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Population and Habitat Characteristics of Tarsius fuscus in Resort Mallawa Bantimurung Bulusaraung, South Sulawesi

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Abstract

Tarsius fuscus is one of the conservation priority species in the Bantimurung Bulusaraung National Park (Babul National Park). This study aims to analyze the population and habitat characteristics of *T. fuscus* as part of the conservation management considerations for its population and habitat. The research was conducted in July 2021 in the forests surrounding Bentenge Village and Samaenre Village, Resort Mallawa, Babul National Park. The methods included direct observation, counting the number of individuals in each group, and conducting vegetation analysis at *T. fuscus* sighting locations. The observations revealed a population of 48 individuals across 13 groups, with an overall population density of 0.109 individuals per hectare. Population density was higher in secondary dryland forest compared to scrubland. The number of juveniles and infants in both habitat types was lower than the number of adults. *T. fuscus* was found in two types of habitats: secondary dryland forests (SDF) and scrubland, each with specific ranges of physical parameters. Vegetation analysis showed that SDF was dominated by the mana-mana tree (*Blumeodendron kurzii*) with an important value index (IVI) of 57.72%, while scrubland was dominated by the kemiri tree (*Aleurites moluccana*) with an IVI of 40.75%. Both habitats were dominated by species from the Moraceae family and included jambu air seedlings (*Syzygium aqueum*).

Keywords: Babul National Park, *Blumeodendron kurzii*, habitat characteristic, Moraceae family, population of *Tarsius fuscus*

1. Introduction

Tarsius fuscus or Makassar tarsier is the smallest primate in the world endemic to South Sulawesi. Based on IUCN Red List (2020), *T. fuscus* status vulnerable to extinction due to the downward trend in its population. The conservation status of *T. fuscus* in Indonesia has not been established, this is proven by the fact that *T. fuscus* in the list of protected species according to the latest decree in Permen LHK No. P.106 of 2018. Bantimurung Bulusaraung National Park (Babul National Park) is one of the protection areas for priority species, one of which is *T. fuscus* so that its population and habitat remain sustainable. Babul National Park is in two regions, namely Maros and Pangkep Regencies, South Sulawesi.

Practices of *illegal logging* and changes in forest vegetation into other areas such as settlements, agriculture, shifting cultivation, harvesting of rattan, bamboo, and so on lead to habitat fragmentation which threatens the wildlife in it including tarsiers. The population of *T. fuscus* in Babul National Park tends to decline due to habitat fragmentation, forest degradation, and poaching. The existence of tarsiers is influenced by vegetation conditions which affect the diversity of insects as the tarsier feed [1]. The insect diversity may be driven by the plant species richness of different vegetations [2]. Abbas et al [3] also stated that higher plant diversity can enhance the reproduction and fitness of plant-associated insects.

The villages of Bentenge and Samaenre are two villages that are directly adjacent to the forest area of the Mallawa Resort, Babul National Park. Based on information from residents and the national park, there have been encounters with *T. fuscus* in forest areas around these villages. Research on the habitat of *T. fuscus* was previously conducted at the Balocci Resort, Babul National Park by Mustari et al. [4]. There is no valid evidence regarding the population and habitat conditions of *T. fuscus* in the forest area around Bentenge and Samaenre Villages, Resort Mallawa. Therefore, a study is needed that aims to analyze the condition of the population and habitat characteristics of *T. fuscus* in forest areas in the region. The results of this study can be used as a reference and consideration tool for efforts to conserve *T. fuscus* in Babul National Park, especially the Mallawa Resort.

2. Materials and Methods

2.1. Time and Location

This research was held from 2 to 12 July 2021. The land cover type surveyed in this research are secondary dryland forest, scrubland, and plantations. Secondary dryland forest is forest with logged or cleared mineral soils that have been successionally reforested. Scrubland is vegetation dominated by shrubs and herbs. Plantations are artificial vegetation created by humans for the purpose of planting certain types of plants that are useful to humans. Data collection was carried out in the forest area around Bentenge Village and Samaenre Village, Resort Mallawa, Babul National Park, Maros, South Sulawesi Province (Figure 1).

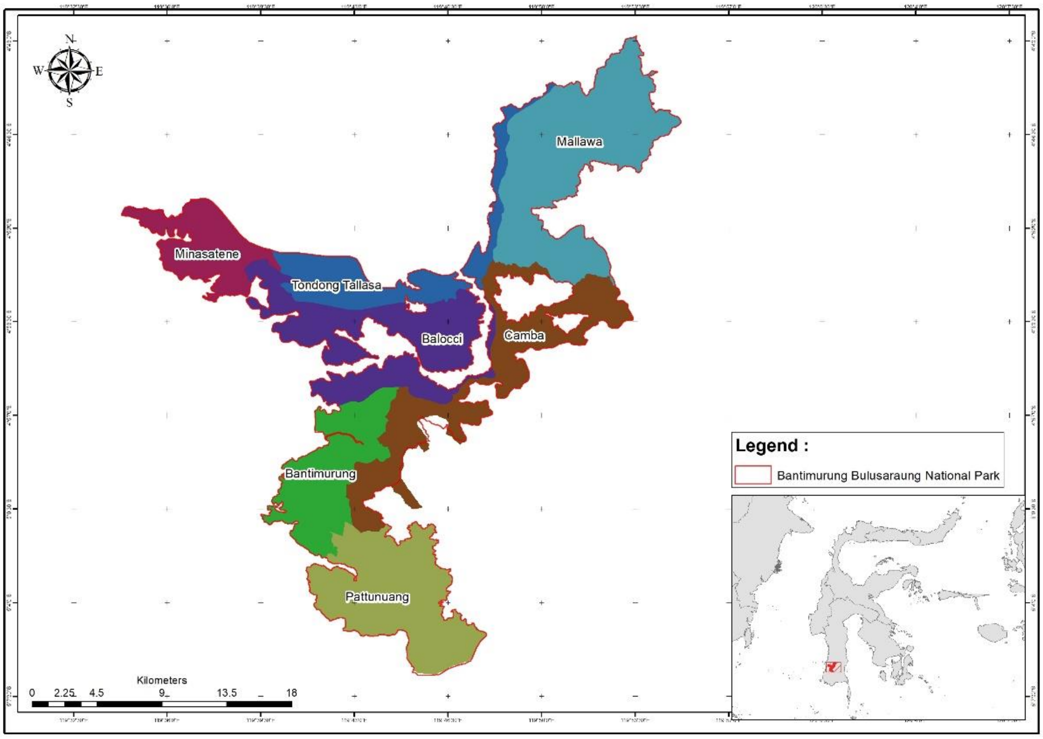

Figure 1. Research site map in Batimurung Bulusaraung National Park. Map source: Decree of Ministry of Environment and Forestry of the Republic of Indonesia No. 389/Menhut-II/2004 dated 18/10/2004

2.2. Data Collection and Analysis

The method used to collect data on the distribution and group sizes of tarsiers was direct encounters. Observations began with an exploration to locate and mark the coordinates of each group using a Global Positioning System (GPS). The collected data were then processed using ArcMap GIS 10.5. Determination of the presence of tarsier can be marked by their sound. According to Andriyani et al. [5], tarsiers will usually make sounds when they leave and return to their nests. Searching for *T. fuscus* can also be done by smelling the urine of it around the nest. Tarsiers will usually mark their nests or home ranges with urine in the morning [6]. Tarsiers were observed for 3 hours in the morning (04:00 am – 07:00 am). Accumulative data collection was carried out for 10 days with proportion of *T. fuscus* observation for 30 hours. Habitat data collection was conducted after tarsier observations in the morning, with a total duration of approximately 60 hours. The data collected for population assessment included the number of individuals in each group, the sex (male and female) of adult individuals within each group, and the age class of each group (infant, juvenile, subadult, adult).

Abiotic data from the environment surrounding the *T. fuscus* groups were collected to analyze the characteristics of their habitat. The data included group coordinates, air temperature, and relative humidity. Land cover types were determined based on the coordinates of each group. The coordinates from each encounter were overlaid onto the land cover map to obtain information about land cover type. Temperature and humidity data were collected through direct measurements at the observation site using a thermo-hygrometer. These measurements were taken during the vegetation analysis in the morning, right after the tarsiers entered their nesting sites. The thermo-hygrometer was placed in the center of the vegetation analysis plot for approximately 30 minutes to ensure the device's readings were stable. This approach was used to obtain real-time data, given that real-time temperature data from GIS may not always be available, especially if the location is obscured by clouds and cannot be detected by satellites such as Landsat 8/OLI.

The vegetation analysis was conducted to determine the structure and composition of the habitat. This was performed using the plot method at the locations that served as substrates for each tarsier group. Three plots were established at each meeting point, with the total number of plots being cumulative across all meeting points (Total Plot = 3 × number of encounter sites). The orientation of the plots was aligned with the dominant movement direction of the tarsiers to accurately represent the area around the tarsier group's substrate, supporting their various activities. Each plot was subdivided into four parts: a 20×20 m plot, a 10×10 m plot, a 5×5 m plot, and a 2×2 m plot. The 2×2 m plots were specifically placed on trees or sites where the tarsiers nest, allowing for the collection of regeneration data for these nest trees. The layout of the plots is illustrated in Figure 2.

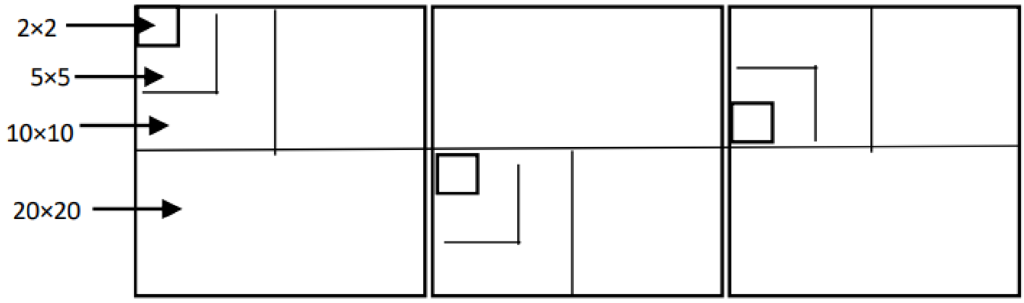

Figure 2. Illustration of the vegetation analysis plot

The data collected for each plot size varied as follows: tree data were collected in the 20×20 m plots, pole data in the 10×10 m plots, sapling data in the 5×5 m plots, and seedling data in the 2×2 m plots. Trees were defined as woody plants with diameters greater than 20 cm (measured at breast height, 130 cm from the ground). Poles were defined as woody plants with diameters between 10 cm and 20 cm. Saplings were smaller trees with diameters below 10 cm and heights above 1.5 m, while seedlings were saplings with heights under 1.5 m. Vegetation analysis data were collected from the afternoon until late afternoon, outside of the tarsier's active hours.

The total population was calculated by summing the individuals in all observed groups. Tarsier population density was determined by dividing the total population by the study area. The sex ratio was calculated by comparing the number of adult males to females. The age class ratio was derived by comparing the number of individuals in each age class, which was divided into four categories: adult, sub-adult, juvenile, and infant. Adults were identified by their large body size, with females sometimes carrying infants. Sub-adults were recognized by their medium body size. Juveniles were characterized by their smaller body size and more active movement compared to other age classes. Infants were the smallest individuals in the group, typically carried by an adult female.

The environmental abiotic parameters were analyzed in relation to the presence and distribution of tarsier encounters and the surrounding vegetation. The data from the vegetation analysis were processed to assess the structure and composition of the vegetation around the tarsier nests. Vegetation analysis in an area will yield several key metrics: species density (D), relative density (RD), frequency of a species (F), relative frequency (RF), dominance of a species (Dom), relative dominance (RDom), and importance value index (IVI). These metrics are obtained through the following calculations:

$$D\left(\frac{ind}{ha}\right) = \frac{The\ number\ of\ individu\ in\ each\ species}{Sample\ unit\ area} \quad (1)$$

$$RD(\%) = \frac{D}{Overall\ density} \times 100\% \quad (2)$$

$$F = \frac{The\ number\ of\ plots\ of\ species\ found}{Overall\ plots\ in\ the\ sample\ unit} \quad (3)$$

$$RF(\%) = \frac{F}{Overall\ frequency} \quad (4)$$

$$Dom = \frac{Dom}{Overall\ dominance} \quad (5)$$

$$RDom(\%) = \frac{Dom}{Overall\ dominance} \times 100\% \quad (6)$$

IVI of seedlings and saplings (%) = RD + RF (7)

IVI of poles and trees (%) = RD + RD + Rdom (8)

3. Results and Discussion

3.1. Result

During the observation, 48 individuals of *T. fuscus* were found across different groups. The overall adult male-to-female ratio was 1:1.36, and the ratio of adults, sub-adults, juveniles, and infants was 33:4:8:3. The population density of *T. fuscus* at the study site was 0.109 individuals per hectare. A total of 10 groups, comprising 39 individuals, were found in secondary dryland forest, while 3 groups, consisting of 9 individuals, were located in scrubland (Table 1).

Table 1. Groups and individual count of *T. fuscus* in two land covers

Habitat	Age Class Ratio				Sex Ratio		Population	
	Adult	Sub-adult	Juvenile	Infant	Male (adult)	Female (adult)	Individu	Groups
SDF	27	1	8	3	11	16	39	10
Scrubland	6	3	0	0	3	3	9	3
TOTAL	33	4	8	3	14	19	48	13

*SDF = Secondary Dryland Forest

From the total population, the density of T. fuscus in the secondary dryland forest was 0.122 individuals per hectare, while in the scrubland it was 0.075 individuals per hectare. Juveniles and infants were scarce, with infants observed in only three groups and juveniles in eight groups within the secondary dryland forest; none were found in the scrubland. This indicates an uneven distribution of offspring (juveniles and infants) across groups. The observations revealed that T. fuscus was present in two types of land cover at the study site: secondary dryland forest and scrubland, at elevations ranging from 554 to 891 meters above sea level and slopes ranging from 3.45% to 56.37%. The encounter map of T. fuscus for this research is shown in Figure 3.

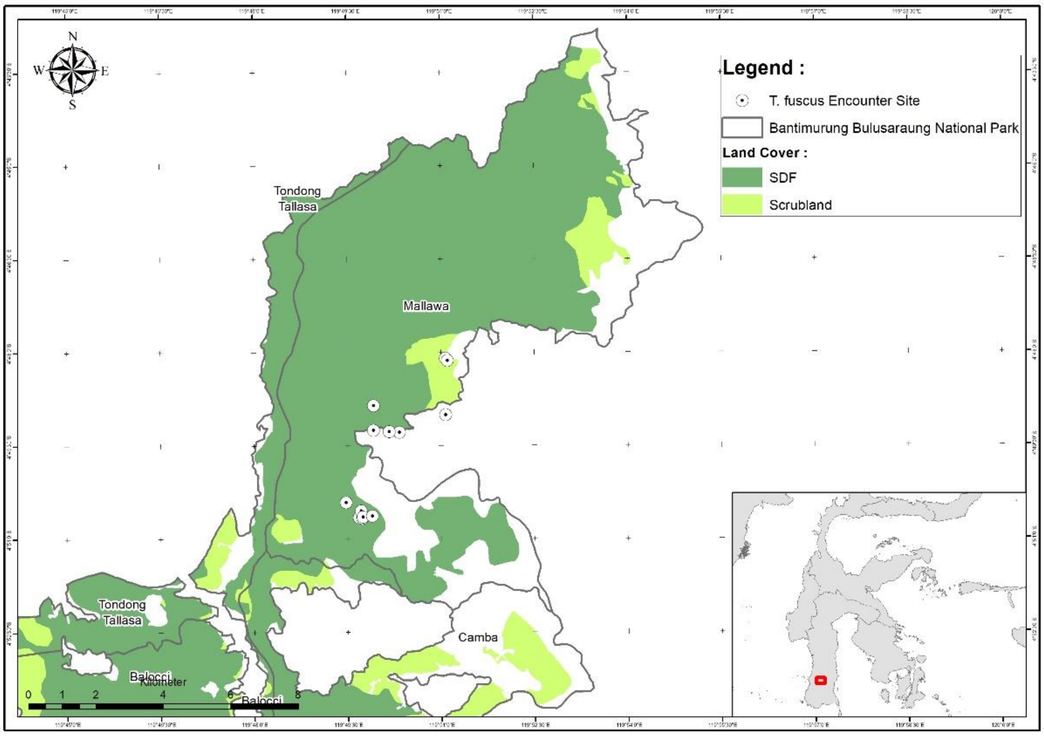

Figure 3. Distribution map of *Tarsius fuscus* in Mallawa Resort, Bantimurung Bulusaraung National Park in SDF (Secondary Dryland Forest) and scrubland

The air temperature measured during the study period was 22.27 – 24.11°C in the morning with relative humidity in the range of 88.49 – 93.72%. Meanwhile, the light intensity obtained from measurements around the nests of *T. fuscus* was in the range of 205.89 – 1524.62 Lux depending on the density of the canopy and the weather during data collection. Vegetation analysis was carried out on each land cover of *T. fuscus*. This is intended to describe the differences between the vegetation structure in the secondary dryland forest and in the scrubland. Vegetation analysis on *T. fuscus* consisted of 30 plots in secondary dryland forest and 9 plots in scrubland. The values of the three highest IVI ratings for each land cover are listed in Table 2.

Table 2. The three highest Important Value Index (IVI) for each growth level in secondary dryland forest and srubland

Growth Level	Secondary Dryland Forest		Scrubland	
	Species Name	Percentage of IVI (%)	Species Name	Percentage of IVI (%)
Tree	*Aleurites moluccana*	40.76	*Blumeodendron kurzii*	57.72
	Lithocarpus celebicus	35.45	*Ficus sumatrana*	25.25
	Nothaphoebe patentinervis	21.81	*Lithocarpus celebicus*	22.28
Pole	*Lithocarpus celebicus*	67.81	*Blumeodendron kurzii*	44.34
	Litsea elliptica	49.38	*Syzygium aqueum*	41.46
	Arthophyllum diversifolium	47.9	*Myristica impressa*	27.63
Sapling	*Leea angulata*	41.04	*Syzygium aqueum*	37.82
	Syzygium aqueum	17.96	*Aglaia tomentosa*	16.29
	Dracontomelon dao	17.31	*Saccopetalum* sp.	13.74
Seedling	*Syzygium aqueum*	70.03	*Syzygium aqueum*	52.82
	Leea indica	27.36	*Calophyllum* sp.	26.73
	Leea angulata	17.85	*Saccopetalum* sp.	10.57

A total of 72 plant species were recorded in the vegetation analysis plots in scrubland. Almost all of the plants found were trees, with only one species, rattan (Calamus sp.), being a palm. The species with the highest IVI at the seedling and sapling stages was Jambu air (Syzygium aqueum). The dominant plants at the pole and tree stages were Mana-mana (Blumodendron kurzii).

The vegetation analysis of the secondary dryland forest produced a list of 50 plant species across four forms, including 92% trees, 4% shrubs, and 2% each bamboo and ferns. Apart from the scrubland area, Jambu air seedlings (Syzygium aqueum) were also found in the secondary dryland forest with the highest IVI among other species. In this forest, saplings were dominated by Mali-malisi (Leea angulata), pole-level plants were dominated by Kasunu (Lithocarpus celebicus), and at the tree level, Kemiri (Aleurites moluccana) was the species with the highest abundance. Both land covers were similarly dominated by the Moraceae family

3.2. Discussion

The population density of *T. fuscus* found in this study like the previous result of Mustari *et al*. [4] in their research at the Balocci Resort, Babul National Park, which found that the population density of *T. fuscus* in the secondary forest was higher than in other land covers. The vegetation density of secondary dryland forest is higher than the scrubland. Andriyani et al. [5] also find a similar thing that the nesting site of *T. fuscus* mainly found in the higher vegetation density. Compared to scrubland, secondary dryland forest has more complete components for tarsiers such as *T. fuscus*, from the need for food, the need for shelter, and the need for movement. Based on the observation, kajuara karisa batang tree (*Ficus sumatrana*) and mana-mana tree (*Blumeodendron kurzii*) are the most used substrate by the *T. fuscus* in their daily activity. It is due to the suitable structure and size of the tree to support their movement. To support their movement, tarsiers need branches of small diameter (<4 cm) for hunting and exploring, medium diameter (4 – 8 cm) for resting and marking home ranges, and large diameter (> 8 cm) as shelter [4]. Those facts are the reason why many encounters of *T. fuscus* are found in the secondary dryland forest. The *T. fuscus* offspring (juvenile and infant) was uneven in both land cover and only found with very little number in secondary dryland forest. The low number of juveniles compared to the adults was also found in the previous research of *T. lariang* in Lore Lindu National Park [7]. It shows that the population of tarsiers is decreasing [7].

Based on the research of Andriyani *et al*. [5] encounter points *T. fuscus* were only found in primary dryland forests as much as 55.56% and in secondary dryland forest as much as 44.44%. Andriyani *et al.* [5] stated that *T. fuscus* was not found in scrubland, while in this observation *T. fuscus* was also found in the scrubland. In scrubland, there are still several types of plants with shrubs that are used by tarsiers in their daily activities. One of the plant species found in scrubland and often used by tarsiers in their daily activities is *Pandanus sp*. *T.fuscus* was found hiding between large pandanus leaves. Other substrates used by tarsiers in scrubland include rock crevices on cliffs and bamboo clumps. Besides that, the scrubland is still near the secondary dryland forest. The abudance of insects as a type of tarsier's food is also observed to be still quite high in scrubland so that *T.fuscus* can still be found.

The habitat of *T. fuscus* in this research was found at 554 – 891 m ASL with a slope range of 3.45 – 56.37% which means scattered from flat to steep topography. In the previous research, *T. fuscus* also found at 75 – 360 m asl with a slope range of 0 – 25% [8] wich means *T. fuscus* in Babul National Park also can be found in the lower altitude with more limited topography range. Sandego et al. [9] revealed that the presence of tarsiers in primary forest is supported by the availability of sufficient food and minimal human activity. According to Adihaningrum et al. [10], topographic variations have a considerable influence on the distribution and intensity of rainfall in an area. The real form of this statement that was found was the existence of several local rain phenomena during the data collection process at the research location. Rainfall intensity and vegetation in a location are related [11], in this case especially vegetation in *T. fuscus*. Furthermore, vegetation will affect the microclimate that exists in a location such as air temperature, air humidity, and light intensity. According to previous research, tarsiers prefer to live in temperatures around 23.3 – 29.2°C [5]. This is still relevant but have wider temperature range than this research results that *T. fuscus* found in the habitat with a temperature of 22.27 – 24.11°C. This difference may be caused by the different seasons of the data collection.

A plant species with a high IVI indicates the dominance role of that species over other species in its community [12]. In addition, species with the highest IVI have a greater chance of maintaining growth and sustainability and stability of their existence. Plants with a high IVI value in the vegetation habitat of an animal species, in this case, *T. fuscus*, indicate that these species are important for fulfilling their needs and for their survival, namely for shelter, foraging, movement, and for breeding. This is indicated by the abundance of these dominant species at the meeting points or nests of *T. fuscus*. The presence of a plant species in the habitat of *T. fuscus* is thought to be influenced by the types of insects and small animals it feeds on. Information obtained from the analysis of *T.fuscus* habitat characteristic shows its exsistence in secondary dryland forests and scrublands that are still maintained. The location of tarsier encounters in secondary dryland forest and scrubland is quite close to the community area like plantation areas. It shows that human activities around tarsier habitat do not interfere directly if the carrying capacity of *T. Fuscus* habitat is still sufficient. Besides that, the low nuber of juvenile and infant of *T. fuscus* also can be concerned by the national park management to maintain the habitat carrying capacity and the security of tarsier populations from various threats in all zones of national park, especially the zone adjacent to the human activity areal.

4. Conclusions

At the Mallawa Resort, Bantimurung Bulusaraung National Park, particularly in Bentenge and Samaenre Villages, the population of *T. fuscus* consists of 48 individuals distributed among 13 groups, with a density of 0.109 individuals per hectare. The ratio of adult males to females is 1:1.36 which shows that almost in balance ratio due to tarsier tend to be a monogamous primate. The ratio of adults, sub-adults, juveniles, and infants is 33:4:8:3. The number of juveniles and infants is relatively low compared to adults, especially in the scrubland. This ratio indicates that the population of *T. fuscus* is decreasing.

T. fuscus at the study site inhabits two types of land covers: secondary dryland forest (SDF) and scrubland, with an altitude range of 554–891 meters above sea level (m ASL) and a slope of 3.45–56.37%. The average air temperature around *T. fuscus* was 22.27–24.11°C, with an average relative humidity of 88.49–93.72% in the morning. The average light intensity measured was 205.89–1524.62 Lux. Based on vegetation analysis, the secondary dryland forest is dominated by Kemiri tree (*Aleurites moluccana*) with an IVI of 40.76%, while the scrubland is dominated by Mana-mana tree (*Blumeodendron kurzii*) with an IVI of 57.72%. Both land covers are dominated by the Moraceae family and Jambu air seedlings (*Syzygium aqueum*).

Author Contributions

SAM: Conceptualization, Methodology, Software, Data Collection, Data Analitics, Writing - Review & Editing; **DAP:** Conceptualization, Methodology, Data Collection, Data Analitics; **A:** Conceptualization, Methodology, Data Analitics; **LEM:** Conceptualization, Methodology, Data Analitics; **RR:** Software, Spatial Data Analitics; **TAL:** Editing and Formatting; **AHM:** Supervise and Review

Conflicts of interest

There are no conflicts to declare.

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