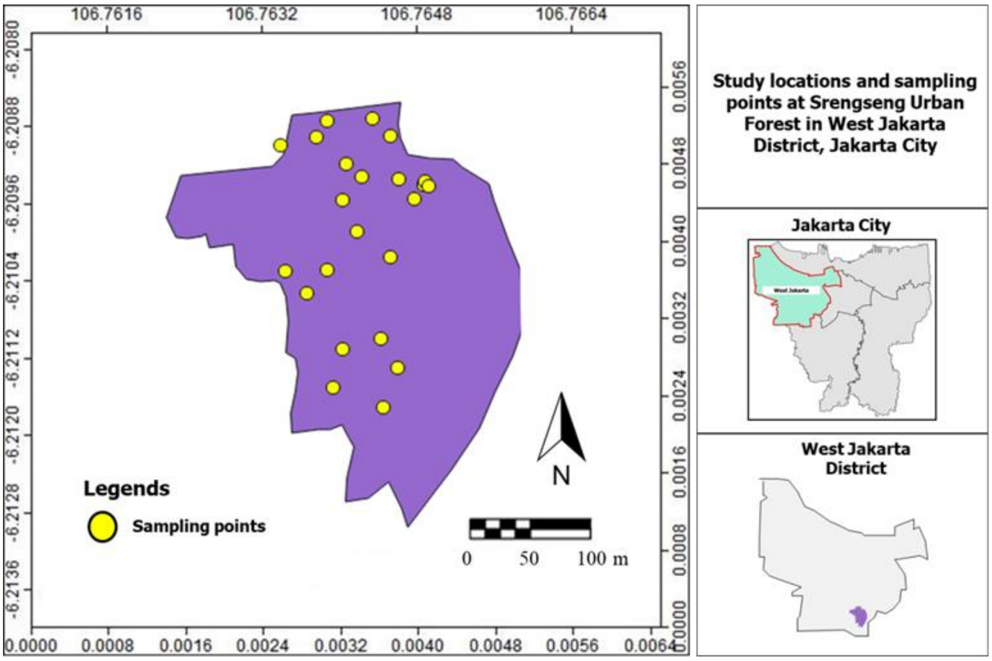

Figure 1. Study locations and sampling points at Srengseng Urban Forest in West Jakarta District, Jakarta City

RESULTS

Species and Family Diversities

In total there were 828 individuals of understory shrub have been collected. Those individuals were belonging to 20 species and 12 families (Table 1). The common species according to the numbers of individuals were in the following order of *Rivina humilis, Acalypha siamensis, Cordyline fruticosa, Syzigium paniculatum* > *Caesalpinia pulcherrima*. Then *Rivina humilis* and *Acalypha siamensis* were understory shrub species that have dominated the understory shrub community in the Srengseng Urban Forest, While, there were understory shrub species that were very rare in the Srengseng that include *Xhantostemon* sp., *Abelmoschus esculentus, Morus alba, Gardenia jasminoides*, and *Glycosmis pentaphyla*. Those species were considering very rare since the numbers of individuals of those species were very low in comparisons to other species.

According to the families, there were several families that were considered as common understory shrub since those families have several genera present in Srengseng, Those families were in the following order Solanaceae (4 species), Myrtaceae (3 species), Euphorbiaceae (3 species), Rubiaceae (2 species). While regarding numbers of individuals of each family (Fig. 2), there were 2 families with notably numbers of individuals. Those families were Euphorbiaceae and Petiveriaceae.

Spatial Pattern

Fig. 3 shows the composition pattern based on the numbers of individuals for both species and families. It is clear that the northern parts of the urban forest have more species and families. The numbers of species and families were declining toward the central and southern parts of the urban forest. Based on Fig. 4, there were some species distribution patterns that were clustered or fragmented and distributed all over the urban forest. *Glycosmis pentaphyla, Cordyline fruticosa, Morus alba, Gardenia jasminoides, Pseuderanthenum carruthersii*, and *Syzigium oleana* were observed clustered in the north. In contrast, there were some species that were distributed randomly. Those species include *Acalypha siamensis, Solanum diphyllum, Caesalpinia pulcherrima,* and *Rivina humilis*.

Diversity Pattern

Based on the calculations of the Shannon-Wiener index of diversity, the mean of H' was 0.671. The diverse understory shrubs, along with two notable spatial patterns, led to the heterogeneous diversity patterns. It is obvious, as can be seen in Fig. 5, that the eastern parts of the urban forest were characterized by higher understory shrub diversity than other parts. The lowest understory shrub diversity was observed in the western and southern parts of the forest. The results show that almost 62.78% of the total Srengseng Urban Forest area has an H' diversity range of 1.001–

1.500. In comparison, 8.62% of the total urban forest area has an H' diversity range of 0.501–1.000. The area of urban forest with the lowest diversity in the H diversity range of 0.000 to 0.500 reaches 28.58%, as can be seen in Fig 6.

Table 1. Understory shrub species, families, and numbers of individuals from Srengseng Urban Forest in West Jakarta District, Jakarta City

Species	Family	Numbers of individuals	Percentages
Xhantostemon sp. F.Muell.		1	0.12
Syzigium paniculatum Gaertn	Myrtaceae	110	13.28
Syzigium oleana F.Muell.		51	6.15
Glycosmis pentaphylla Retz	Rutaceae	4	0.48
Capsicum annuum Linnaeus		34	4.1
Capsicum chinense Jacq.	Solanaceae	8	0.96
Solanum diphyllum Linnaeus		17	2.05
Solanum bahamense Linnaeus		5	0.6
Cordyline fruticosa Linnaeus	Asparagaceae	120	14.49
Exocaria cochinensis Linnaeus		26	3.14
Acalypha siamensis Linnaeus	Euphorbiaceae	126	15.12
Codiaeum variegatum Linnaeus		10	1.2
Tabernaemontana sp. Linnaeus	Apocynaceae	30	3.62
Abelmoschus esculentus Linnaeus	Malvaceae	1	0.12
Coffea canephora Pierre	Rubiaceae	10	1.2
Gardenia jasminoides J.Ellis		4	0.48
Morus alba Linnaeus	Moraceae	2	0.24
Caesalpinia pulcherrima Linnaeus	Fabaceae	84	10.14
Rivina humilis Linnaeus	Petiveriaceae	132	15.94
Pseuderanthenum carruthersii Seem	Acanthaceae	53	6.4
Total		828	100

Table 2. Comparisons of understory shrub diversities from other urban forests

Locations	H' value ranges	No. of species ranges	Sources
Metro Cebu, Philippines	0.774 - 2.775	11 - 85	Flores et al. (2020)
Cilegon, Banten	-	7 - 58	Muhlisin et al. (2021)
Cemoro Sewu, Magetan	-	5 - 9	Hidayah & Roziaty. (2022)
Rajolelo, Bengkulu Tengah	1.059 – 1.282	21	Sihaloho & Pariyanto. (2022).
Srengseng, Jakarta	0.000 - 1.508	20	This study

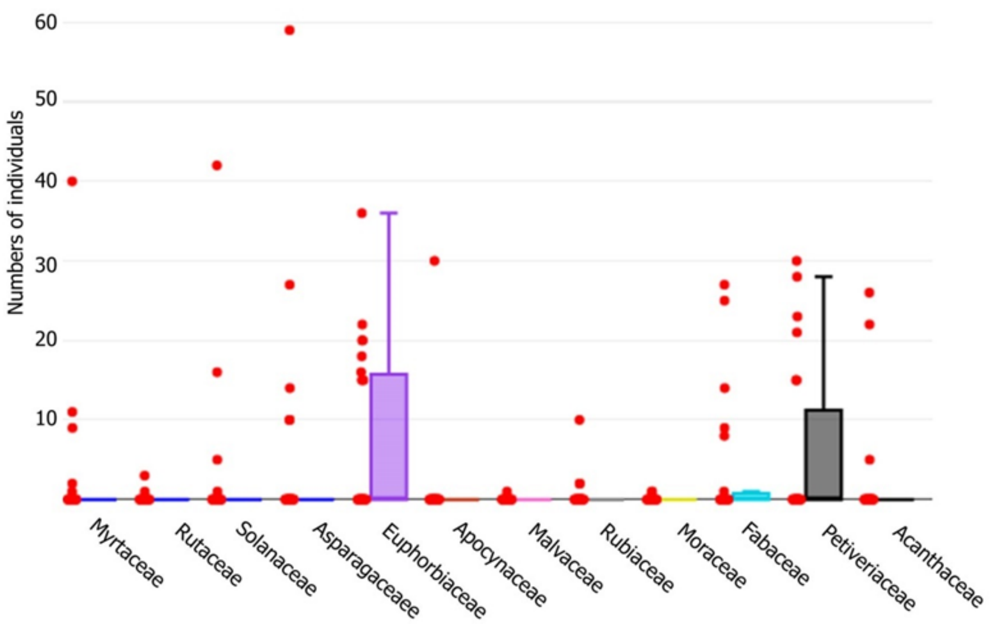

Figure 2. Boxplots of numbers of individuals based on understory shrub families at Srengseng Urban Forest in West Jakarta District, Jakarta City

DISCUSSION

Numbers of understory shrub species recorded in this study is in comparison and within the ranges of numbers of species find in other urban forests whether at regional scales at South East Asia and national levels (Table 2). It indicates that Srengseng Urban Forest has potential to support the biodiversity of particular understory shrub species. The understory shrubs were fragmented distributed all over Srengseng developing small patches as can be observed in some species. The patterns of fragmented understory shrubs distributed into small patches were in agreement with results from (Wu & Hu, 2020) that also reporting fragmented shrubs at urban scale ecosystems.

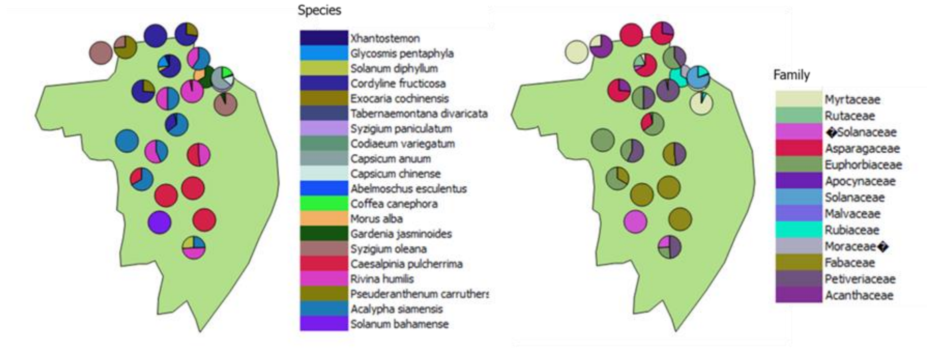

Figure 3. Composition patterns of each understory shrub species and families based on the numbers of individuals at Srengseng Urban Forest in West Jakarta District, Jakarta City

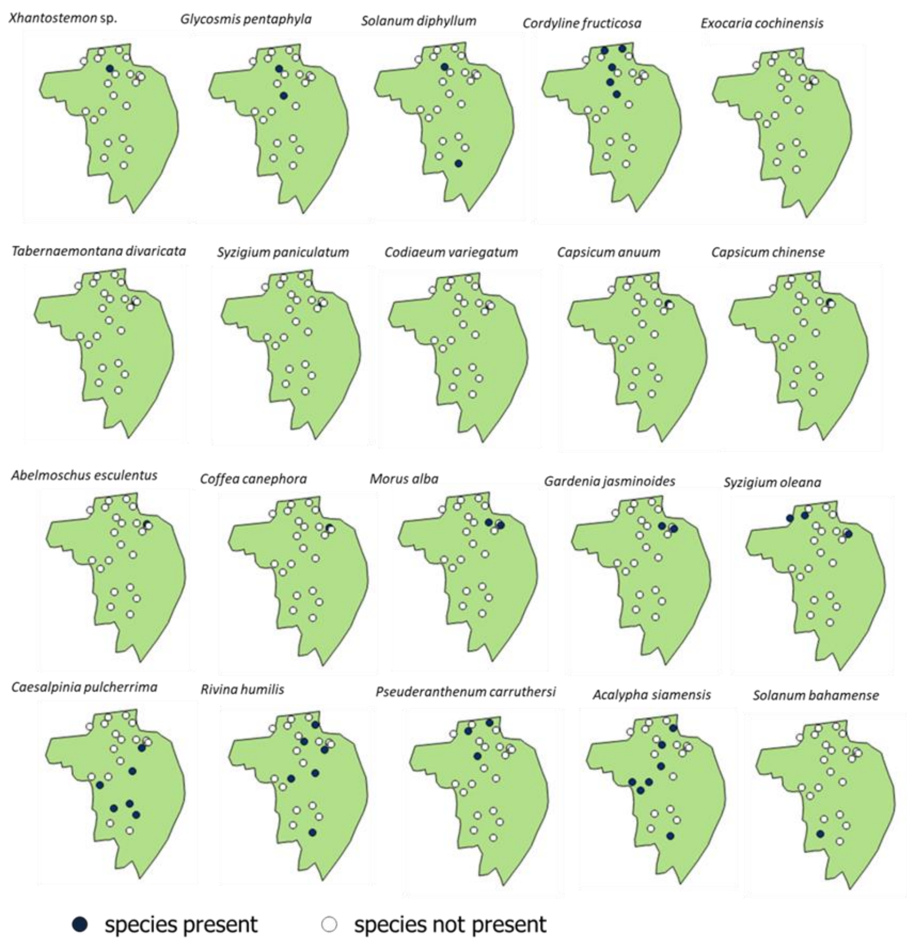

Figure 4. Spatial distributions of each understory shrub species presences at Srengseng Urban Forest in West Jakarta District, Jakarta City (blue dots: species present, white dots: species absent)

The presence and abundance of understory shrubs in Srengseng can be explained by their functional use in the parks. Rather than being used as covers or ornamental parks, shrubs were typically used as fences or to define different sections of the park (Flores et al., 2020). Shrubs were defined as having solid trunks and branches that could act as barriers and were used as fences. Usually, urban forest management favors the selection of a shrub community because understory shrubs structurally contain small to medium-sized plants. Shrub species was in the undeveloped area (Zhang et al., 2022) and this is coincided with the fact that Srengeseng Urban Forest is an area designated as open green space where developments are limited.

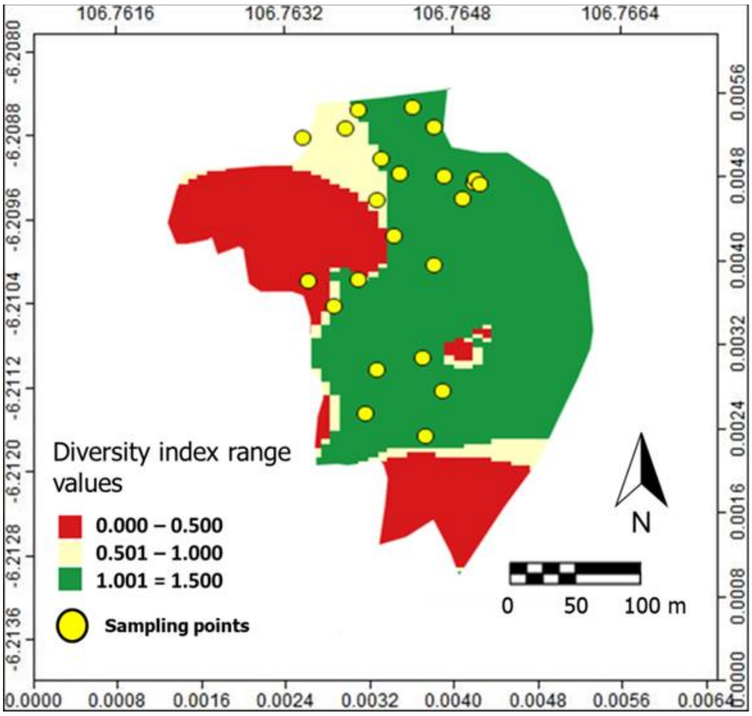

Figure 5. Diversity (H') patterns of each understory shrub species at Srengseng Urban Forest in West Jakarta District, Jakarta City. This H' pattern map is developed using spatial pattern analysis and interpolation method

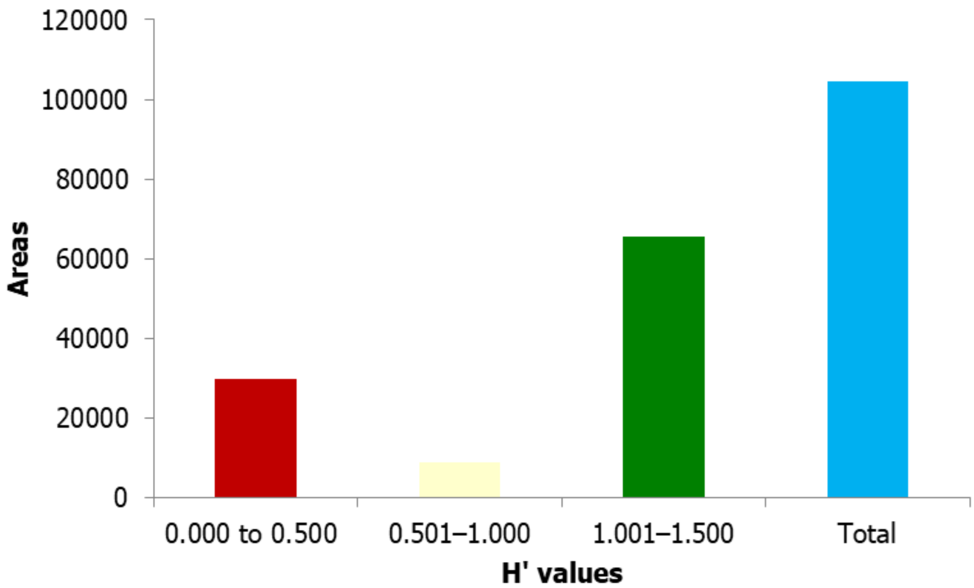

Figure 6. Areas (m^2) of H' value classes related to the total areas of Srengseng Urban Forest in West Jakarta District, Jakarta City

In urban forest settings, some species were planted to be used as a fence. While others were planted for other purposes, including aesthetic purposes (Muhlisin et al., 2021). This explains why the forest's diversity is so high in the north. Also in this area, some species were clustered in the north. At Srengseng Urban Forest, the northern parts are designated as recreation areas for visitors. Then, to attract more visitors, for the first time, more shrubs were planted in this part in comparison to other parts. The concept applied in this area is open space with fewer trees and more ornamental understory plants. Then the management cleared some trees, which allowed more sunlight and accelerated the photosynthesis of understory species. This access to sunlight explains why there are more shrubs in these areas.

CONCLUSIONS

This study has elaborated, using GIS, the spatial diversity pattern of understory shrubs at the urban level. To conclude, the use of GIS is very useful to discern the spatial patterns of understory shrubs at urban levels. The GIS analysis concludes that the understory shrub species were either clustered or distributed randomly. The GIS and spatial analysis also conclude that the eastern parts of the urban forest have the highest understory shrubs, as indicated by higher H' values in comparison to the H values either in the western or southern parts of Srengseng.

RECOMMENDATIONS

The valuable findings elaborated from this study are the identification and determination of which parts of the Srengseng Urban Forest have high diversity. Then this spatial information can be used to determine which parts of the forest should be conserved and protected first. Then, considering the results, this study recommends the conservation action plan in particular for the eastern parts of the Srengseng Urban Forest since these parts have higher diversity in comparison to other parts, whether they are in the west or south.

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AUTHOR CONTRIBUTIONS

GRK: field data collection, research implementer; EN: interpretation, manuscript writing; WW: interpretation, manuscript writing; AB: proofreading; A: data analysis, map making.

CONFLICTS OF INTEREST

The authors declare there is no conflict of interest related to financial funding and authorship order for this article.

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