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RESEARCH ARTICLE OPEN ACCESS

Diversity of Trees Species in The Natural Ecosystems of Development Area for Eco-Forest Green Open Space at Pangkalan Kerinci City, Indonesia

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Abstract. Eco-Forest green open space (GOS) development is one of the ways to achieve sustainable urban development in Pangkalan Kerinci City. The information of structure and composition of the natural tree species growing in the green open space was required as a basis to formulating future rehabilitation strategy. This study aims to analysed the diversity and composition of tree species at the development area of Eco-Forest GOS. The data used in this study was primary data of tree species, dbh, frequency and density. Data collected by field observation using a systematic sampling method. Data analysis was carried out by estimate the diversity parameters including diversity index, richness, and evenness. Species composition assessed by important value index. Spatial interpolation of the diversity index and tree density was carried out by spline interpolation method using ArcGIS 10.7 software. The analysis result shows that the diversity of natural tree species was decreases by increasing the live cycle of tree. There are three dominant species in this location, which *Ilexcymosa*, *Litsea firma*, and *Stemonurus secundiflorus*. Spatial analysis shows that 51.5% of the green space area classified into low diversity and density category, while 13.2% was classified as high diversity and density class. Efforts to achieved the successful of GOS management by use the information of vegetation's structure and composition as one of the inputs to develop the regeneration and rehabilitation system. At the same time, it is necessary to increases the dimensions of human, institutional and financial management that supports biodiversity conservation in the green open space

Keywords: Biodiversity conservation; eco-forest; green open space; natural regeneration; sustainable city

Introduction

Pangkalan Kerinci City is Pelalawan District's Capital which rapid development in Riau Province. In 1998, the population was no more than 7 thousand peoples, then at 2018 became around 134.7 thousand people. Its means that over the last 20 years the population has increased 19 times. Based on the growth trend, it is estimated that the population in Pangkalan Kerinci in 2028 will reach 252.4 thousand people. The accelerated development in this city due to the rapid development of the pulp and paper, palm oil and oil, and gas mining industries. This is become a motivation for people to migrating to Pangkalan Kerinci (Syah, 2013) and (BPS, 2020)

The rapid development of Pangkalan Kerinci City has caused several environmental problems includes: an increases environmental pollution, sanitation, garbage, noise, social inequality, the loss of indigenous knowledge and its culture, crimes, and public health (Ciptakarya, 2018). In addition, the living culture of industrial society with routine activities in factories-offices caused work pressure and a high level of saturation (Le, 2019). Communities whom living in industrial areas needs recreation to several tourism destination to refresh their condition during holidays before carrying out normal activities at workplace (ILO, 2012)

Green open space (GOS) development in Pangkalan Kerinci City is one of ways to improve the quality of urban areas towards sustainable urban development by preserving the ecological, economic and social functions. Green open space will increase the absorption of CO_2 gas and pollutants (Permata et al, 2015), be able to reduce noise (Harjanti and Anggraini, 2020), stabilize water systems, maintain biodiversity, as a sources of local food producers (Haq, 2011), and preserve local wisdom (Lullulangi et al, 2020). GOS is a place for environmental education and tourism which help improves the community's economy and increases environmental awareness (Rahayu et al, 2019). The GOS management also in line with Pelalawan district's policy, which has launched the Pelalawan Exotic programs, which realizing the sustainable development of tourism sector as an alternative resource (Bappeda Pelalawan, 2021)

There are several approaches in the green open space development, one of which is to use an eco-forest system which considers aspects of ecosystem restoration naturally, sustainable management, and environmental education (Kwon, 2006). In the development of Eco-Forest GOS, the restoration aspect has an important role, especially in creating the ecosystem services provided by green open space as well as meets to tourism demand. Afrianto et al in his research succeeded in establishing the suitability of species in GOS based on three criteria include: silvicultural, management and aesthetics (Afrianto et al, 2021). The information of bio-geophysics aspect includes: stand structure and composition, growth and soil conditions, microbes, and climate in an ecosystem was needed to build a silvicultural strategy (Kim and Ban, 2015). Information and understanding of vegetation structure is useful to manages the ecosystems in a more sustainable way (Fatonah et al, 2021). This study aims to analyze the diversity and composition of tree species of ecosystem at the development area of Eco-Forest GOS in Pangkalan Kerinci City. This information expected will be used as one of inputs of future sustainable management plans.

Material and Methods

This research was conducted in the location of eco-forest GOS development area in Pangkalan Kerinci City, Pelalawan District, Riau Province. This area has covered by young shrubs, where in some areas there are still native trees plants of its natural ecosystems. This vegetation has potential to be preserved as plants to fill green open space. This research was conducted during August – September 2021. The data collection technique in this study was field observation with systematic sampling techniques (Figure 1). The sample unit was square plot with 20x20m size. The plot consists of sub plots 20x20m for tree measurement (dbh ≥ 20 cm); 10x10m for poles measurement (dbh 10-20 cm); 5x5 m to for sapling (dbh 5-10 cm); and 2x2 m for seedling (tree height < 1.3 m) (Prasetyo et al, 2017). Plots layout distributed systematically with 100 x 100 m grid distance. The measurement of all trees in plots include: species identification and dbh measurements.

Analysis of the data refers to vegetation analysis standard by estimate several species diversity parameters, include Shannon-Wiener diversity index, eveness and richness at each tree life level (Turkis & Elmas, 2018). The important value index (IVI) was expressed to assess species composition in the GOS (Atsbha et al, 2019). The IVI value of each tree life level was standardized or normalized referring to Mastop et al (2017), which normalized IVI data to (0.1), by divided it's with the maximum of IVI value. Spatial analysis of diversity and density was carried out using the spline interpolation method (Kamaruddin et al, 2018) using ArcGIS 10.7 software for mature trees (dbh ≥ 10 cm) (Fashing et al, 2019). Quantile analysis (Nawari et al, 2021) was carried out to classify the diversity and tree density into three categories (low, medium and high) based on the distribution of the data, which generated in

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the spatial interpolation. The spatial interpolation results as a basis to determining regeneration strategies.

Results and Discussion

The analysis results shows that the diversity of woody tree species in the Eco-Forest GOS area is highest at the seedling level, then decreases at a higher tree life level. This shows that the number of species and individual trees at the seedling level is higher than at the trees level (Figure 1). Several things that affect the decline of species diversity from early tree live level to the higher level in this area due to this green open space location previously was idle land that is not managed properly. Some residents were harvested the stand at the sapling to trees level for their household wood especially for building pegs, house fences and flagpoles. After this land was acquired by the Pelalawan District Government, then the staffs were carried out to prohibit tree cutting. Quesada & Kuuluvainen (2020) in their research explain that forest use has a negative impact on the diversity of forest compositions.

At the seedling level, the number of species reached 16 tree species, while at the tree level it decreased to three main species include: *Ilex cymosa*, *Litsea firma*, and *Stemonurus secundiflorus*. These three types were available to grow in all trees life level because they have sufficient individual distribution in all life level. This allows the three types to fill the GOS's areas with natural regeneration. while the other species have incomplete distributions which hinder their regeneration process. In the past some of GOS area was degraded and land have been opened, which is indicated by the emergence of the invasive species *Acacia mangium* at the Poles level. However, this invasion did not run optimally, which was indicated by its low abundance at the seedling and sapling levels (Figure 2 and Table 1).

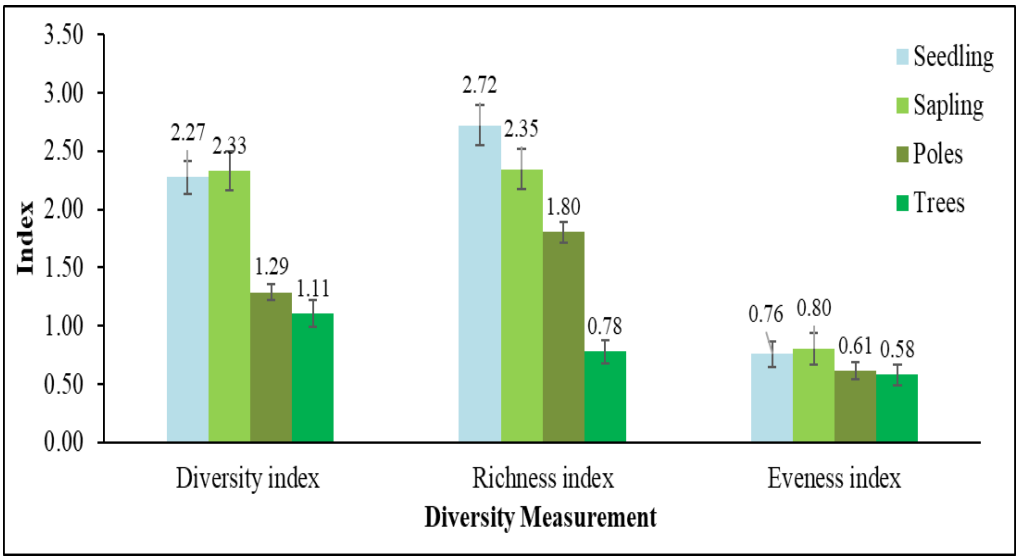

Figure 1. The species diversity parameters in different tree life level at GOS area

The development of modern land rehabilitation technology is taking into account the natural ecological process, which by developing seed-production blocks to carry out natural regeneration (Suryanto et al, 2011). Natural processes will further increase the accuracy of site species matching and the success of land rehabilitation. At the same time with a proper control, this approach also considers the purpose of land use, which considering the ability of species to provide ecosystem services (Kettle, 2010). Ecosystem function is highly dependent on the stability and complexity of the species structure and composition, as well as it ecological processes (Bauhus & Schmerbeck, 2010). The selection of silviculture in the development area of Eco-Forests GOS could be harmonized with several types of ecosystem

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services, such as the provision of non-timber forest products to support food sources, handicrafts and medicines, pollution absorption, soil and water conservation, supporting wildlife and biodiversity conservation, and to create an aesthetic value that supports tourism development directly.

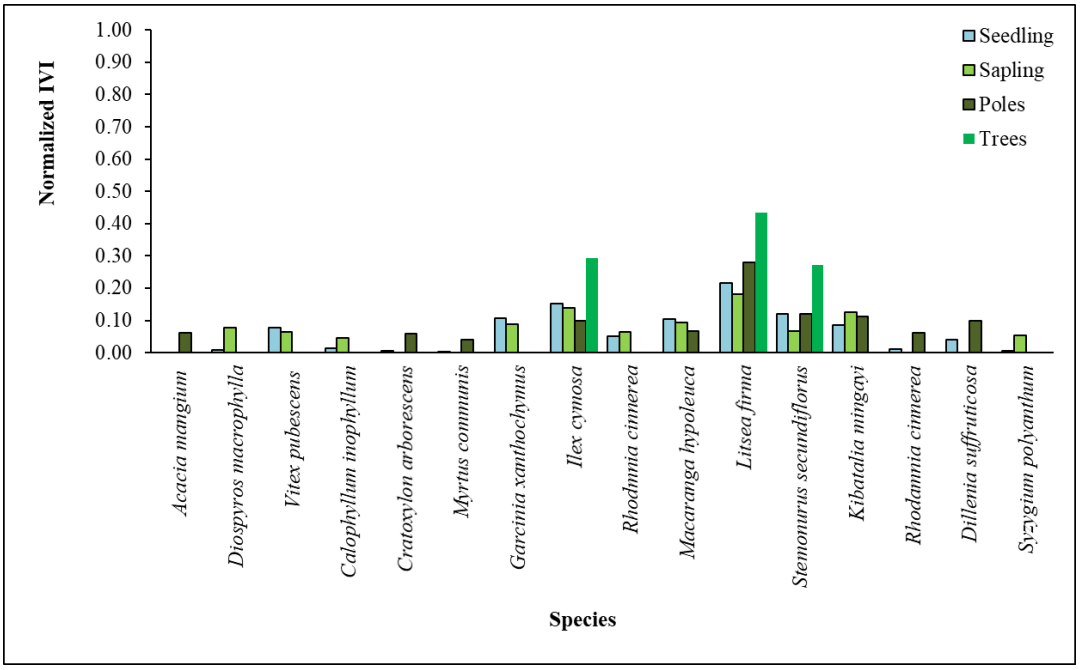

Figure 3: Normalized important value index of species in GOS area

Tabel 1: Important value index (IVI) and normalized IVI of tree species in development area of Eco-Forest GOS

Species	Important Value Index (IVI) (%)				Normalized IVI			
	SD	SP	PL	TR	SD	SP	PL	TR
Acacia mangium	0.0	0.0	18.5	0.0	0.00	0.00	0.06	0.00
Diospyros macrophylla	1.6	23.5	0.0	0.0	0.01	0.08	0.00	0.00
Vitex pubescens	15.5	19.4	0.0	0.0	0.08	0.06	0.00	0.00
Calophyllum inophyllum	2.8	13.8	0.0	0.0	0.01	0.05	0.00	0.00
Cratoxylon arborescens	1.2	0.0	17.4	0.0	0.01	0.00	0.06	0.00
Myrtus communis	0.8	0.0	12.1	0.0	0.00	0.00	0.04	0.00
Garcinia xanthochymus	21.2	26.5	0.0	0.0	0.11	0.09	0.00	0.00
Ilex cymosa	30.3	41.3	29.8	88.0	0.15	0.14	0.10	0.29
Rhodmnia cinnerea	10.3	19.1	0.0	0.0	0.05	0.06	0.00	0.00
Macaranga hypoleuca	20.8	28.4	20.4	0.0	0.10	0.09	0.07	0.00
Litsea firma	43.2	54.0	84.2	130.4	0.22	0.18	0.28	0.43
Stemonurus secundiflorus	23.9	19.9	35.9	81.7	0.12	0.07	0.12	0.27
Kibatalia mingayi	17.0	37.8	33.5	0.0	0.09	0.13	0.11	0.00
Rhodamnia cinnerea	2.4	0.0	18.2	0.0	0.01	0.00	0.06	0.00
Dillenia suffruticosa	8.0	0.0	29.9	0.0	0.04	0.00	0.10	0.00
Syzygium polyanthum	1.0	16.3	0.0	0.0	0.01	0.05	0.00	0.00
Total	200	300	300	300	1	1	1	1

Note: SD =seeding, SP=sapling, PL= poles and TR=trees
Sources: Primary data analysis (2021)

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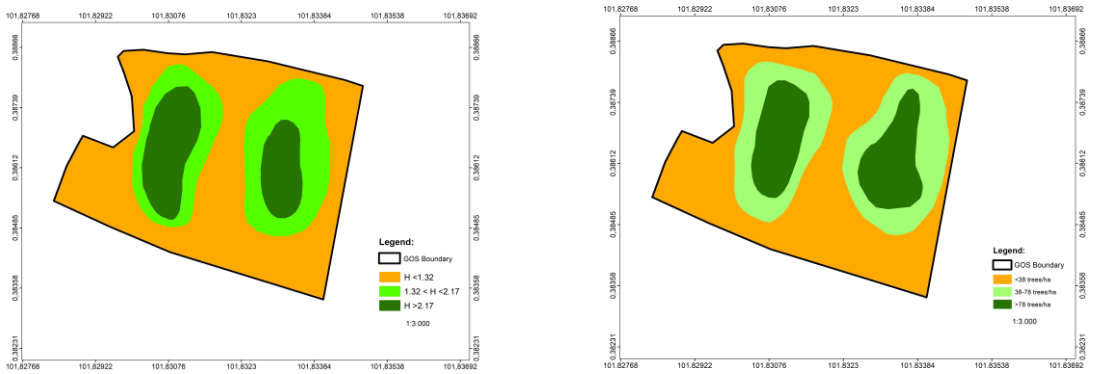
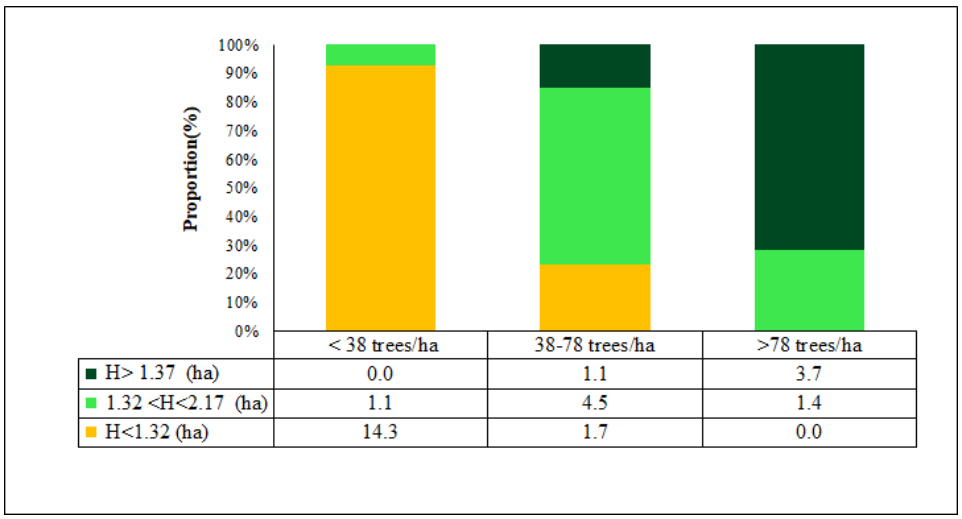
Spatial analysis of the diversity index and density of mature trees with dbh ≥ 10 cm showed that about 51.5% of the total GOS area (27 ha) which classified Zone I: which is low diversity (Shannon-Wiener's diversity index (H) < 1,32) and low tree density class (< 38 trees/ha). trees/ha). Meanwhile, 13.2% of the total area classified into Zone II: which is high diversity (H>2.17) and high tree density class (> 78 trees/ha). The areas which classified as higher tree diversity followed by higher tree density (Figure 3 and Figure 4). Areas within in Zone II was potential to be used as seed orchard blocks to provide natural seeds for Zone I. Its to maintain the ecological process by natural regeneration. The human control to accelerate the regeneration by building nurseries around GOS area. Several technologies potentially to be used in the nurseries include: accelerated germination technology (Bramasto et al, 2018), the use of shoot cuttings (Sulicantini et al, 2014), and tissue culture techniques (Nurhidayah et al, 1996). The rehabilitation in the areas with low diversity and density classes can be carried out by planting local endemic tree species that are not included in the species list in the GOS ecosystem. Planting local endemic species, especially fruit producers, can increase the attractiveness of GOS for tourism development (Bulut et al, 2010).



(a) (b)

Figure 3. Diversity class map (a); and Tree density class map (b)



	< 38 trees/ha	38-78 trees/ha	>78 trees/ha
H> 1.37 (ha)	0.0	1.1	3.7
1.32 <H<2.17 (ha)	1.1	4.5	1.4
H<1.32 (ha)	14.3	1.7	0.0

Figure 4. The distribution of GOS area based on species diversity and tree density class

The information of vegetation structure includes diversity and composition of natural tree species along with-it spatial distribution in the eco-forest GOS will help managers to determine rehabilitation techniques and its sustainable management. In addition to focus on the natural resource management by proper rehabilitation program, strengthening the sustainability of GOS management should be encouraged through the stability of the

dimensions of human-institutional and financial resources. In this management aspects, the development of GOS with an eco-forest approach could be synergized with several existing regional superior programs. For example, the development GOS available to support the creative public spaces as part of the Exotic Pelalawan program (Gunarto, 2015). Green open space rehabilitation efforts also available to be synergized with the biodiversity park development, which is one of the mainstay programs of private companies to meets the standards of the company's performance rating program in environmental management (PROPER), especially for the biodiversity conservation aspect (Gunawan & Sugiarti, 2015). Community participation in biodiversity conservation that is designed with proper engagements process, starting with capacity building, management and development of biodiversity conservation technology has empirically proven effective to achieved the sustainability (Brooks et al, 2013)

Conclusion

Based on the analysis result, it can be concluded that the diversity of species in the natural ecosystem inside the development area of Eco- Forest Green open space (GOS) in Pangkalan Kerinci City is highest at the seedling level and decreases follows increases tree life level. There are three species that dominate and have fulfilled the structure at all tree life level include: *Ilex cymosa*, *Litsea firma*, and *Stemonurus secundiflorus*. Spatially, 51.5% of the GOS is classified as Zone I with low diversity and density class, while 13.2% was classified as Zone II which high diversity and density class. With the eco-forest concept that prioritizes natural regeneration processes, areas in Zone II could be used as blocks for seed production. Meanwhile, Zone I can be used as intensive rehabilitation zones by utilizes seeds produced from seed production blocks. Efforts to accelerate the success of regeneration should be supported by nurseries development around the site proper propagation techniques. Beside to prepared sustainable rehabilitation system which a part of natural resource management, the development of Eco-Forest GOS could be expressed by improving the dimensions of human resource management, institutional and financial management. This collaborative process by integrating the green open space development with several community-based biodiversity conservation programs.

The research result was recommended to be used as one of an input for policy maker to establish sustainable management policy of Eco-Forest GOS. The research enhancement was opened by includes species competition as parameters and environmental services produced by green open space ecosystem.

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