The diversity of trees and open green spaces (OGS) at Universitas Syiah Kuala

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Abstract. Research on diversity of trees and open green spaces (OGS) at Universitas Syiah Kuala has done from March to June 2017. The purpose of the study is to investigate (1) diversity of trees and (2) ratio open green spaces of Universitas Syiah Kuala. Twenty observation stations in the form of office space become samples of this research. This research uses quadrate methods as many as 100 sample plots from all stations. This research data were analyzed using Shannon species diversity index formula-Wienner (H), while the ratio of OGS was analyzed the formula developed by Joga and Ismaun. The conclusions of this research are (a) it is found forty-eight trees of 28 familia, (b) The index of tree species diversity categorized at a medium level with a value H of 2.179, and (c). Generally, office units at the Universitas Syiah Kuala have a very poor and weak OGS.

1. Introduction

Currently, the threat of global warming has implications for the increasing needs of the community, especially in the urban areas of Open Green Space (OGS). Nowadays, the development of urban development shows a tendency of unbalanced development activities [1]. Today’s event is more oriented towards the fulfillment of chambers with facilities and infrastructure in the form of physical building [2].

Therefore, to anticipate the spread of the previous movement above, it needs to action toward the accelerated development of the city to become a green city; at least it could compensate for the acceleration of environmental degradation. The remaining land can be directed to establish an open green space. OGS is an approach and application of one or more OGS functions in urban vegetation groups to achieve protection, recreation, aesthetics, and other functional purposes for the benefit of urban communities [3]. The OGS is essential for the reduction of carbon dioxide (CO₂) through fixation vegetation and to fulfill the needs of oxygen (O₂) for breathing, especially humans [4]. For urban environmental management in Indonesia, there has been set Law No. 26, 2007, about the management of OGS that requires as much as 30% of the area [5].

OGS is part of the open spaces in the urban areas that are filled by plants and vegetation to support the direct and indirect benefits of OGS for the city in terms of safety, comfort, well-being, and beauty aspects [6]. OGS can be found in hospitals, offices, schools, colleges, and other places. The more
diverse the plants will add beauty to the OGS. Therefore, aspects of diversity should become an essential instrument in developing the OGS widely, no exception for campus area, which is inhabited by tens of thousands of students doing their activities, for example, Universitas Syiah Kuala.

Universitas Syiah Kuala (Unsyiah) is one of higher educations in Banda Aceh, which has an area of approximately 9,437,209 m². Greenspace on campus is part of the urban green space that ideally has functions that support the academic activities on campus, which includes students, faculty members, and employees; therefore, Unsyiah’s infrastructure development is obliged to be balanced with the availability of adequate green space. The result of observation within the Unsyiah area shows that there are green spaces overgrown with a variety of plants. However, there is no information yet whether the intended OGS is in the category good or otherwise meeting the criteria set by the law of the landscape management [7].

Plant on OGS has an ecological functions and it also has the capacity of architecture, namely (i) component of physical barriers, (ii) limiting visual control, (iii) Wind and sun controls (climate control), (iv) producing shadow shade, and (v) accentuation and beauty of the environment (aesthetic values). Besides, plants have other functions as (i) preventing erosion (erosion control) and (ii) habitat (wild habitats). So up to date, there has not been obtained information about the level to a diversified and the ratio of green space at Universitas Syiah Kuala.

2. Methodology
Universitas Syiah Kuala is located on Jalan. Nyak Arief T. Banda Aceh Darussalam with a total area of 9,437,209 m². Unsyiah has various facilities such as laboratories, Head Office Administration, Institutions, Quality Assurance Agency, Student Organization, Academic Services Unit, Research and Student Affairs, and other supporting facilities for activities both academic and community activities from outside the campus. The study was conducted at twenty stations; the layout of the observation plot is presented in Figure 1.

Data on the frequency (F) and the density (D) tree is collected by using quadrate method as much as 5 plots each observation station with an area of 10 m x 10 m, so the total quadrate observations as much as 100 pieces, and the chosen place is done subjectively and quadrate is also used to obtain data on extensive green space.

The observed variable includes density (D) and frequency (F) for calculating important value (IV) of each species were obtained through the Relative Frequency (RF) + Relative Density (RD); IV calculation results are then used to calculate Species Diversity Index (Ĥ) [8].

\[
Ĥ = \Sigma p_i \ln p_i
\]

where: \(p_i = \frac{n_i}{N}\)
\(n_i = \) number of the important value of the species,
\(N = \) Number of significant value across species
\(\ln = \) Natural Logarithm (natural number)

To make all index values of various species diversity (Ĥ) on-Wiener Shan can be interpreted its meaning, then it is used the following criteria: The value of Ĥ range from 0-7 if \(Ĥ \leq 1\) category is very low, if \(Ĥ \geq 1-2\) low category, if \(Ĥ \geq 2-3\) medium category, if \(Ĥ \geq 3-4\) high category, and if \(Ĥ \geq 4\) categories are very high [9] [10].

Things to consider in the provision of OGS is the extent of green space itself. Based-on Law No. 26 the Year 2007 on Spatial Planning, the proportion of OGS is at least 30% of the total area. To calculate the ratio using the formula as follows [5]. The category of OGS use the following criteria; >40% very good, >30% good, <30% poor and <10% very poor.

\[
\text{OGS Ratio} = \frac{\text{Wide of OGS}}{\text{Wide of total area}} \times 100\%
\]
3. Results and Discussion

3.1. Compositions, Importance Value, and Diversity of Trees

Based on the research results on the composition of trees at twenty observation stations, it is found that as much as 46 tree species consisting of 28 families, presented in Table 1. Arecaceae dominates the composition of the vegetation consisted of five species, and these are Roysronia regia, Veitchia merillii, Cocus nucifera, Elaeis guineensis, and Corypha utan. Thus, it can be argued that these five species can adapt to their environment, in addition to human intervention in planting the species. Arecaceae is one of the most prominent families for humans. Its members are widely used in everyday life such as handicrafts, food and beverage, traditional medicine, decoration, building materials and also can bring profits in terms of the economy [11].

According to Table 1, it is found that none of the families are representative of the striking species because a few species represent each family. Represented Familia of 3-5 is a type of Myrtaceae, Annonaceae, Fabaceae, Mimosaceae, Moraceae, and Arecaceae. This group is relatively better tolerated than others for life. The percentage of species at twenty stations show that there are six species that have attendance rate > 50% ie Pterocarpus indicus (8.837 %), Swietenia mahagoni (7.442%), Samanea saman (6.512%), Minusops elengi (6.047%), Tamarindus indica (5.115%) and Roystonia regia (5.115%).

The number of observed of 46 species belong to thirty families. The significance of each species on the whole station is relatively small (Table 1). Thus we can argue that the research areas relatively homogeneous vegetation, but there are six kinds of plants that have significant value is relatively high compared to the others, namely P. Indica (20.722), S. mahagoni (20.676), Polyathia longifolia (15.000), M. Elengi (13.600), Roysonia regia (13.391), and S. saman (11.296). The importance value (IV) of plant species in a community is one parameter that indicates the role of the plant species in the community. The presence of a plant species in an area shows the ability to adapt to habitat and wide tolerance to environmental conditions. The larger the critical value of a species, the higher the level of mastery over the community and vice versa [12,13].

The dominance of a particular species in a community occurs if the species concerned successfully locate most of the existing resources compared with other species [14]. Thus, it can be argued that the species has an important high value (Table 1) is a species that dominates the campus area of Unsyiah, Banda Aceh. The lowest importance value of the plant is referred to Phyllantus acidus (0.382), Psidium
guava (0.343), *Averrhoa carambola* (0.276), and *Averrhoa bilimbi* (0.276) which means that these species are species that have small level of dominance, meaning that the adaptability and tolerance are relatively low in the community. It will have an impact on the existence of a species. If there is a pressure that cannot be overcome by these species, the impact will be the loss of a species in a community.

**Table 1.** The composition, importance value and diversity index of the tree at Universitas Syiah Kuala

| Local Names       | Scientific Names         | Families          | IV   | H   | Percentage |
|-------------------|--------------------------|-------------------|------|-----|------------|
| Angsana           | Pterocarpus indicus      | Papilionaceae     | 20.722 | 0.211 | 8.837      |
| Mahoni            | Swietenia mahagoni       | Meliaceae         | 20.676 | 0.193 | 7.442      |
| Glodokan Tjang    | Polyalthia longifolia    | Annonaceae        | 15.000 | 0.127 | 4.651      |
| Tanjung           | Mimosaops elengi         | Sapotaceae        | 13.600 | 0.145 | 6.047      |
| Palem raja        | Rosytonia regia         | Areceaceae        | 13.391 | 0.127 | 5.116      |
| Trenbesi          | Samanea saman            | Fabaceae          | 11.296 | 0.137 | 6.512      |
| Asam Jawa         | Tamarindus indica        | Fabaceae          | 9.116  | 0.103 | 5.116      |
| Jati              | Tectona grandis          | Lamiaceae         | 9.111  | 0.093 | 3.721      |
| Palem putri       | Veitchia merillii        | Areceaceae        | 8.934  | 0.104 | 4.651      |
| Cemara Laut       | Casuarina equisetifolia  | Casuarinaceae     | 8.878  | 0.095 | 4.186      |
| Ketapang          | Terminalia catappa       | Combretaceae      | 6.845  | 0.073 | 2.791      |
| Kelapa            | Cocos nucifera           | Areceaceae        | 6.383  | 0.074 | 3.721      |
| Savit             | Elaeis guineensis       | Areceaceae        | 5.187  | 0.045 | 1.860      |
| Pepaya            | Carica papaya            | Cariceaceae       | 3.429  | 0.045 | 2.326      |
| Mamba             | Azadirachta indica       | Meliaceae         | 3.384  | 0.042 | 2.326      |
| Mangga            | Mangifera indica         | Anacardiacae      | 3.056  | 0.045 | 2.791      |
| Acasia            | Acacia auriculiformis    | Fabaceae          | 3.011  | 0.039 | 1.860      |
| Bambu Kuning      | Bambusa vulgaris         | Poaceae           | 2.959  | 0.028 | 0.930      |
| Kembang Merak     | Caesalpinia pulcherrima  | Caesalpinaceae    | 1.953  | 0.022 | 0.930      |
| Ki Acret          | Spathodea campanulata    | Bignoniacae       | 2.649  | 0.034 | 1.860      |
| Kenanga           | Cananga oordata          | Annonaceae        | 2.571  | 0.024 | 0.930      |
| Ekaliptus         | Eucalyptus camaldulensis | Myrtaceae         | 2.532  | 0.030 | 1.395      |
| Cemara kipas      | Platycladus orientalis   | Cupressaceae      | 2.525  | 0.037 | 2.326      |
| Ceri/Kersen       | Muntingia calabara L.    | Elaeocarpaceae    | 2.397  | 0.030 | 1.395      |
| Karet kebo        | Ficus elastica Roxb.     | Moraceae          | 2.147  | 0.028 | 1.395      |
| Jambu air         | Eugenia aqua             | Myrtaceae         | 1.750  | 0.020 | 0.930      |
| Mengkudu          | Morinda citrifolia       | Rubiaceae         | 1.705  | 0.024 | 1.395      |
| Gebang            | Corypha utan             | Areceaceae        | 1.649  | 0.020 | 0.930      |
| Flamboyan         | Delonix regia            | Fabaceae          | 1.303  | 0.013 | 0.465      |
| Beringin          | Ficus benjamin           | Moraceae          | 1.297  | 0.020 | 1.395      |
| Cemara Norfolk    | Araucaria heterophylla   | Araucariaceae     | 1.289  | 0.018 | 0.930      |
| Sirsak            | Annona muricata Linn     | Annonaceae        | 1.151  | 0.016 | 1.395      |
| Ficus kuning      | Ficus sp.                | Moraceae          | 1.039  | 0.012 | 0.465      |
| Kerai Payung      | Filicium decipiens       | Sapindaceae       | 0.956  | 0.014 | 0.930      |
| Jeruk Bali        | Citrus maxima            | Rutaceae          | 0.951  | 0.014 | 0.930      |
| Nyamplung         | Calophyllum inophyllum   | Guttiferae        | 0.738  | 0.010 | 0.465      |
| Kapuk randu       | Ceiba pentandra          | Malvaceae         | 0.694  | 0.009 | 0.465      |
| Pisang kipas      | Ravenala madagascariensis| Musaceae          | 0.584  | 0.008 | 0.465      |
| Pisang            | Musa paradisiaca         | Musaceae          | 0.532  | 0.008 | 0.465      |
| Jamblang          | Syzygium cumini          | Myrtaceae         | 0.513  | 0.008 | 0.465      |
| Campaka           | Michelia campaka         | Magnoliaceae      | 0.413  | 0.007 | 0.465      |
| Petai Cina        | Leucaena leucocephala    | Mimosaceae        | 0.406  | 0.007 | 0.465      |
| Cermai            | Phyllantus acidus        | Phyllantaceae     | 0.382  | 0.006 | 0.465      |
| Jambu Klutuk      | Psidium guajava          | Myrtaceae         | 0.343  | 0.006 | 0.465      |
| Belimbing hintang | Averrhoa bilimbi         | Oxalidaceae       | 0.276  | 0.005 | 0.465      |
| Belimbing wuluh   | Averrhoa carambola       | Oxalidaceae       | 0.276  | 0.005 | 0.465      |

Total 200 2.18 100
3.2. Diversity of tree
The results of the tree diversity index at twenty stations noted that fourteen stations have a diversity index of the medium category, and six stations are low diversity index categories (Table 2).

Table 2. Diversity Index species (\(\hat{H}\)) and the ratio of green open space (OGS) of the tree at Universitas Syiah Kuala

| Observation Station                                      | \(\hat{H}\) | Category | Number of Species |
|----------------------------------------------------------|-------------|----------|-------------------|
| Faculty of Veterinary                                    | 2.634       | Medium   | 15                |
| Faculty of Agriculture                                   | 2.584       | Medium   | 17                |
| Faculty of Law                                           | 2.564       | Medium   | 15                |
| Faculty of Engineering                                   | 2.557       | Medium   | 14                |
| Faculty of Teacher Training and Education                | 2.545       | Medium   | 14                |
| Library                                                  | 2.496       | Medium   | 13                |
| Faculty of Mathematics Natural Science                   | 2.427       | Medium   | 13                |
| Faculty of Medicine                                      | 2.291       | Medium   | 12                |
| Administration Office                                    | 2.219       | Medium   | 10                |
| Public Lecture Room                                      | 2.218       | Medium   | 11                |
| Faculty of Marine and Fisheries                          | 2.215       | Medium   | 10                |
| Faculty of Economic and Business                         | 2.166       | Medium   | 11                |
| Faculty of Nursing                                      | 2.089       | Medium   | 10                |
| Mesjid Jami’                                             | 2.087       | Medium   | 9                 |
| Student Hall                                             | 1.966       | Low      | 8                 |
| Postgraduate Building                                    | 1.938       | Low      | 8                 |
| Faculty of Social and Political Science                  | 1.720       | Low      | 7                 |
| Language Center                                          | 1.676       | Low      | 6                 |
| Faculty of Dentistry                                     | 1.661       | Low      | 6                 |
| Student Dormitory                                        | 1.643       | Low      | 7                 |

The level of diversity of tree species at the Universitas Syiah Kuala showed the number of \(\hat{H} = 2.179\), included in the medium category. It shows that the species composition has not been ideal. Therefore, it is required to add trees with different species so that the result of the level of species diversity is higher. The higher the index value \(\hat{H}\), the higher the species diversity, ecosystem productivity, fewer pressures on ecosystems, and better stability of the ecosystem [15].

Ecosystems have regularity as the embodiment of the ecosystem’s ability to maintain themselves, organize themselves, and by itself able to maintain back the balance [16]. The balance in an ecosystem known as homeostatic, has the meaning as the ability of ecosystems to withstand changes in the overall system [17].

Ecosystem conditions in the balance have the meaning that the ecosystems have been established in this ecosystem that is the OGS in the campus to reach a climax so that an ecosystem has a great endurance to deal with various disruptions that may happen. The survival of the ecosystem depends on the age of the ecosystem. Ecologically there is the term resilience that has the meaning of an ecosystem's ability to recover after being exposed to interference. The faster the condition of the ecosystem is recovering means more disturbances that can be overcome so that it has high resilience. The resilience is the nature of an ecosystem that provides the possibility of these ecosystems recover to its original after a disturbance [18].

In addition to maintaining high diversity, communities require regular and random distractions. The highly stable community extends regionally, and homogeneous, showing a lower species diversity than consisting of woods form a mosaic or regionally and interrupted at a certain time either by fire, wind, flood, disease, and human intervention. Commonly, the increase of the species after the disturbance has passed, there will be an increase in the diversity of species to the point of the dominance of few species that live long and large size, thus reversing the tendency becomes diversity decreases [19].
The data in Table 2 presents the diversity index of tree species at Universitas Syiah Kuala in which all stations are relatively the same. Fifteen stations have a diversity index with categories in the range of 2.087 to 2.634, while the lower categories ranged from 1.661 to 1.966. Value $H$ range from 0-7. If $H \leq 1$ category is very low, if $H \geq 1$-2 is low category, if $H \geq 2$-3 is the medium category, if $H \geq 3$-4 is the high category, and if $H \geq 4$ categories are very high [9,10].

Based on the value of diversity index (Table 2) noted that the number of species does not always generate a high diversity index. For example, at station 7 (FV) with the number of species 15 generates diversity index species 2.634 whereas at station 4 (FA) with the number species 17 generates diversity index species 2.584, this fact indicates that the diversity index species be determined by the variation value being expressed every species at each sampling unit. This diversity index ($H$) can be regarded as information about the community. The more varied the composition of the variables, the more difficult to estimate each sample unit, even though in general, that many species are likely to generate high species diversity index [9,19,20].

3.3. Open Green Spaces (OGS)

The result of the percentage showed that four observation stations had a very good category, three observation stations had a good category, eight observation stations had the poor category, and five observation stations had a very poor category (Table 3).

| Observation Station | OGS  | Category       |
|---------------------|------|----------------|
| MJ                  | 60%  | Very good      |
| FEB                 | 47%  | Very good      |
| AO                  | 44%  | Very good      |
| SH                  | 43%  | Very good      |
| PLR                 | 38%  | Good           |
| L                   | 35%  | Good           |
| FMF                 | 35%  | Good           |
| FN                  | 26%  | Poor           |
| FSPS                | 25%  | Poor           |
| FD                  | 20%  | Poor           |
| FV                  | 19%  | Poor           |
| FL                  | 16%  | Poor           |
| FA                  | 14%  | Poor           |
| FMNS                | 14%  | Poor           |
| FM                  | 11%  | Poor           |
| SD                  | 10%  | Very poor      |
| FTTE                | 9%   | Very poor      |
| FE                  | 7%   | Very poor      |
| PB                  | 6%   | Very poor      |
| LC                  | 1%   | Very poor      |

The data analysis result showed that the ratio and segmentation of OGS of 20 observation stations (Table 3) found that four stations have very good category OGS> 40% ie; Masjid Jami’ (60%), Student Center (43%), Faculty of Economics and Business (47%) and Administration Office (44%), three stations have OGS in category good> 30% Public Lecture Room (37,80%), Faculty of Marine and Fisheries (35%) and Library of Unsyiah (35%), five stations that have not good category of OGS<1 0%, ie; Students Dormitory (9,80%) Faculty of Teacher Training and Education (8,84%), Faculty of Engineering (7%), Postgraduate building (6.22%) and Language Center (1%), specifically for this latter
required severe attention. The wider a region, the wider the need for green open space [21]. Based on the results of research, it is found that the most significant area in the Faculty of Agriculture is 69,904 m². Meanwhile, the OGS is only 14% of the entire area, so it can be said that the green space at the Faculty of Agriculture is considered poor. Previous research conducted in Syiah Kuala District for the broadest area requires OGS of 427.32 Ha [21]. The high demand for green open space in the district of Syiah Kuala is because the district has the largest area among other districts. This is in accordance with the opinion of the [22] stating that if the determination of the area of green open space based on the percentage of a city, the wider the city will be more broadly also the green space that must be provided and in the micro-scale region with the largest area in the city the broader proportion of green space compared to sub-districts that have a smaller area.

Universitas Syiah Kuala, which is located in Syiah Kuala sub-district has a role in fulfilling the needs of green open space, therefore in five observation stations having green space <10% must get attention from the campus. Create an ecological balance in urban areas, and it is necessary to plant and develop OGS sufficiently by the minimal needs of a region [21]. OGS is part of an urban open space containing plants that accidentally or intentionally planted to support the direct or indirect benefits from the OGS. The plantation is a manufacturer that produces oxygen for all living things on earth, and therefore the need for a good green space is an absolute necessity. Referring to the result of the calculation of species diversity index is very relevant to make efforts of planting other plant species with two main objectives that are, to fulfill the achievement of good diversity index and to fulfill green open space, which is classified bad. The Law on Spatial Planning has been stipulated in Article 26 of 2007 which states that ideally, OGS in a region is 30% of the total area. This provision is a government policy to reforest the city as one way for nature conservation.

The shape and function of OGS can be developed and adapted to the suitability of available space. It is expected that through this process, the realization of the region or sub-region by the wishes of the community and supports the conditions of a good environment can be formed. The spatially close connection occurs between the area of OGS of an urban area and the positive impact that will be obtained from biophysical functions, so it can be right in assuming that this effect is proportional to the area of OGS.

Spacious and structure determination of this social function based on the needs and preferences of society, so, the OGS is built in addition to oxygen providers, it can also have a function that corresponds to its place. For example, the OGS on campus should support educational activities such as the provision of nameplate on each tree so that students could know tree species in the campus area, in line with research said that the availability of information on OGS of FPN UGM to improve the function of education in the green room feels very appropriate by 94% of respondents, as many as 90% of respondents agreed to facilities such as nameplate information (name tags) that displays the local name and the Latin name of plants. Based on the results of a survey conducted to all academicians of FPN UGM, 52% of respondents answered most of the local names of plants in OGS of FPN UGM and 98% of respondents did not know most of the Latin names of plants in OGS FPN UGM" [7]. Therefore, Universitas Syiah Kuala may consider creating a nameplate to each tree so that the tree preservation of green space located on the campus has contributed to the function of education for its students and also instill an understanding of the value of preservation for students.

4. Conclusions
Based on the result of the study concluded that; (a) The level of diversity of tree species at the Universitas Syiah Kuala showed the number of $H = 2.179$ (medium). There are 46 species of trees found belonging to 28 families. The six plants that have significant value are relatively high compared to the others, namely *P. indica* (20,722), *S. mahagoni* (20,676), *P. longifolia* (15,000), *M. elengi* (13,600), *R. regia* (13,391), and *S. saman* (11,296). There are 3-5 species of Myrtaceae, Annonaceae, Fabaceae, Mimosaceae, Moraceae, and Arecaaceae. This group is relatively better tolerated than others for life. The percentage of species at twenty stations show that there are six species that have attendance rate > 50%, ie *P. indicus* (8,837 %), *S. mahagoni* (7,442%), *S. saman* (6,512%), *M. elengi* (6,047%), *T. indica*...
(5.115%) and R. regia (5.115%). (b). The diversity of tree in observation station found that fourteen stations had medium category and six stations had low category (c). There are four stations have very good category OGS> 40% ie; Masjid Jami’ (60%), Student Center (43%), Faculty of Economics and Business (47%) and Administration Office (44%), three stations have OGS in category good> 30%. Public Lecture Room (37.80%), Faculty of Marine and Fisheries (35%) and Library of Unsyiah (35%), five stations that have very poor category of OGS<10% ie; Students Dormitory (9.80%) Faculty of Teacher Training and Education (8.84%), Faculty of Engineering (7%), Postgraduate building (6.22%) and Language Center (1%).

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