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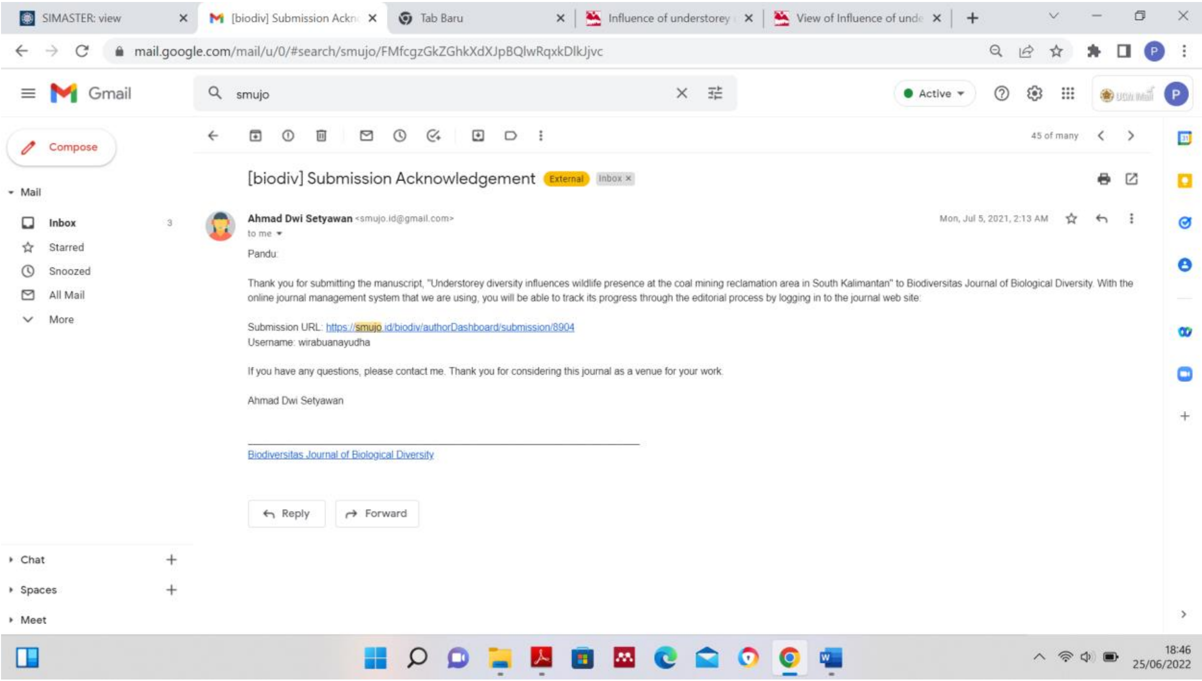

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Understorey diversity influences wildlife presence at the coal mining reclamation area in South Kalimantan

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This study aims to evaluate the influence of understorey diversity on wildlife presence at the coal miniing reclamation area in South Kalimantan. Results found understorey diversity significantly influence the wildlife presence at the reclamation site, particularly for aves species. Interestingly, higher understorey diversity considerably improves the number of aves species. In the first period, there are 10 understorey families and 3 aves species that appeared in the study site. Meanwhile, in the second observation, the number of understorey families increases around 22 families while the existence of aves species reaches 26 species. These findings indicates the presence of understorey plays essential contribution to improve the ecosystems stability at the coal mining reclamation area, particularly related to the wildlife diversity.

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Understorey diversity influences wildlife presence at the coal mining reclamation area in South Kalimantan

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Abstract. The existence of understorey at the coal mining reclamation area provides important contribution to improving the environmental quality, particularly related to the wildlife presence. This study investigates the influence of understorey diversity on the wildlife presence at the coal mining reclamation area managed by PT Borneo Indobara in South Kalimantan. Ecological survey was conducted in three different reclamation sites that classified based on the dominant species for supporting the reclamation process, including *Paraserianthes falcataria (*L-1*), Anthocephalus cadamba (*L-2*)*, and mixed of both species (L-3). Data collection was undertaken in two different observation periods, i.e. August 2019 and 2020. Results found at the first observation, there were 10 families of understorey observed from the survey, in which the highest diversity was recorded in L-2 (7 species), followed by L-1 (6 species) and L-3 (4 species). Meawhile, the wildlife presence in the first periods was only 6 species, consisting of 3 aves and 3 non-aves. The number of wildlife species from every site was relatively equal at the first obsevation. Interestingly, the diversity of understorey considerably increased at the second periods wherein around 22 families were recorded from the inventory. The highest understorey diversity in second observations was recorded in L-1 (30 species), L-2 (24 species), and L-3 (22 species). Higher understorey diversity was also followed by the greater wildlife diversity wherein there were 29 wildlife species in the second observation, consisting of 26 aves species and 3 non-aves species. The highest appearance of aves species was found in L-1 by approximately 19 species while the number of aves species in L-2 and L-3 from the second period was relatively similar with around of 15 species. Based on these results, our study confirms the understorey diversity has a meaningful contribution to improve the wildlife diversity at the coal mining reclamation area, primarily from the diversity of aves species.

Key words: Coal mining, environmental quality, reclamation, understorey, wildlife

Running title: Understorey and wildlife

INTRODUCTION

Coal mining activities are activities that can change the landscape, this is because the mining system is carried out using an open pit mining system, which is also commonly referred to as open cut mining. This mining method is carried out to excavate mineral deposits that exist in a rock, the use of this system is suitable for horizontal ore bodies, so that it can spur high production at low costs (Marinin et al. 2021). The open-pit mining system is carried out by clearing land, removing topsoil and rocks that cover the coal and then taking the coal using excavators and trucks (Setiawan et al. 2021). Therefore, coal mining activities can have an impact on changes in vegetation, changes in soil structure and geology, decrease the soil quality and changes the soil hydrology (Dejun et al. 2016). To anticipate these problems, the activity after excavation of coal deposits is land reclamation, reclamation is not only closing the mining hole but returning topsoil on top of the rock cover, for revegetation activities it is important to ensure the success of reclamation. These reclamation and revegetation activities will restore plant communities and ecosystems around mining so it can reduce the effects of mining activities on the environment (Buta et al. 2019).

Implementation of post-mining land reclamation activities carried out at PT Borneo Indobara using fast growing species such as *Paraserianthes falcataria* and *Antocephalus cadamba* as well as additional plants such as *Pterocarpus indicus*, *Mangifera indica*, *Swietenia macrophylla*, and *Acacia mangium* that grow naturally. In addition to these species, under the reclamation plant stands, understorey such as grass, ferns and herbs are often overgrown, especially the species *Acacia mangium* which grows on its own without planting. Therefore, the presence of this understorey is sometimes considered as a weed that disturbs the main crop, so sometimes cleaning is done. Ecological clearing of land under stands will have an impact on decreasing the diversity of understorey which is very meaningful for the health of the soil in the reclamation area. Cleaning of understorey under tree stands in the reclamation area is thought to reduce the presence of fauna. Sasaki et al. (2015) reports the changes in plant habitat on mining areas will affect wildlife populations. In addition, a study conducted by Partasasmita et al. (2017) published the use of vegetation space by birds is divided into the lower stratum in the form of understorey plants and the upper stratum in the form of tree crowns. Furthermore, Bradfer-Lawrence et al. (2018) stated that there are various species of birds that like habitats in stratum D and E which are dominated by understorey species. Meanwhile, the presence of fauna in the reclamation area is one indicator of land recovery after coal mining activities.

Understorey plants in ecosystems play a very important role, apart from being a source of nutrients, preventing erosion and a source of germplasm as well as a source of food for animals (Mestre et al. 2017). Therefore, to determine the important role of understorey for the presence of animals in the reclamation area, research is needed, to test the level of animal presence after cleaning the understorey and to analyze the presence of understorey after cleaning for one month and for one year. The purpose of this study was to analyze the effect of the presence and diversity of understorey on the level of wildlife presence of the aves and non-aves in the reclamation area after coal mining.

MATERIALS AND METHODS

Study area

The study site was located in the coal mine reclamation area carried out in the reclamation area of the coal mining concession of PT Borneo Indobara. The research was implemented in 14 months, including field preparation, understorey cleaning stage and data collection stage and also analysis stage. The observation stage was carried out in 2 stages of observation, which are the first observation in August 2019 and the second observation in August 2020. The location of this research is geographically located at coordinates E115˚54'38" 115˚39'00" and S3˚35'30" 3˚36'30". It is a reclamation area with 2 main types of plants, i.e. *Paraserianthes falcataria* and *Antocephalus cadamba* which were established in 2013. The research site is administratively situated in Sungai Loban District, Tanah Bumbu Regency, South Kalimantan Province (Figure 1). The field survey was undertaken in three different site of reclamations that classified based on the dominant vegetation species (Table 1)

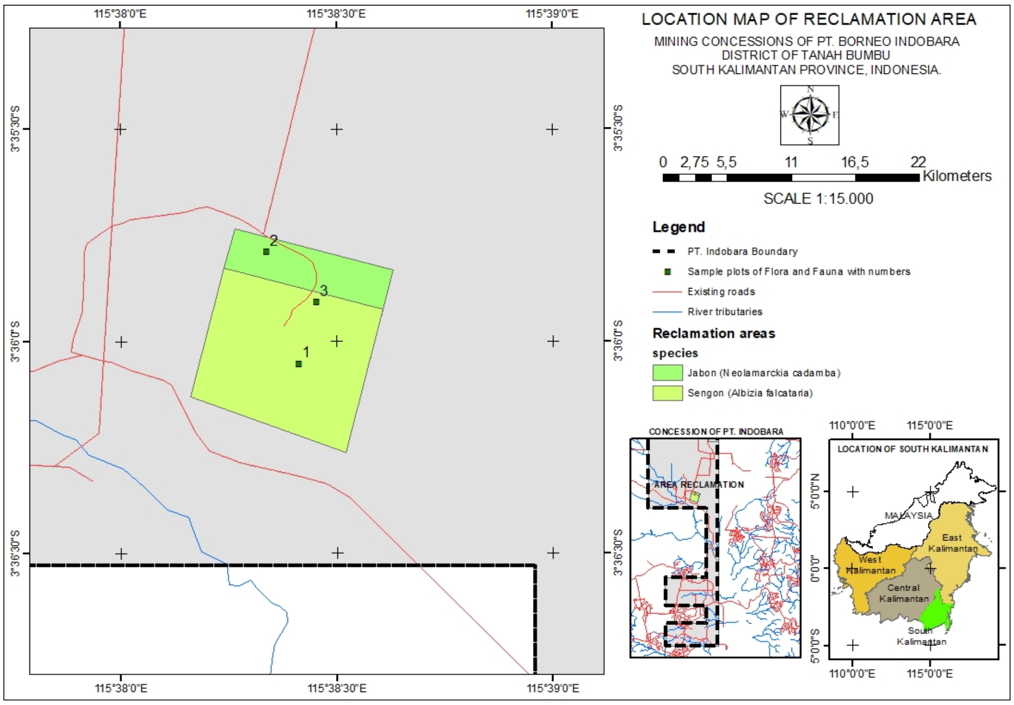

Figure 1. The study site of coal mining reclamation area in the PT Borneo Indobara. The number indicated the position of sampling location.

Table 1. Location of ecological survey for monitoring understorey diversity and wildlife presence at the coal mining reclamation area

Site	Species	Symbol	Planting year
1	*Paraserianthe falcataria*	L-1	2013
2	*Antocephalus cadamba*	L-2	2013
3	Mixed species (*P. falcataria x A. cadamba*)	L-3	2013

Procedures

This research was conducted in a reclamation area with plant species *Paraserianthes falcataria* and *Antocephalus cadamba*, the data collected included two types of data, that are data on the presence and diversity of understorey and wildlife. The research treatment was by cleaning the understorey in the reclamation plant area in a combination, that are manual and chemical, land clearing was carried out once and then observations were carried out. Field observations were collected in 2 stages of observation, the first stage of observation carried out after one month of understorey cleaning activities and the second phase of observation after one year of understorey cleaning activities. During this one year the understorey is allowed to grow and develop without any disturbance. At each stage of observation, identification of the presence of understorey species and the presence of wildlife species, such as aves and non-aves (mammals and reptiles) is carried out, this treatment is carried out to identify the presence and diversity of understorey and wildlife species after land clearing activities.

Understorey data were taken using the straight line method as many as 6 measuring plots at each observation point. The measurement plot size is 2 x 2 m, each measuring plot is given an interval of one plot with the next measuring plot so that the path length is 24 m, while the observation data for understorey flora includes species presence, relative frequency, relative density, important value index and diversity of understorey species. The understorey recorded were grasses, herbs, ferns and woody plant seedlings included in the observation plot.

Wildlife observation data was taken at the understorey observation point, data was taken using the point sampling method with a circle radius of 25 m, each point data was taken in the morning from 07.00 to 11.00 and the afternoon time was taken at 14.00-18.00. The data recorded includes the types of species and the number of individual species of wild animals encountered. The recorded wildlife consists of bird species (aves fauna), mammals and reptiles. The observed wildlife in the form of aves can be identified using MacKinnon et al (2010). Non-aves wild animals in the form of mammals were identified by Francis (2013) or Payne et al (2000). Non-aves wild animals in the form of reptiles were identified using Das (2010).

Data analysis

Analysis of understorey data using the formula to calculate the Important Value Index according to Lü et al. (2011), that is :

Relative density = (Density of a species)/(Density of all species)x 100 (1)

Relative frequency = (Frequency of a species)/(Frequency of all species)x 100 (2)

Important value index = Relative density + Relative frequency (3)

Importance Value Index (IVI) for understorey plants ranges from 0 - 200. If the value is close to 200, then a species has a higher ecological level in a community and if it is close to 0, its ecological control is lower in the community.The diversity index is calculated using the formula by (Naidu & Kumar 2016), the formulation is as follows:

H' = - (pi) ln (pi) where pi = ni/N (4)

where H' was Diversity index, ni indicates abundance of every species, and N was total sample observed. The greater H' of a community indicates that the community is getting better. The value of H' equal to 0 can occur if there is only one species in one sample and maximum H if all species have the same number of individuals and this indicates a perfectly distributed abundance. The criteria for the diversity index based on Shannon-Wiener was expressed below (Djufri et al. 2016):

Table 2. Criteria of diversity index based on Shannon-Wiener

H' value	Descriptions
< 1	Low diversity
1-3	Moderate diversity
>3	High diversity

The analysis of IVI was only applied for understorey vegetatio while the determination of Shannon-Wiener Index was done for understorey and wildlife.

RESULTS AND DISCUSSION

Understorey Diversity

The results of the first stage of understorey identification, that is one month after the understorey cleaning activities were carried out at the three observation sites, were found the presence of understorey species as many as 11 species from 10 families (Table 3). The eleven understorey species are species that naturally appear after land clearing treatment, this indicates that these species can be categorized as pioneer plant species. Based on the calculation results of the understorey diversity at the site L-1, there were 6 species of understorey with a diversity of 1.54 according to the Shannon-Wiener index having low criteria. *Melastoma candidium*, *Imperata cylindrica* have the highest important value index. In the site observation of L-2 were found 7 species of understorey from 6 families with a diversity of 1.71 having a low classification. *Imperata cylindrica* and *Blechnum orientale* has an index value of the highest importance. At the site observations L-3, there were 4 species of understorey from 4 families with a species diversity index of 1.27 having a low classification. *Imperata cylindrica* and *Puerania javanica* have the highest importance value index.

Table 3. Presence and diversity of understorey species on the reclamation area after one month of slashing

No.	Species	Family	L1		L2		L3	
			AP	IVI	AP	IVI	AP	IVI
1	*Ageratum conyzoides*	Asteraceae	✓	7.3	✓	6.5		
2	*blechnum orientale*	Blechnaceaea			✓	43.5		
3	*Brachiaria mutica*	Graminaea			✓	13.0		
4	*Imperata cylindrica*	Poaceae	✓	48.5	✓	71.2	✓	93.5
5	*Macroptillium lathyroides*	Palpilionaceae			✓	17.8		
6	*Melastomacandidum*	Melastomataceae	✓	79.5				
7	*Passiflora foetida*	Passifloraceae					✓	26.8
8	*Pueraria javanica*	Fabaceae	✓	14.6			✓	41.0
9	*Pueraria phaseoloides*	Palpilionaceae	✓	20.1	✓	26.8		
10	*Scleria disasters*	Cyperaceae	✓	30.1			✓	38.7
11	*Scoparia dulcis*	plantaginaceae			✓	21.2		
	H' of each observation site		**1.54**		**1.71**		**1.27**	
	H' of entire reclamation site				**2.09**			

Note: AP (apperance); IVI (important value index)

Imperata cylindrica has a fast adaptability to grow as a pioneer plant in reclamation areas where land clearing is carried out, this is because the roots of the reeds in the form of rhizomes under the ground remain alive even though the top of the plant is damaged and even fires (Soendjoto et al. 2014). Therefore, *Imperata cylindrica* will grow quickly even in marginal soil conditions, this is what makes the presence of *Imperata cylindrica* sometimes considered as weeds if it is shaded by other species with denser canopy densities (Kone et al. 2013). In addition to the *Melastoma candidium* also has a high adaptability because this species is resistant to acid soils and is even able to absorb aluminum toxins in the soil, the height of this shrub can reach 0.5-4 meters (Watanabe et al. 2005). Therefore, by increasing the growth of *Melastoma candidium*, will be able to suppress the growth rate of *Imperata cylindrica* because the canopy is higher and denser.

The species diversity index of all plots in the reclamation area after one month of understorey cleaning shows diversity index of 2.09 with a moderate classification. The types of understorey that are present after land clearing can be utilized to be developed into a type of land precondition to improve soil properties in the post-coal mining reclamation area. Not all plants are able to grow and adapt to marginal soils after coal mining. This is because the soil in the coal mine reclamation area has many soil limiting factors, including low soil porosity and high soil density (Noviyanto et al. 2017). So that the presence of understorey species can be considered as an adaptive species to post-coal mining land.

Understorey is a source of biodiversity and an indicator of post-mining land recovery (Komara et al. 2016). The presence of plants, both woody plants and understorey plants, will reduce the bulk density of the soil, due to the influence of root penetration into the soil (Ghestem et al. 2011). In addition, the presence of plants will produce biomass that can improve soil structure, increase soil porosity and reduce bulk density (Adekiya et al. 2021).

When viewed from an ecological point, the presence of natural understorey indicates a tendency for post-mining soil to become healthier. Improvement of post-mining soil health can occur due to sources of organic matter from understorey or higher vegetation that die or due to improved microclimate under vegetation. Understorey species that grow naturally on post-mining land will show a fairly high adaptability of species to post-mining land conditions. This variety of understorey plants besides to improve soil properties, it can also function in improving ecosystems, especially improving habitat for animals. The variety of understorey is one source of food for animals, one of which is bird species (Wilson et al. 2006). The reduction in plant species in the lower stratum will narrow food sources and habitats for birds to breed (Narango et al. 2017).

Reclaimed land is land that is still in the process of improving both the physical and chemical properties of the soil, so that disturbances to existing plants, both woody plants and understorey plants, will be slower in the recovery of these species to grow and develop again. Therefore, understorey cleaning activities will put pressure on the development of post-mining land biodiversity restoration. Understorey plants have a function as a source of germplasm wealth and also have an ecological function that can prevent the rate of soil erosion, even understorey regeneration accelerates biomass production to improve soil properties (Noviyanto et al. 2017).

The results of understorey identification after one year of understorey cleaning (Table 4) showed that there was an increase in the number of individual presences and an increase in the index of understorey species diversity in the reclamation area after one year understorey was allowed to grow and develop. The results of the understorey identification in the reclamation area after one year of cleaning activities were found to be 36 species of understorey from 22 families. For one year understorey was left undisturbed, there was an increase in the presence of understorey up to 327%. Based on the calculation of the important value index and the diversity index of understorey species at location 1 found 30 understorey species from 22 families with a species diversity index of 3.15 having a high index classification. On location 2 there were 24 understorey species from 18 families with a species diversity index of 2.91 with a moderate index classification and at location 3 observations there were 22 understorey species from 15 families with a species diversity index of 2.93 with a medium classification index. The species diversity index in all plots in the reclamation area during observations one year after slashing showed a species diversity index of 3.35 with a high classification.

Table 4. Presence and diversity of understorey species observed in the reclamation area one year after understorey clearing

No	Species	Family	L-1		L-2		L-3	
			AP	IVI	AP	IVI	AP	IVI
1	*Abelmoschus moschatus*	Malvaceae	✓	3.1				
2	*Acacia mangium*	Fabaceae	✓	6.7			✓	13.0
3	*Ageratum conyzoides*	Asteraceae	✓	15.1	✓	16	✓	13.5
4	*Anacardium ocidentale*	Anacardiaceae			✓	1		
5	*Arachis pintoi*	Fabaceae	✓	4.1	✓	7	✓	7.7
6	*Asystasia gangetica*	Acanthaceae	✓	7.0	✓	7	✓	8.6
7	*Bauhinia kockiana*	Fabaceae	✓	6.1	✓	7	✓	6.4
8	*blechnum orientale*	blechnaceae	✓	5.5			✓	8.4
9	*Boehmeria nivea*	Urticaceae	✓	2.6	✓	5	✓	9.3
10	*Brachiria mutica*	Graminaeae	✓	6.5	✓	10		
11	*Bytneria maingrayi*	Malvaceae			✓	7		
12	*Calopogium mucunoides*	Leguminaceae	✓	10.2	✓	11	✓	14.1
13	*trifolia Cayratia*	Vitaceae	✓	4.9			✓	6.2
14	*Centrosema molle*	Fabaceae	✓	4.9			✓	7.5
15	*l Chromolaena odorata,*	Asteraceae	✓	6.5	✓	8	✓	11.9
16	*Cyperus eragrostis*	Cyperaceae			✓	6		
17	*patens Cyrtococcum*	Poaceae	✓	7.7				
18	*Dicran linearis opteris*	Gleicheniaceae	✓	6.7	✓	7		
19	*Fimbristylis littoralis*	Cyperaceae	✓	7.1	✓	8		
20	*Hyptis capitata*	Lamiaceae	✓	7.0	✓	7	✓	7.7
21	*Imperata cylindrica*	Poaceae	✓	9.0	✓	15	✓	13.5
22	*Ipomea cordatriloba*	Convolvulaceae			✓	6		
23	*Macaranga tanarius*	Euphorbiaceae	✓	6.0			✓	5.5
24	*Mangifera indica*	Anacardiaceae	✓	5.6	✓	6		
25	*Melastoma candidum*	Melastomataceae	✓	16.5	✓	18	✓	15.2
26	*Mimosa pudicaMangifera Indica*	Fabaceae	✓	6.0	✓	7	✓	8.6
27	*Passiflora foetida*	Passifloraceae	✓	7.2	✓	8	✓	6.4
28	*Phylantuss reticulatus*	Phyllanthaceae	✓	5.5	✓	7	✓	8.4
29	*Phyllanthus debilis*	Phyllanthaceae	✓	4.2			✓	8.6
30	*Pterocarpus indicus*	Fabaceae					✓	4.6
31	*Rhynchospora corymbosa*	Cyperaceae	✓	3.9				
32	*disasters Scleria*	Cyperaceae	✓	13.6	✓	13	✓	8.8
33	*Swietenia macrophylla*	Meliaceae			✓	8		
34	*Syzygium aqueum*	Myrtaceae	✓	3.4				
35	*cordataUncaria*	Rubiaceae	✓	4.5	✓	6	✓	6.0
36	*Vitex pinnata*	Lamiaceae	✓	3.3				
	H' of each observation site		**3.3**		**3.09**		**3.04**	
	H' of entire reclamation site				**3.35**			

Note: AP (apperance); IVI (important value index)

The growth of understorey for one year without disturbance in the reclamation area show the addition of understorey species very fast. The addition of this species indicates that the soil in the reclamation area has developed with increasing soil health. This improvement in soil health is marked by improvements in soil physical properties and improvements in soil chemical properties, including an increase in pH and soil cation exchange capacity (Noviyanto et al. 2017, Buta et al.

2019, Pratiwi et al. 2021). The diversity of understorey plants also plays an important role in accelerating soil development. Changes of understorey on the soil surface in evolving provide a faster response than trees, these changes are an important part in the formation of annual litter and will turn into soil (Su et al. 2019). The crowns of *P. falcataria* and *A. cadamba* have not dense crowns so that sunlight will reach the forest floor with a high intensity, this provides sufficient growing space for the presence of understorey.

The type of *Melastoma candidum* at all observation locations has the highest IVI, this indicates that this species is consistently able to become a pioneer and has high adaptation in post-coal mining areas. The species, *Imperata cylindrica* which initially had an IVI similar to that of *Melastoma candidum*, were observed one year after cleaning and shifted by other species, such as *Ageratum conyzoides*. According to the results of research by Komara et al. (2016), one of the understorey species *Ageratum conyzoides* observed 16 years after reclamation had an important value index of the third order of 29 species present in the post-coal mining reclamation area in East Kalimantan. Several types of understorey in the form of woody plant seedlings that are present in the reclamation area are woody plant species that naturally grow and develop, these types are *Macaranga tanarius*, *Syzygium aqueum* and *Vitex pinnata*. However, there are also several types of woody plants in the seedling phase that are included in the observation plot, which are species present due to planting, such as *Mangifera Indica*, *Pterocarpus indicus* and *Swietenia macrophylla*.

From 36 species of understorey that were present in the reclamation area after 1 year of understorey cleaning activities, there were 15 species of understorey that were always present at the three observation locations. One of the species that always present at three observation locations is *Chromolaena odorata*, this species is able to grow on marginal land and fertile land (Hamdani et al. 2017), the growth of *Chromolaena odorata* on land is able to produce litter which contains a lot of nutrients because this species suitable as raw material for making compost, besides that this species is also able to suppress the growth of *Imperata cylindrica* (Juniarti 2017). Accumulatively, soil improvement with the presence of understorey and higher vegetation will improve the function of complex ecosystems, from microorganisms to macroorganisms (Pan et al. 2018) .

There is also a species of *M. candidum* which dominates the important values in all observation locations, is a species that produces quite a lot of flowers as a source of food for various kinds of wild animals, both insects and flower-eating birds. The variety of understorey especially, understorey species that produce flowers will be an attraction for wild animals in the form of aves, mammals, reptiles, amphibians and even insects to migrate to the reclamation area looking for food sources.

Wildlife presence

The identified wildlife includes aves and non-aves (mammals and reptiles). The results of the identification of the aves fauna (table 5) show that there is a change in the presence and diversity of fauna which is quite high within an increase in the presence of understorey. The classification of species presence and diversity index in the observation one month after cleaning activities as many as 3 species with a species diversity index of 0.90 (H'=low) increased in observations one year after cleaning activities 26 bird species were identified with a species diversity index of 3 ,35 (H'=high). According to Casas et al. (2016), the presence and diversity of birds is strongly influenced by the composition and structure of vegetation. Changes the structure of vegetation which include understorey, saplings, poles and trees will affect the presence of animals. The existence of food sources and habitat suitability will be attractive reasons to attract animals migration to the reclamation area, until the reclaimed plants become a climax. According to (Boer 2009) stated that in the area of land reclamation and rehabilitation, the presence of avifauna (fauna aves) will continue to change towards the composition commonly found in natural forests.

Birds are the most practical group of animals and are often used to detect and respond quickly to environmental changes (Wong & Candolin 2015). In bird watching after the understorey cleaning activities, the habitat of birds and other animals changes, this causes animal migration to an undisturbed area. According to (Liang et al. 2021), the community of bird species will decline and migrate due to a decrease in habitat suitability. Habitat improvement through the process of succession of understorey in the reclamation area by allowing it to grow and develop for one year without disturbance, the presence of understorey increases to show high diversity, this causes the bird community to reappear until it reaches a diversity index with high calcification. According to (Swab et al. 2017) the initial succession of reclamation areas in the form of grass contributed greatly to the increase in songbird populations. The development of bird and other animal species will develop gradually following the succession of plants, therefore mining land reclamation methods to create biodiversity will determine the rate of presence and composition of bird species (Al-Reza et al. 2016)

Aves fauna found in the reclamation area after one year of understorey cleaning activities as much as 7.70% are categorized as water birds, such as *Todiramphus chloris*, *Actitis hypoleucos* and most (92.30%) are categorized as water birds, this has been explained by Ducks Unlimited New Zealand (2017), that there are 8 families on the west coast and 34 families of waterbirds in the world and 33 bird families described by Wetlands International (2020). The presence of water birds in the reclamation area because there is a former mining pit water source near the reclamation area.

Not only wildlife depend on plants, but also the presence and condition of plants is also influenced by the presence of animals. Many plants require birds, mammals or other animals to help pollinate (Ratto et al. 2018). In another side, many species of birds often forage and make nests in the stratum of understorey such as *Orthotomus ruficeps, Prinia flaviventris, Centropus bengalensis*, *Rhipidura javanica*, *Lanius schach*, *Lonchura punctulata* etc. The diversity of understorey and high density is a good habitat for various animals to grow and develop well (Valladares et al. 2016)v. Birds or small animals, such as *Orthotomus ruficeps and Prinia flaviventris*, can hide from predators in thickets of leaves/shrubs. *Centropus bengalensis* likes trees that are not too high and thick underatorey for foraging, playing, sheltering, and nesting (Rajpar & Zakaria 2011).

Table 5. Presence and diversity of aves fauna in the reclamation area during observations one month and one year after understorey cleaning

No.	Species	Family	First Observation			Second Observation		
			L-1	**L-2**	**L-3**	**L-1**	**L-2**	**L-3**
1	*Gerygone sulphurea*	Acanthizidae				✓		✓
2	*Aegithina tiphia*	Aegithinidae				✓		✓
3	*Todiramphus chloris*	Alcedinidae				✓		
4	*Artamus leucoryn*	Artamidae	✓					✓
5	*Caprimulgus affinis*	Caprimulgidae				✓		
6	*Orthotomus ruficepsf*	Cisticolidae				✓	✓	✓
7	*Prinia flaviventris*	Cisticolidae				✓	✓	✓
8	*Geopelia striata*	Columbidae				✓		✓
9	*Spilopelia chinensis*	Columbidae	✓	✓	✓	✓		
10	*Centropus bengalensis*	Cuculidae						✓
11	*Dicaeum trochileum*	Dicaeidae				✓	✓	
12	*Dicaeum trigonostigma*	Dicaeidae				✓		
13	*Lonchura punctulata*	Estrildidae				✓	✓	✓
14	*Hirundinidae*	Estrildidae						
15	*Hirundo rustica*	Estrildidae					✓	✓
16	*Hirundo tahitica*	Estrildidae				✓		✓
17	*Lanius schach*	Laniidae						✓
18	*Meropidae*	Laniidae						
19	*Merops viridis*	Laniidae					✓	✓
20	*Nectariniidae*	Laniidae						
21	*Anthreptes malacensis*	Laniidae				✓	✓	
22	*Cinnyris jugularis*	Laniidae					✓	
23	*Dendrocopos moluccensis*	Picidae				✓	✓	✓
24	*Pycnonotidae*	Picidae						
25	*Pycnonotus aurigaster*	Picidae				✓	✓	✓
26	*Pycnonotus goiavier*	Picidae	✓	✓	✓	✓	✓	
27	*Rhipiduridae*	Picidae						
28	*Rhipidura javanica*	Picidae				✓	✓	
29	*Actitis hypoleucos*	Scolopacidae						✓
30	*Sturnidae*	Scolopacidae						
31	*Acridotheres javanicus*	Scolopacidae				✓	✓	✓
32	*Vangidae*	Scolopacidae						
33	*Hemipus hirundinaceus*	Scolopacidae				✓	✓	✓
	H' of each observation site		0,69	0,64	0,64	2,90	2,69	2,77
	H' of entire reclamation site			0.90			3.17	

Table 6. Presence and diversity of non-aves fauna in the reclamation area during observations one month and one year after cleaning the understorey

No	Species	Family	First Observation	Second Observatio
1	*Bronchocela jubata*	Agamidae	✓	✓
2	*Eutropis multifasciata*	Scincidae	✓	✓
3	*Callosciurus notatus*	Sciuridae	✓	
4	*Varanus salvator*	Varanidae		✓
	H' of entire reclamation site		**1.10**	**1.10**

Clean puddles are not only a habitat for animals (wildlife) to breed, but also a source of food for animals. Around the reclamation area there is a puddle pool which is a place for animals to drink and find food, such as the water bird *Todiramphus chloris*. Moreover, in puddle, dragonfly larvae develop and after adulthood are food for Merops viridis birds, besides that adult dragonflies are consumed not only by Merops viridis, but other bird species that eat flying insects (Arbeiter et al. 2014).

Wildlife of non-aves fauna species in the reclamation area has not changed much, found 3 species of non-aves fauna on observation one month after the understorey cleaning activities, namely *Eutropis multifasciata*, *Bronchocela jubata*, *Callosciurus notatus*. One year after the understorey cleaning, *Eutropis multifasciata*, *Bronchocela jubata* and *Varanus salvator* were found (Table 6).

The non-aves fauna species were identified as 1 species of mammal, that are Callosciurus notatus, while 3 reptiles, that are *Bronchocela jubata, Eutropis multifasciata* and *Varanus salvator*, these species were found by direct encounter. The recovery of the presence of non-aves fauna species in the reclamation land was slower than the recovery of the presence of avian fauna species, the factor of stand density and the availability of food sources greatly influenced the encounter of this mammal species. In the ex-coal mining area that has been rehabilitated with a plant age of up to 10 years with dense understorey conditions, 15 species of mammals can be found (Soendjoto et al. 2015). The establishment of a micro-climate under the stands as well as a comfortable, calm and safe atmosphere with a variety of plants as a source of food is very much needed by animals to find food, rest, play, hide from predators, sing and breed.

Finally, this study concluded the increased diversity of understorey in the reclamation area is an attraction for the presence of fauna, especially the aves fauna, if later both understorey and woody plants develop to resemble natural forest habitats, not only aves fauna but also non-aves fauna can migrate to the reclamation area. The presence of understorey is a place for animals to rest, hide, shelter, nest, find food and make sounds and even breed.

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SUBMISSION CHECKLIST

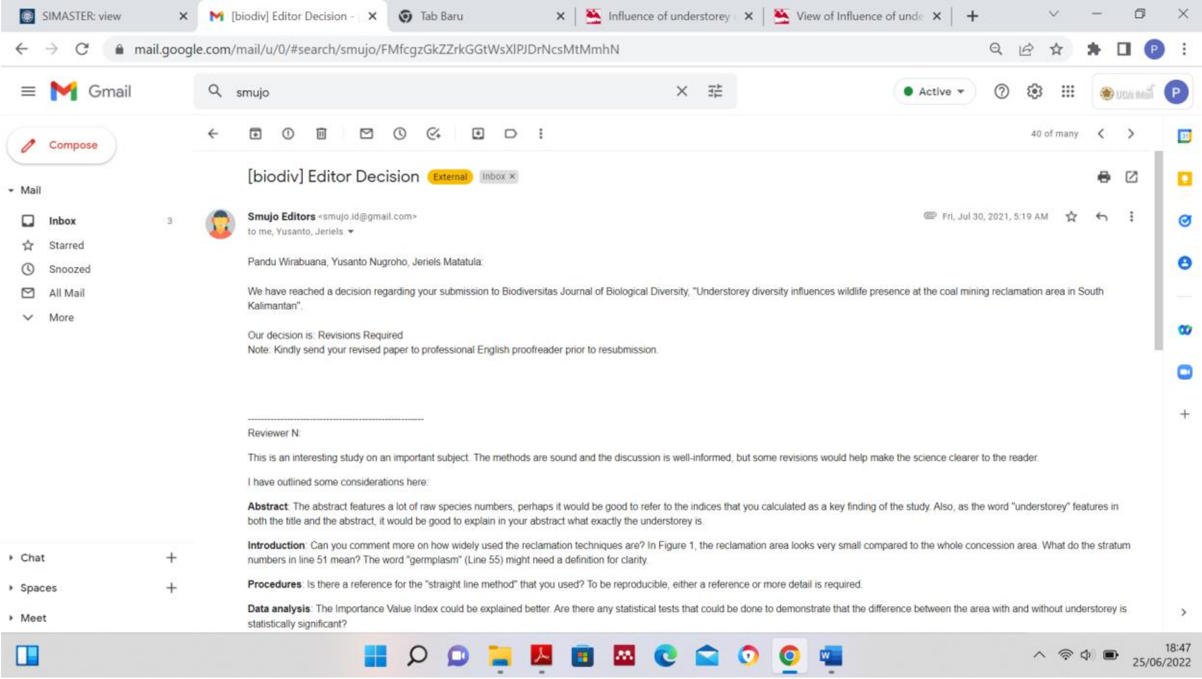
Ensure that the following items are present:

The first corresponding author must be accompanied with contact details:	**Give mark (X)**
• E-mail address	X
• Full postal address (incl street name and number (location), city, postal code, state/province, country)	X
• Phone and facsimile numbers (incl country phone code)	X

All necessary files have been uploaded, and contain:	
• Keywords	X
• Running titles	X
• All figure captions	X
• All tables (incl title and note/description)	X

Further considerations	
• Manuscript has been “spell & grammar-checked” Better, if it is revised by a professional science editor or a native English speaker	X
• References are in the correct format for this journal	X
• All references mentioned in the Reference list are cited in the text, and vice versa	X
• Colored figures are only used if the information in the text may be losing without those images	X
• Charts (graphs and diagrams) are drawn in black and white images; use shading to differentiate	X

KEPUTUSAN EDITOR 30 JULI 2021 – REVISED



[biodiv] Editor Decision

Smujo Editors <smujo.id@gmail.com>
to me, Yusanto, Jeriels
Fri, Jul 30, 2021, 5:19 AM

Pandu Wirabuana, Yusanto Nugroho, Jeriels Matatula:

We have reached a decision regarding your submission to Biodiversitas Journal of Biological Diversity, "Understorey diversity influences wildlife presence at the coal mining reclamation area in South Kalimantan".

Our decision is: Revisions Required
Note: Kindly send your revised paper to professional English proofreader prior to resubmission.

Reviewer N:

This is an interesting study on an important subject. The methods are sound and the discussion is well-informed, but some revisions would help make the science clearer to the reader.

I have outlined some considerations here:

Abstract: The abstract features a lot of raw species numbers, perhaps it would be good to refer to the indices that you calculated as a key finding of the study. Also, as the word "understorey" features in both the title and the abstract, it would be good to explain in your abstract what exactly the understorey is.

Introduction: Can you comment more on how widely used the reclamation techniques are? In Figure 1, the reclamation area looks very small compared to the whole concession area. What do the stratum numbers in line 51 mean? The word "germplasm" (Line 55) might need a definition for clarity.

Procedures: Is there a reference for the "straight line method" that you used? To be reproducible, either a reference or more detail is required.

Data analysis: The Importance Value Index could be explained better. Are there any statistical tests that could be done to demonstrate that the difference between the area with and without understorey is statistically significant?

UGM Mail **Pandu Yudha Adi Putra Wirabuana <pandu.yudha.a.p@ugm.ac.id>**

[biodiv] Editor Decision

1 message

Smujo Editors <smujo.id@gmail.com> Fri, Jul 30, 2021 at 5:18 AM
To: Pandu Wirabuana <pandu.yudha.a.p@ugm.ac.id>, Yusanto Nugroho <yusanto_1977@yahoo.co.id>, Jeriels Matatula <jerielsforestry@gmail.com>

Pandu Wirabuana, Yusanto Nugroho, Jeriels Matatula:

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Procedures: Is there a reference for the "straight line method" that you used? To be reproducible, either a reference or more detail is required.

Data analysis: The Importance Value Index could be explained better. Are there any statistical tests that could be done to demonstrate that the difference between the area with and without understorey is statistically significant?

Results and discussion: What is meant by "practical" (Line 239)? Is calcification really the right word (Line 245)? Is the website of Ducks Unlimited New Zealand the best reference to use (Line 251)? A scholarly paper or book might be better.

General points:

There are a number of places where the paper refers to "one month of understorey cleaning" and "one year of understorey cleaning". From what I understand of the methods, this should be "one month *after* understorey cleaning" and "one year *after* understorey cleaning". One month *of* cleaning would mean that the understorey was cleaned continuously for a month, one month *after* cleaning means that it was cleaned and then left alone for a month. I think *after* is what you want, based on line 87 "During this one year the understorey is allowed to grow and develop without any disturbance."

It wasn't clear to me why the animals were divided into Aves and non-Aves, instead of referring to mammals and reptiles separately. The reason for this division should be given the first time that it appears, i.e. in the Abstract. Additionally, in most cases it is simpler to use the word "birds" than "Aves"! But if you are referring to the scientific class, remember that Aves has a capital A.

There are a few scientific names that need to be formatted correctly (italics, with the first letter of the genus capitalised and the first letter of the species in lower-case), for example on Figure 1 and line 275. I don't think "*Scleria disasters*" is right!

Recommendation: Revisions Required

Biodiversitas Journal of Biological Diversity

W-Understorey diversity influences wildlife presence at the coal mining reclamation area in South Kalimantan.doc
638K

Influence of understorey diversity on wildlife at the coal mining reclamation area in South Kalimantan, Indonesia

Abstract. The existence of understorey at the coal mining reclamation area provides an important contribution to improve the environmental quality, especially the wildlife presence. Therefore, this study aims to determine the influence of understorey diversity on the wildlife at the coal mining reclamation area managed by the PT Borneo Indobara, South Kalimantan. This study used an ecological survey ~~which was~~ conducted in three ~~different~~ reclamation areas classified ~~based~~ on the basis of~~on~~ the dominant species ~~that~~ supporting the process, namely *Paraserianthes falcataria* (L-1), *Anthocephalus cadamba* (L-2), and a mixture of both species (L-3). The data were collected in two ~~different~~ observation periods, namely August 2019 and 2020. The results showed that at the first observation, ~~10~~ ten families of understorey were observed from the survey and the highest diversity was recorded in L-2 (H'=1.71), followed by L-1 (H'=1.54), and L-3 (H'=1.27). Meanwhile, the wildlife in the first periods was only 6 species which consists of 3 ~~aves~~ birds and non-aves each and the number of species from every site was relatively equal at the first observation. In the second observation, the diversity of understorey significantly increased with approximately 22 families from the inventory. The highest understorey diversity in this observation was recorded in L-1 (H'=3.30), L-2 (H'=3.05), and L-3 (H'=3.04). Also, ~~a~~ the higher understorey diversity was followed by the ~~greater~~ higher wildlife with 29 species, which consists of 26 aves and 3 non-aves. The highest appearance of aves species was in the L-1 with approximately 19 species, while the number of aves in L-2 and L-3 was relatively similar with approximately 15 species. Based on these results, the understorey diversity has a significant contribution to improve the wildlife diversity at the coal mining reclamation area, primarily from the aves species.

Keywords: Coal mining, environmental quality, reclamation, understorey, wildlife

Running title: Understorey and wildlife

INTRODUCTION

Coal mining is activities ~~that~~ changeing the landscape due to the use of an open pit in mining operations~~, which is~~ commonly referred to as open-cut mining. This method is carried out to excavate mineral deposits that exist in a rock, and this is suitable for horizontal ore bodies for high production at low costs (Marinin et al. 2021). Meanwhile, the open-pit mining system is carried out by clearing land, removing topsoil and rocks that cover the coal, and taking the coal using excavators and trucks (Setiawan et al. 2021). Therefore, coal mining activities influence changes in vegetation, soil structure, and geology, decrease the quality, and change the soil hydrology (Dejun et al. 2016). To anticipate these problems, successful land reclamation is required after excavation of coal deposits, which involves the closing of the mining hole and returning of topsoil to cover the rock for revegetation activities. These reclamation and revegetation activities restore plant communities and ecosystems around mining to reduce the effects of mining operations on the environment (Buta et al. 2019).

Implementation of post-mining land reclamation activities was carried out at PT Borneo Indobara using fast-growing species such as *Paraserianthes falcataria* and *Antocephalus cadamba* with the addition of *Pterocarpus indicus*, *Mangifera indica*, *Swietenia macrophylla*, and *Acacia mangium* plants that grow naturally. Furthermore, understorey such as grass, ferns, and herbs are often overgrown, especially the species *Acacia mangium* that grows naturally. Meanwhile, the presence of this understorey is considered as a weed that disturbs the main crop, and~~ sometimes~~ the cleaning is sometimes carried out. The ecological clearing of land under the stands has an impact on ~~decreasing~~ decrease in the diversity of understorey which is important for the soil health in the reclamation area. Moreover, cleaning of understorey under tree stands in the reclamation area reduces the presence of fauna. Sasaki et al. (2015) stated that the changes in plant habitat in mining areas affect wildlife populations. A previous study by Partasasmita et al. (2017) stated that the use of vegetation space by birds is divided into the lower stratum in form of understorey plants and the upper in form of tree crowns. Furthermore, Bradfer-Lawrence et al. (2018) stated that there are various species of birds that like habitats in stratum D and E which are dominated by understorey species. Therefore, the presence of fauna in the reclamation area is an indicator of land recovery after coal mining activities.

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The understorey plants in ecosystems play a very important role, namely a source of nutrients, germplasm, food for animals, and preventing erosion (Mestre et al. 2017). Hence, a study is required to determine the important role of understorey for the wildlife in the reclamation area and evaluate the level of animals and also analyze the presence of understorey after cleaning for one month and a year. T~~herefore, t~~his study aims to analyze the effect of understorey presence and diversity on the level of the wildlife of the aves and non-aves in the reclamation area after coal mining.

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MATERIALS AND METHODS

Study area

The site was located in the reclamation area of PT Borneo Indobara where the coal mining operation is carried out. This study was implemented in 14 months at different stages, namely field preparation, understorey cleaning, data collection, and analysis. Meanwhile, the observation was carried out in 2 stages, with the first in August 2019 and the second in 2020. The geographical coordinates of location ~~is~~ areat E115˚54'38" 115˚39'00" and S3˚35'30" 3˚36'30". The reclamation area is with 2 main types of plants, namely *Paraserianthes falcataria* and *Antocephalus cadamba* which were established in 2013. The site is administratively situated in Sungai Loban District, Tanah Bumbu Regency, South Kalimantan Province (Figure 1). The field survey was carried out in three~~3 different~~ sites of reclamations classified based on the dominant vegetation species (Table 1).

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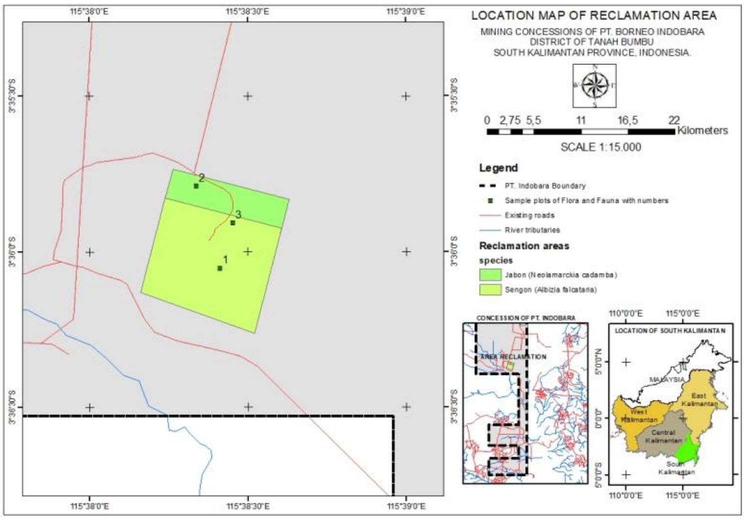

Figure 1. The study site of coal mining reclamation area in the PT Borneo Indobara. The number indicated the position of sampling location

Table 1. Location of ecological survey for monitoring understorey diversity and wildlife presence at the coal mining reclamation area

Site	Species	Symbol	Planting year
1	*Paraserianthe falcataria*	L-1	2013
2	*Antocephalus cadamba*	L-2	2013
3	Mixed species (*P. falcataria* ~~x~~ × *A. cadamba*)	L-3	2013

Procedures

This study was conducted in a reclamation area with plant species *Paraserianthes falcataria* and *Antocephalus cadamba*, and the two types of data collected include the presence and diversity of understorey and wildlife. The treatment was carried out by cleaning the understorey in the reclamation area in a manual and chemical combination, while land clearing was conducted once and observations were made subsequently. Moreover, field observations were conducted in two2 stages, where the first was after one month and the second after one year of understorey cleaning activities. During this one year, the understorey was allowed to grow and develop without any disturbance. At each stage of observation, identification of the presence of understorey species and wildlife species, such as aves and non-aves (mammals and reptiles) was carried out. This treatment was carried out to identify the presence and diversity of understorey together with wildlife species after land clearing activities.

Understorey data were obtained using the transect-line method up to six6 measuring plots at each observation point. The measuring plot size was 2 ×x 2 m and each was spaced at an interval of one plot to achieve a path length of 24 m. Meanwhile, the observation data for understorey flora include species presence, relative frequency and density, important value index, and diversity of understorey species. The understorey recorded were grasses, herbs, ferns, and woody plant seedlings and were included in the observation plot.

Wildlife observation data were obtained at the understorey point using the sampling method with a circle radius of 25 m, while each point data were recorded in the morning from 07.00 to 11.00 and the afternoon at 14.00-18.00. The data recorded include the types and the number of individual species of wildlife encountered, which consists of bird species (aves bird fauna), mammals, and reptiles. The observed wildlife in form of aves was identified using MacKinnon et al (2010). Furthermore, non-aves wildlife in form of mammals was identified by Francis (2013) or Payne et al (2000), and those in form of reptiles were identified using Das (2010).

Data analysis

Analysis of understorey data using the formula to calculate the Important Value Index according to Lü et al. (2011), that is :

Relative density = (Density of a species)/(Density of all species)x 100 (1)

Relative frequency = (Frequency of a species)/(Frequency of all species)x 100 (2)

Important value index = Relative density + Relative frequency (3)

Importance Value Index (IVI) for understorey plants ranges from 0 - 200. If the value is close to 200, then a species has a higher ecological level in a community and if it is close to 0, its ecological control is lower in the community. The diversity index is calculated using the formula by (Naidu & Kumar 2016), the formulation is as follows:

$H' = -\,(pi)\ \ln\,(pi)$ where $pi = ni/N$ (4)

where H' was the Diversity index, ni indicates an abundance of every species, and N was the total sample observed. The greater H' of a community indicates that the community is getting better. The value of H' equal to 0 can occur if there is only one species in one sample and maximum H if all species have the same number of individuals and this indicates a perfectly distributed abundance. The criteria for the diversity index based on Shannon-Wiener was expressed below (Djufri et al. 2016):

Table 2. Criteria of diversity index based on Shannon-Wiener

H' value	Descriptions
< 1	Low diversity
1-3	Moderate diversity
>3	High diversity

The analysis of IVI was only applied for understorey vegetation while the determination of the Shannon-Wiener Index was done for understorey and wildlife.

RESULTS AND DISCUSSION

Understorey diversity

The results of the first stage of understorey identification which is (one month after cleaning activities) showed that the presence of understorey species is 11 from 10 families (-Table 3). These species naturally appear after land clearing treatment and are categorized as a pioneer plants. Based on the calculation of the understorey at the site L-1, there were six6 species with a diversity of 1.54 according to the Shannon-Wiener index having low criteria, while *Melastoma candidium* and *Imperata cylindrica* have the highest important value index. In the site observation of L-2, there were 7 seven species of understorey from 6 six families with a diversity of 1.71 having a low classification, while *Imperata cylindrica* and *Blechnum Orientale* have an index value of the highest importance. Furthermore, in the site observation L-3, there were 4 four species of understorey from 4 four families with a diversity of 1.27 having a low classification, while *Imperata cylindrica* and *Puerania javanica* have the highest importance value index.

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Table 3. Presence and diversity of understorey species on the reclamation area after one month of slashing

No.	Species	Family	L1		L2		L3	
			AP	**IVI**	**AP**	**IVI**	**AP**	**IVI**
1	*Ageratum conyzoides*	Asteraceae	✓	7.3	✓	6.5		
2	*blechnum orientale*	Blechnaceaea			✓	43.5		
3	*Brachiaria mutica*	Graminaea			✓	13.0		
4	*Imperata cylindrica*	Poaceae	✓	48.5	✓	71.2	✓	93.5
5	*Macroptillium lathyroides*	Palpilionaceae			✓	17.8		
6	*Melastomacandidum*	Melastomataceae	✓	79.5				
7	*Passiflora foetida*	Passifloraceae					✓	26.8
8	*Pueraria javanica*	Fabaceae	✓	14.6			✓	41.0
9	*Pueraria phaseoloides*	Palpilionaceae	✓	20.1	✓	26.8		
10	*Scleria disasters*	Cyperaceae	✓	30.1			✓	38.7
11	*Scoparia dulcis*	plantaginaceae			✓	21.2		
	H' of each observation site		**1.54**		**1.71**		**1.27**	
	H' of entire reclamation site				**2.09**			

Note: AP (apperance); IVI (important value index)

Imperata cylindrica has fast adaptability to grow as a pioneer plant in reclamation areas where land clearing is carried out. This is because the roots of the reeds in form of rhizomes under the ground remain alive even though the top of the plant is damaged and fired (Soendjoto et al. 2014). This plant grows quickly in marginal soil conditions which makes it to be considered as weeds when shaded by other species with denser canopy densities (Kone et al. 2013). In addition, the *Melastoma candidium* also has high adaptability because of its resistance to acid soils and ability to absorb aluminum toxins and the height is approximately 0.5-4 meters (Watanabe et al. 2005). Therefore, an increase in *Melastoma candidium* suppresses the growth rate of *Imperata cylindrica* because the canopy is higher and denser.

The species diversity index ~~of~~ in all plots in the reclamation area after one month of understorey cleaning showed a diversity index of 2.09 with a moderate classification. Meanwhile, the types of understorey ~~that are~~ present after the land clearing ~~is~~ are used to develop a type of land precondition to improving soil properties in the post-coal mining reclamation area. However, not all plants were able to grow and adapt to marginal soils after coal mining because the soil in the reclamation area has many limiting factors such as low porosity and high density (Noviyanto et al. 2017). Therefore, the presence of understorey species is considered an adaptive species to post-coal mining land.

Moreover, the understorey is a source of biodiversity and an indicator of post-mining land recovery (Komara et al. 2016). Similarly, the presence of woody and understorey plants reduces the bulk density of the soil due to the influence of root penetration into the soil (Ghestem et al. 2011). The presence of these plants produces biomass that improves soil structure, increases porosity, and reduces bulk density (Adekiya et al. 2021).

Ecologically, the presence of natural understorey shows a tendency for post-mining soil to become healthier. Moreover, improvement of post-mining soil health occurs due to sources of organic matter from understorey, death of higher vegetation, or improved microclimate. Furthermore, understorey species that grow naturally on post-mining land showed fairly high adaptability to the land conditions. This variety of understorey plants also improve the ecosystems, especially habitat for animals, and serves as a source of food for animals such as bird species (Wilson et al. 2006). However, the reduction in plant species in the lower stratum narrowed food sources and habitats for birds to breed (Narango et al. 2017).

Land reclamation is the process of improving the physical and chemical properties of the soil for the disturbances of woody and understorey plants to be slower in the recovery of these species to grow and develop again. Therefore, understorey cleaning activities place pressure on the development of post-mining land biodiversity restoration. Meanwhile, understorey plants function as a source of germplasm wealth, prevent the rate of soil erosion ecologically, and accelerates biomass production to improve soil properties (Noviyanto et al. 2017).

The results of understorey identification after one year of understorey cleaning (Table 4) showed that there was an increase in the number of individual presences and the index of species diversity in the reclamation area after it was allowed to grow and develop. Furthermore, the results showed that there were 36 species of understorey from 22 families. During this period, understorey was left undisturbed and there was an increase in the presence of understorey of approximately 327%. Based on the calculation of the important value and the diversity index at location 1, there were 30 understorey species from 22 families with a diversity of 3.15 having a high classification. At location 2, there were 24 species from 18 families with a diversity index of 2.91 and a moderate classification. Furthermore, at location 3, there were 22 understorey species from 15 families with a diversity index of 2.93 and a medium classification. Therefore, the species diversity index in all plots in the reclamation area during observations of one year after slashing showed a value of 3.35 with a high classification.

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Table 4. Presence and diversity of understorey species observed in the reclamation area one year after understorey clearing

No	Species	Family	L-1		L-2		L-3	
			AP	**IVI**	**AP**	**IVI**	**AP**	**IVI**
1	*Abelmoschus moschatus*	Malvaceae	✓	3.1				
2	*Acacia mangium*	Fabaceae	✓	6.7			✓	13.0
3	*Ageratum conyzoides*	Asteraceae	✓	15.1	✓	16	✓	13.5
4	*Anacardium ocidentale*	Anacardiaceae			✓	1		
5	*Arachis pintoi*	Fabaceae	✓	4.1	✓	7	✓	7.7
6	*Asystasia gangetica*	Acanthaceae	✓	7.0	✓	7	✓	8.6
7	*Bauhinia kockiana*	Fabaceae	✓	6.1	✓	7	✓	6.4
8	*blechnum orientale*	blechnaceae	✓	5.5			✓	8.4
9	*Boehmeria nivea*	Urticaceae	✓	2.6	✓	5	✓	9.3
10	*Brachiria mutica*	Graminaeae	✓	6.5	✓	10		
11	*Bytneria maingrayi*	Malvaceae			✓	7		
12	*Calopogium mucunoides*	Leguminaceae	✓	10.2	✓	11	✓	14.1
13	*trifolia Cayratia*	Vitaceae	✓	4.9			✓	6.2
14	*Centrosema molle*	Fabaceae	✓	4.9			✓	7.5
15	*l Chromolaena odorata,*	Asteraceae	✓	6.5	✓	8	✓	11.9
16	*Cyperus eragrostis*	Cyperaceae			✓	6		
17	*patens Cyrtococcum*	Poaceae	✓	7.7				
18	*Dicran linearis opteris*	Gleicheniaceae	✓	6.7	✓	7		
19	*Fimbristylis littoralis*	Cyperaceae	✓	7.1	✓	8		
20	*Hyptis capitata*	Lamiaceae	✓	7.0	✓	7	✓	7.7
21	*Imperata cylindrica*	Poaceae	✓	9.0	✓	15	✓	13.5
22	*Ipomea cordatriloba*	Convolvulaceae			✓	6		
23	*Macaranga tanarius*	Euphorbiaceae	✓	6.0			✓	5.5
24	*Mangifera indica*	Anacardiaceae	✓	5.6	✓	6		
25	*Melastoma candidum*	Melastomataceae	✓	16.5	✓	18	✓	15.2
26	*Mimosa pudica*	Fabaceae	✓	6.0	✓	7	✓	8.6
27	*Passiflora foetida*	Passifloraceae	✓	7.2	✓	8	✓	6.4
28	*Phylantuss reticulatus*	Phyllanthaceae	✓	5.5	✓	7	✓	8.4
29	*Phyllanthus debilis*	Phyllanthaceae	✓	4.2			✓	8.6
30	*Pterocarpus indicus*	Fabaceae					✓	4.6
31	*Rhynchospora corymbosa*	Cyperaceae	✓	3.9				
32	*disasters Scleria*	Cyperaceae	✓	13.6	✓	13	✓	8.8
33	*Swietenia macrophylla*	Meliaceae			✓	8		
34	*Syzygium aqueum*	Myrtaceae	✓	3.4				
35	*cordataUncaria*	Rubiaceae	✓	4.5	✓	6	✓	6.0
36	*Vitex pinnata*	Lamiaceae	✓	3.3				
	H' of each observation site		**3.30**		**3.09**		**3.04**	
	H' of entire reclamation site				**3.35**			

Note: AP (apperance); IVI (important value index)

The growth of understorey for one year without disturbance in the reclamation area showed the additional species very fast, which indicates that the soil has developed with an increase in soil health. This improvement in soil health is marked by improvements in the physical and chemical properties such as an increase in pH and soil cation exchange capacity (Noviyanto et al. 2017, Buta et al. 2019, Pratiwi et al. 2021). Similarly, the diversity of understorey plants plays an important role in accelerating soil development. Meanwhile, changes of understorey on the soil surface in evolving provide a faster response than trees, which are important in the formation of annual litter that decomposed into the soil (Su et al. 2019). The crowns of *P. falcataria* and *A. cadamba* are not dense, therefore, sunlight reaches the forest floor with a high intensity, which provides sufficient growing space for the presence of understorey.

Furthermore, the type of *Melastoma candidum* at all observation locations has the highest IVI, which showed that these species are capable of becoming a pioneer with high adaptation in post-coal mining areas. Meanwhile, *Imperata cylindrica* which initially had an IVI similar to the *Melastoma candidum* was observed one year after cleaning and shifted by other species, such as *Ageratum conyzoides*. A previous study by Komara et al. (2016) showed that *Ageratum conyzoides*

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observed 16 years after reclamation had an important value index of the third order of 29 species in the post-coal mining reclamation area in East Kalimantan. Meanwhile, several types of the understorey in form of woody plant seedlings in the reclamation area that grow and develop naturally include *Macaranga tanarius*, *Syzygium aqueum*, and *Vitex pinnata*. Also, there are several types of woody plants in the seedling phase included in the observation plot and are present due to planting, include *Mangifera Indica*, *Pterocarpus indicus*, and *Swietenia macrophylla*.

Out of the 36 species of understorey ~~that were~~ presented in the reclamation area after 1 year of cleaning activities, 15 were always present at the three observation locations. Meanwhile, one of these species is *Chromolaena odorata*, which grows on marginal and fertile land (Hamdani et al. 2017). The growth of this plant on land produces litter which contains a lot of nutrients due to its suitability as raw material for making compost and it also suppresses the growth of *Imperata cylindrica* (Juniarti 2017). Therefore, soil improvement with the presence of understorey and higher vegetation improves the function of complex ecosystems, from microorganisms to macroorganisms (Pan et al. 2018).

The species of *M. candidum* which dominates the important values in all observation locations produces several flowers as a source of food for various kinds of insects and flower-eating birds. Moreover, the variety of understorey that produces flowers attracts wild animals such as ~~aves~~birds, mammals, reptiles, amphibians, and insects to migrate to the reclamation area in search of food sources.

Wildlife Presence

The identified wildlife includes aves and non-aves (mammals and reptiles), meanwhile.~~,~~ T~~t~~he identification of the aves fauna (Table 5) showed that there is a change in its presence and diversity which is significantly high within an increase in the understorey. The classification of species presence and diversity index in the observation of one month after cleaning activities were 3 species with an index of 0.90 (H'=low), while 26 were observed one year after cleaning activities with an index of 3.35 (H'=high). According to Casas et al. (2016), the presence and diversity of birds are strongly influenced by the composition and structure of vegetation. Similarly, changes in the structure of vegetation which include understorey, saplings, poles, and trees affect the presence of animals. The existence of food sources and habitat suitability attract animals' migration to the reclamation area until the reclaimed plants become a climax. A previous study (Boer 2009) showed that in the area of land reclamation and rehabilitation, the presence of avifauna (fauna aves) changes continuously towards the common composition in natural forests.

Birds are the most practical group of animals and are often used to detect and respond quickly to environmental changes (Wong & Candolin 2015). During observation after the understorey cleaning activities, the habitat of birds and other animals changes, which leads to migration to an undisturbed area. According to (Liang et al. 2021), the community of bird species declines and migrates due to a decrease in suitable habitat. Meanwhile, habitat is improved through the process of succession of the understorey in the reclamation area by allowing it to grow and develop for one year without disturbance. Also, the presence of understorey increases to show high diversity, which makes the bird community reappear until it reaches a high classification index. A previous study ~~by~~ (Swab et al. 2017) showed that the initial success of reclamation areas in form of grass contributed to the increase in songbird populations. The development of bird and other animal~~ specie~~s evolve gradually with the succession of plants~~,~~. T~~t~~herefore, the use of mining land reclamation methods to create biodiversity determines the rate of presence and composition of bird species (Al-Reza et al. 2016)

The ~~aves~~ bird fauna in the reclamation area after one year of understorey cleaning activities were approximately 7.70% and categorized as water birds, such as *Todiramphus Chloris*, *Actitis hypoleucos*. Out of the 92.30% of the water birds, as described by Ducks Unlimited New Zealand (2017), there are 8 families on the west coast and 34 in the world, and 33 as described by Wetlands International (2020). The presence of waterbirds in the reclamation area is due to the availability of former mining pit water sources close to the area.

Not only does wildlife depend on plants, the presence and condition of plants are also influenced animals because vegetation requires birds, mammals, or other animals for pollination (Ratto et al. 2018). Meanwhile, many species of birds often forage and make nests in the stratum of understorey such as *Orthotomus ruficeps, Prinia flaviventris, Centropus bengalensis, Rhipidura javanica, Lanius schach, Lonchura punctulata,* etc. The diversity of understorey and high density isi a good habitat for various animals to grow and develop (Valladares et al. 2016)v. Birds or small animals, such as *Orthotomus ruficeps and Prinia flaviventris*, hide from predators in thickets of leaves/shrubs. Similarly, *Centropus bengalensis* likes short trees with thick understorey for foraging, playing, sheltering, and nesting (Rajpar & Zakaria 2011).

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Table 5. Presence and diversity of aves fauna in the reclamation area during observations one month and one year after understorey cleaning

No.	Species	Family	First observation			Second observation		
			L-1	L-2	L-3	L-1	L-2	L-3
1	*Gerygone sulphurea*	Acanthizidae				✓		✓
2	*Aegithina tiphia*	Aegithinidae				✓		✓
3	*Todiramphus chloris*	Alcedinidae				✓		
4	*Artamus leucoryn*	Artamidae	✓					✓
5	*Caprimulgus affinis*	Caprimulgidae				✓		
6	*Orthotomus ruficepsf*	Cisticolidae				✓	✓	✓
7	*Prinia flaviventris*	Cisticolidae				✓	✓	✓
8	*Geopelia striata*	Columbidae				✓		✓
9	*Spilopelia chinensis*	Columbidae	✓	✓	✓	✓		
10	*Centropus bengalensis*	Cuculidae						✓
11	*Dicaeum trochileum*	Dicaeidae				✓	✓	
12	*Dicaeum trigonostigma*	Dicaeidae				✓		
13	*Lonchura punctulata*	Estrildidae				✓	✓	✓
14	*Hirundinidae*	Estrildidae						
15	*Hirundo rustica*	Estrildidae					✓	✓
16	*Hirundo tahitica*	Estrildidae				✓		✓
17	*Lanius schach*	Laniidae						✓
18	*Meropidae*	Laniidae						
19	*Merops viridis*	Laniidae					✓	✓
20	*Nectariniidae*	Laniidae						
21	*Anthreptes malacensis*	Laniidae				✓	✓	
22	*Cinnyris jugularis*	Laniidae					✓	
23	*Dendrocopos moluccensis*	Picidae				✓	✓	✓
24	*Pycnonotidae*	Picidae						
25	*Pycnonotus aurigaster*	Picidae				✓	✓	✓
26	*Pycnonotus goiavier*	Picidae	✓	✓	✓	✓	✓	
27	*Rhipiduridae*	Picidae						
28	*Rhipidura javanica*	Picidae				✓	✓	
29	*Actitis hypoleucos*	Scolopacidae						✓
30	*Sturnidae*	Scolopacidae						
31	*Acridotheres javanicus*	Scolopacidae				✓	✓	✓
32	*Vangidae*	Scolopacidae						
33	*Hemipus hirundinaceus*	Scolopacidae				✓	✓	✓
	H' of each observation site		**0,69**	**0,64**	**0,64**	**2,90**	**2,69**	**2,77**
	H' of entire reclamation site			**0.90**			**3.17**	

Table 6. Presence and diversity of non-aves fauna in the reclamation area during observations one month and one year after cleaning the understory

No	Species	Family	First observation	Second observatio
1	*Bronchocela jubata*	Agamidae	✓	✓
2	*Eutropis multifasciata*	Scincidae	✓	✓
3	*Callosciurus notatus*	Sciuridae	✓	
4	*Varanus salvator*	Varanidae		✓
	H' of entire reclamation site		**1.10**	**1.10**

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Clean puddles are a habitat for animals to breed and also a source of food~~,~~ ~~hence~~Hence, the pool at the reclamation area is a place for animals to drink and find food, especially the waterbird *Todiramphus chloris*. In a puddle, dragonfly larvae develop, and after adulthood is food for *Merops* ~~*V*~~*viridis* ~~birds~~ and other insectivore species ~~that~~ consum~~e~~ing flying insects (Arbeiter et al. 2014).

There are ~~3~~ three species of non-aves fauna in the reclamation area as shown by the observation of one month after the understorey cleaning activities, namely *Eutropis multifasciata*, *Bronchocela jubata*, and *Callosciurus notatus*. Meanwhile, one year after the understorey cleaning, *Eutropis multifasciata*, *Bronchocela jubata*, and *Varanus Salvator* were discovered (Table 6).

The non-aves fauna species identified as 1 species of mammal was *Callosciurus notatus*, while 3 reptiles, namely *Bronchocela jubata*, *Eutropis multifasciata*, and *Varanus* ~~*Salvator*~~*salvator*, were obtained by the direct encounter. Meanwhile, the recovery of the presence of non-aves fauna species in the reclamation land was slower than the avian fauna species. The factor of stand density and the availability of food sources significantly influenced the encounter of this mammal species. In the rehabilitated ex-coal mining area with a plant age of up to 10 years in a dense understorey condition, 15 species of mammals were discovered (Soendjoto et al. 2015). Hence, the establishment of a micro-climate under the stands and suitable atmosphere with a variety of plants as a source of food is required for animals to find food, rest, play, hide from predators, sing, and breed.

Based on these results, the increase in the diversity of understorey in the reclamation area attracts the presence of fauna, especially the aves. The development of understorey and woody plants to resemble natural forest habitats makes aves and non-aves fauna migrate to the reclamation area. Therefore, the presence of understorey provides is a place for animals to rest, hide, shelter, nest, find food, make sounds, and breed.

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As the main results are focused on the bird (avoid "aves") species, please, consider here ONLY bird species, by excluding other animals. Especially because mammals and reptiles are in small number of species

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Influence of Understorey Diversity on Wildlife at the Coal Mining Reclamation Area in South Kalimantan

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Abstract. The existence of understorey at the coal mining reclamation area provides an important contribution to improve the environmental quality, especially the wildlife presence. Therefore, this study aims to determine the influence of understorey diversity on the wildlife at the coal mining reclamation area managed by the PT Borneo Indobara, South Kalimantan. This study used an ecological survey which was conducted in three different reclamation areas classified based on the dominant species that support the process, namely *Paraserianthes falcataria (*L-1*), Anthocephalus cadamba (*L-2*)*, and a mixture of both species (L-3). The data were collected in two different observation periods, namely August 2019 and 2020. The results showed that at the first observation, 10 families of understorey were observed from the survey and the highest diversity was recorded in L-2 (H'=1.71), followed by L-1 (H'=1.54), and L-3 (H'=1.27). Meanwhile, the wildlife in the first periods was only 6 species which consists of 3 aves and non-aves each and the number of species from every site was relatively equal at the first observation. In the second observation, the diversity of understorey significantly increased with approximately 22 families from the inventory. The highest understorey diversity in this observation was recorded in L-1 (H'=3.30), L-2 (H'=3.05), and L-3 (H'=3.04). Also, a higher understorey diversity was followed by the greater wildlife with 29 species, which consists of 26 aves and 3 non-aves. The highest appearance of aves species was in the L-1 with approximately 19 species, while the number of aves in L-2 and L-3 was relatively similar with approximately 15 species. Based on these results, the understorey diversity has a significant contribution to improve the wildlife diversity at the coal mining reclamation area, primarily from the aves species.

Keywords: Coal mining, environmental quality, reclamation, understorey, wildlife

Running title: Understorey and wildlife

INTRODUCTION

Coal mining is activities that change the landscape due to the use of an open pit in mining operations, which is commonly referred to as open-cut mining. This method is carried out to excavate mineral deposits that exist in a rock and is suitable for horizontal ore bodies for high production at low costs (Marinin et al. 2021). Meanwhile, the open-pit mining system is carried out by clearing land, removing topsoil and rocks that cover the coal, and taking the coal using excavators and trucks (Setiawan et al. 2021). Therefore, coal mining activities influence changes in vegetation, soil structure, and geology, decrease the quality, and change the soil hydrology (Dejun et al. 2016). To anticipate these problems, successful land reclamation is required after excavation of coal deposits, which involves the closing of the mining hole and returning of topsoil to cover the rock for revegetation activities. These reclamation and revegetation activities restore plant communities and ecosystems around mining to reduce the effects of mining operations on the environment (Buta et al. 2019).

Implementation of post-mining land reclamation activities was carried out at PT Borneo Indobara using fast-growing species such as *Paraserianthes falcataria* and *Antocephalus cadamba* with the addition of *Pterocarpus indicus*, *Mangifera indica*, *Swietenia macrophylla*, and *Acacia mangium* plants that grow naturally. Furthermore, understorey such as grass, ferns, and herbs are often overgrown, especially the species *Acacia mangium* that grows naturally. Meanwhile, the presence of this understorey is considered as a weed that disturbs the main crop, and sometimes cleaning is carried out. The ecological clearing of land under the stands has an impact on decreasing the diversity of understorey which is important for the soil health in the reclamation area. Moreover, cleaning of understorey under tree stands in the reclamation area reduces the presence of fauna. Sasaki et al. (2015) stated that the changes in plant habitat in mining areas affect wildlife populations. A previous study by Partasasmita et al. (2017) stated that the use of vegetation space by birds is divided into the lower stratum in form of understorey plants and the upper in form of tree crowns. Furthermore, Bradfer-Lawrence et al. (2018) stated that there are various species of birds that like habitats in stratum D and E which are dominated by understorey species. Therefore, the presence of fauna in the reclamation area is an indicator of land recovery after coal mining activities.

The understorey plants in ecosystems play a very important role, namely a source of nutrients, germplasm, food for animals, and preventing erosion (Mestre et al. 2017). Hence, a study is required to determine the important role of understorey for the wildlife in the reclamation area and evaluate the level of animals and also analyze the presence of understorey after cleaning for one month and a year. Therefore, this study aims to analyze the effect of understorey presence and diversity on the level of the wildlife of the aves and non-aves in the reclamation area after coal mining.

MATERIALS AND METHODS

Study area

The site was located in the reclamation area of PT Borneo Indobara where the coal mining operation is carried out. This study was implemented in 14 months at different stages, namely field preparation, understorey cleaning, data collection, and analysis. Meanwhile, the observation was carried out in 2 stages, with the first in August 2019 and the second in 2020. The geographical coordinates of location is at E115˚54'38" 115˚39'00" and S3˚35'30" 3˚36'30". The reclamation area is with 2 main types of plants, namely *Paraserianthes falcataria* and *Antocephalus cadamba* which were established in 2013. The site is administratively situated in Sungai Loban District, Tanah Bumbu Regency, South Kalimantan Province (Figure 1). The field survey was carried out in 3 different sites of reclamations classified based on the dominant vegetation species (Table 1).

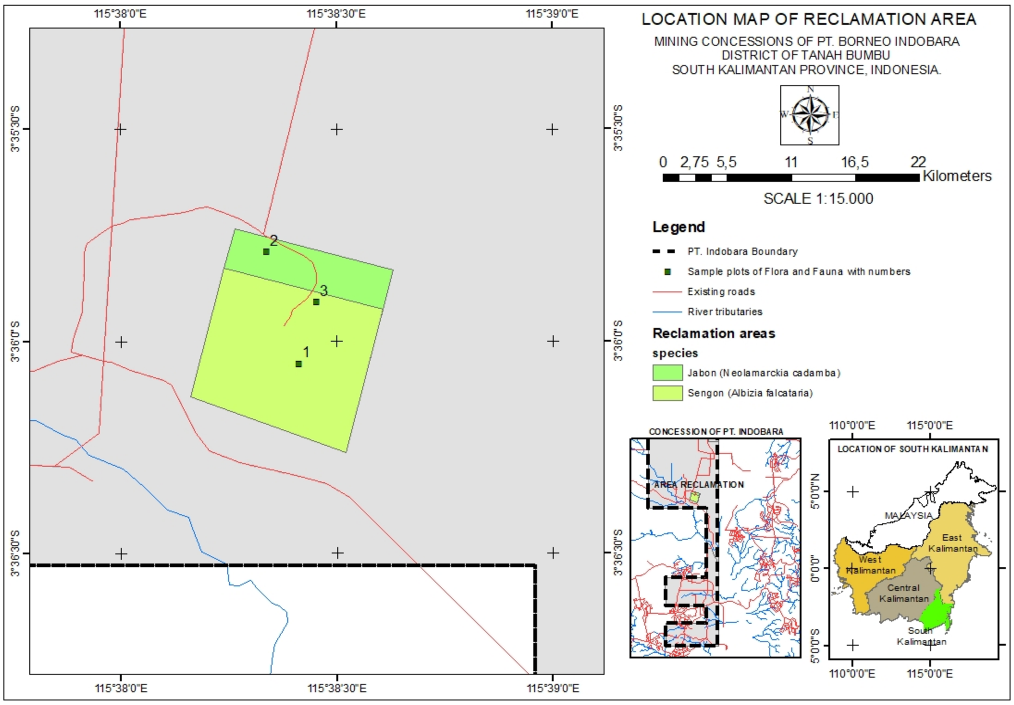

Figure 1. The study site of coal mining reclamation area in the PT Borneo Indobara. The number indicated the position of sampling location

Table 1. Location of ecological survey for monitoring understorey diversity and wildlife presence at the coal mining reclamation area

Site	Species	Symbol	Planting year
1	*Paraserianthe falcataria*	L-1	2013
2	*Antocephalus cadamba*	L-2	2013
3	Mixed species (*P. falcataria x A. cadamba*)	L-3	2013

Procedures

This study was conducted in a reclamation area with plant species *Paraserianthes falcataria* and *Antocephalus cadamba*, and the two types of data collected include the presence and diversity of understorey and wildlife. The treatment was carried out by cleaning the understorey in the reclamation area in a manual and chemical combination, while land clearing was conducted once and observations were made subsequently. Moreover, field observations were conducted in 2 stages, where the first was after one month and the second after one year of understorey cleaning activities. During this one year, the understorey was allowed to grow and develop without any disturbance. At each stage of observation, identification of the presence of understorey species and wildlife species, such as aves and non-aves (mammals and reptiles) was carried out. This treatment was carried out to identify the presence and diversity of understorey together with wildlife species after land clearing activities.

Understorey data were obtained using the transect-line method up to 6 measuring plots at each observation point. The measuring plot size was 2 x 2 m and each was spaced at an interval of one plot to achieve a path length of 24 m. Meanwhile, the observation data for understorey flora include species presence, relative frequency and density, important value index, and diversity of understorey species. The understorey recorded were grasses, herbs, ferns, and woody plant seedlings and were included in the observation plot.

Wildlife observation data were obtained at the understorey point using the sampling method with a circle radius of 25 m, while each point data were recorded in the morning from 07.00 to 11.00 and the afternoon at 14.00-18.00. The data recorded include the types and the number of individual species of wildlife encountered, which consists of bird species (aves fauna), mammals, and reptiles. The observed wildlife in form of aves was identified using MacKinnon et al (2010). Furthermore, non-aves wildlife in form of mammals was identified by Francis (2013) or Payne et al (2000), and those in form of reptiles were identified using Das (2010).

Data analysis

Analysis of understorey data using the formula to calculate the Important Value Index according to Lü et al. (2011), that is :

Relative density = (Density of a species)/(Density of all species)x 100 (1)

Relative frequency = (Frequency of a species)/(Frequency of all species)x 100 (2)

Important value index = Relative density + Relative frequency (3)

Importance Value Index (IVI) for understorey plants ranges from 0 - 200. If the value is close to 200, then a species has a higher ecological level in a community and if it is close to 0, its ecological control is lower in the community. The diversity index is calculated using the formula by (Naidu & Kumar 2016), the formulation is as follows:

H' = - (pi) ln (pi) where pi = ni/N (4)

where H' was the Diversity index, ni indicates an abundance of every species, and N was the total sample observed. The greater H' of a community indicates that the community is getting better. The value of H' equal to 0 can occur if there is only one species in one sample and maximum H if all species have the same number of individuals and this indicates a perfectly distributed abundance. The criteria for the diversity index based on Shannon-Wiener was expressed below (Djufri et al. 2016):

Table 2. Criteria of diversity index based on Shannon-Wiener

H' value	Descriptions
< 1	Low diversity
1-3	Moderate diversity
>3	High diversity

The analysis of IVI was only applied for understorey vegetation while the determination of the Shannon-Wiener Index was done for understorey and wildlife.

RESULTS AND DISCUSSION

Understorey diversity

The results of the first stage of understorey identification which is one month after cleaning activities showed that the presence of understorey species is 11 from 10 families (Table 3). These species naturally appear after land clearing treatment and are categorized as a pioneer plants. Based on the calculation of the understorey at the site L-1, there were 6 species with a diversity of 1.54 according to the Shannon-Wiener index having low criteria, while *Melastoma candidium* and *Imperata cylindrica* have the highest important value index. In the site observation of L-2, there were 7 species of understorey from 6 families with a diversity of 1.71 having a low classification, while *Imperata cylindrica* and *Blechnum Orientale* have an index value of the highest importance. Furthermore, in the site observation L-3, there were 4 species of understorey from 4 families with a diversity of 1.27 having a low classification, while *Imperata cylindrica* and *Puerania javanica* have the highest importance value index.

Table 3. Presence and diversity of understorey species on the reclamation area after one month of slashing

No.	Species	Family	L1		L2		L3	
			AP	IVI	AP	IVI	AP	IVI
1	*Ageratum conyzoides*	Asteraceae	✓	7.3	✓	6.5		
2	*blechnum orientale*	Blechnaceaea			✓	43.5		
3	*Brachiaria mutica*	Graminaea			✓	13.0		
4	*Imperata cylindrica*	Poaceae	✓	48.5	✓	71.2	✓	93.5
5	*Macroptillium lathyroides*	Palpilionaceae			✓	17.8		
6	*Melastomacandidum*	Melastomataceae	✓	79.5				
7	*Passiflora foetida*	Passifloraceae					✓	26.8
8	*Pueraria javanica*	Fabaceae	✓	14.6			✓	41.0
9	*Pueraria phaseoloides*	Palpilionaceae	✓	20.1	✓	26.8		
10	*Scleria disasters*	Cyperaceae	✓	30.1			✓	38.7
11	*Scoparia dulcis*	plantaginaceae			✓	21.2		
	H' of each observation site		**1.54**		**1.71**		**1.27**	
	H' of entire reclamation site				**2.09**			

Note: AP (apperance); IVI (important value index)

Imperata cylindrica has fast adaptability to grow as a pioneer plant in reclamation areas where land clearing is carried out. This is because the roots of the reeds in form of rhizomes under the ground remain alive even though the top of the plant is damaged and fired (Soendjoto et al. 2014). This plant grows quickly in marginal soil conditions which makes it to be considered as weeds when shaded by other species with denser canopy densities (Kone et al. 2013). In addition, the *Melastoma candidium* also has high adaptability because of its resistance to acid soils and ability to absorb aluminum toxins and the height is approximately 0.5-4 meters (Watanabe et al. 2005). Therefore, an increase in *Melastoma candidium* suppresses the growth rate of *Imperata cylindrica* because the canopy is higher and denser.

The species diversity index of all plots in the reclamation area after one month of understorey cleaning showed a diversity index of 2.09 with a moderate classification. Meanwhile, the types of understorey that are present after land clearing is used to develop a type of land precondition to improving soil properties in the post-coal mining reclamation area. However, not all plants were able to grow and adapt to marginal soils after coal mining because the soil in the reclamation area has many limiting factors such as low porosity and high density (Noviyanto et al. 2017). Therefore, the presence of understorey species is considered an adaptive species to post-coal mining land.

Moreover, the understorey is a source of biodiversity and an indicator of post-mining land recovery (Komara et al. 2016). Similarly, the presence of woody and understorey plants reduces the bulk density of the soil due to the influence of root penetration into the soil (Ghestem et al. 2011). The presence of these plants produces biomass that improves soil structure, increases porosity, and reduces bulk density (Adekiya et al. 2021).

Ecologically, the presence of natural understorey shows a tendency for post-mining soil to become healthier. Moreover, improvement of post-mining soil health occurs due to sources of organic matter from understorey, death of higher vegetation, or improved microclimate. Furthermore, understorey species that grow naturally on post-mining land showed fairly high adaptability to the land conditions. This variety of understorey plants also improve the ecosystems, especially habitat for animals, and serves as a source of food for animals such as bird species (Wilson et al. 2006). However, the reduction in plant species in the lower stratum narrowed food sources and habitats for birds to breed (Narango et al. 2017).

Land reclamation is the process of improving the physical and chemical properties of the soil for the disturbances of woody and understorey plants to be slower in the recovery of these species to grow and develop again. Therefore, understorey cleaning activities place pressure on the development of post-mining land biodiversity restoration. Meanwhile, understorey plants function as a source of germplasm wealth, prevent the rate of soil erosion ecologically, and accelerates biomass production to improve soil properties (Noviyanto et al. 2017).

The results of understorey identification after one year of understorey cleaning (Table 4) showed that there was an increase in the number of individual presences and the index of species diversity in the reclamation area after it was allowed to grow and develop. Furthermore, the results showed that there were 36 species of understorey from 22 families. During this period, understorey was left undisturbed and there was an increase in the presence of understorey of approximately 327%. Based on the calculation of the important value and the diversity index at location 1, there were 30 understorey species from 22 families with a diversity of 3.15 having a high classification. At location 2, there were 24 species from 18 families with a diversity index of 2.91 and a moderate classification. Furthermore, at location 3, there were 22 understorey species from 15 families with a diversity index of 2.93 and a medium classification. Therefore, the species diversity index in all plots in the reclamation area during observations of one year after slashing showed a value of 3.35 with a high classification.

Table 4. Presence and diversity of understorey species observed in the reclamation area one year after understorey clearing

No	Species	Family	L-1		L-2		L-3	
			AP	IVI	AP	IVI	AP	IVI
1	*Abelmoschus moschatus*	Malvaceae	✓	3.1				
2	*Acacia mangium*	Fabaceae	✓	6.7			✓	13.0
3	*Ageratum conyzoides*	Asteraceae	✓	15.1	✓	16	✓	13.5
4	*Anacardium ocidentale*	Anacardiaceae			✓	1		
5	*Arachis pintoi*	Fabaceae	✓	4.1	✓	7	✓	7.7
6	*Asystasia gangetica*	Acanthaceae	✓	7.0	✓	7	✓	8.6
7	*Bauhinia kockiana*	Fabaceae	✓	6.1	✓	7	✓	6.4
8	*blechnum orientale*	blechnaceae	✓	5.5			✓	8.4
9	*Boehmeria nivea*	Urticaceae	✓	2.6	✓	5	✓	9.3
10	*Brachiria mutica*	Graminaeae	✓	6.5	✓	10		
11	*Bytneria maingrayi*	Malvaceae			✓	7		
12	*Calopogium mucunoides*	Leguminaceae	✓	10.2	✓	11	✓	14.1
13	*trifolia Cayratia*	Vitaceae	✓	4.9			✓	6.2
14	*Centrosema molle*	Fabaceae	✓	4.9			✓	7.5
15	*l Chromolaena odorata,*	Asteraceae	✓	6.5	✓	8	✓	11.9
16	*Cyperus eragrostis*	Cyperaceae			✓	6		
17	*patens Cyrtococcum*	Poaceae	✓	7.7				
18	*Dicran linearis opteris*	Gleicheniaceae	✓	6.7	✓	7		
19	*Fimbristylis littoralis*	Cyperaceae	✓	7.1	✓	8		
20	*Hyptis capitata*	Lamiaceae	✓	7.0	✓	7	✓	7.7
21	*Imperata cylindrica*	Poaceae	✓	9.0	✓	15	✓	13.5
22	*Ipomea cordatriloba*	Convolvulaceae			✓	6		
23	*Macaranga tanarius*	Euphorbiaceae	✓	6.0			✓	5.5
24	*Mangifera indica*	Anacardiaceae	✓	5.6	✓	6		
25	*Melastoma candidum*	Melastomataceae	✓	16.5	✓	18	✓	15.2
26	*Mimosa pudica*	Fabaceae	✓	6.0	✓	7	✓	8.6
27	*Passiflora foetida*	Passifloraceae	✓	7.2	✓	8	✓	6.4
28	*Phylantuss reticulatus*	Phyllanthaceae	✓	5.5	✓	7	✓	8.4
29	*Phyllanthus debilis*	Phyllanthaceae	✓	4.2			✓	8.6
30	*Pterocarpus indicus*	Fabaceae					✓	4.6
31	*Rhynchospora corymbosa*	Cyperaceae	✓	3.9				
32	*disasters Scleria*	Cyperaceae	✓	13.6	✓	13	✓	8.8
33	*Swietenia macrophylla*	Meliaceae			✓	8		
34	*Syzygium aqueum*	Myrtaceae	✓	3.4				
35	*cordataUncaria*	Rubiaceae	✓	4.5	✓	6	✓	6.0
36	*Vitex pinnata*	Lamiaceae	✓	3.3				
	H' of each observation site		**3.30**		**3.09**		**3.04**	
	H' of entire reclamation site				**3.35**			

Note: AP (apperance); IVI (important value index)

The growth of understorey for one year without disturbance in the reclamation area showed the additional species very fast, which indicates that the soil has developed with an increase in soil health. This improvement in soil health is marked by improvements in the physical and chemical properties such as an increase in pH and soil cation exchange capacity (Noviyanto et al. 2017, Buta et al. 2019, Pratiwi et al. 2021). Similarly, the diversity of understorey plants plays an important role in accelerating soil development. Meanwhile, changes of understorey on the soil surface in evolving provide a faster response than trees, which are important in the formation of annual litter that decomposed into the soil (Su et al. 2019). The crowns of *P. falcataria* and *A. cadamba* are not dense, therefore, sunlight reaches the forest floor with a high intensity, which provides sufficient growing space for the presence of understorey.

Furthermore, the type of *Melastoma candidum* at all observation locations has the highest IVI, which showed that these species are capable of becoming a pioneer with high adaptation in post-coal mining areas. Meanwhile, *Imperata cylindrica* which initially had an IVI similar to the *Melastoma candidum* was observed one year after cleaning and shifted by other species, such as *Ageratum conyzoides*. A previous study by Komara et al. (2016) showed that *Ageratum conyzoides* observed 16 years after reclamation had an important value index of the third order of 29 species in the post-coal mining reclamation area in East Kalimantan. Meanwhile, several types of the understorey in form of woody plant seedlings in the reclamation area that grow and develop naturally include *Macaranga tanarius*, *Syzygium aqueum*, and *Vitex pinnata*. Also, there are several types of woody plants in the seedling phase included in the observation plot and are present due to planting, include *Mangifera Indica*, *Pterocarpus indicus,* and *Swietenia macrophylla*.

Out of the 36 species of understorey that were present in the reclamation area after 1 year of cleaning activities, 15 were always present at the three observation locations. Meanwhile, one of these species is *Chromolaena odorata*, which grows on marginal and fertile land (Hamdani et al. 2017). The growth of this plant on land produces litter which contains a lot of nutrients due to its suitability as raw material for making compost and it also suppresses the growth of *Imperata cylindrica* (Juniarti 2017). Therefore, soil improvement with the presence of understorey and higher vegetation improves the function of complex ecosystems, from microorganisms to macroorganisms (Pan et al. 2018).

The species of *M. candidum* which dominates the important values in all observation locations produces several flowers as a source of food for various kinds of insects and flower-eating birds. Moreover, the variety of understorey that produces flowers attracts wild animals such as aves, mammals, reptiles, amphibians, and insects to migrate to the reclamation area in search of food sources.

Wildlife Presence

The identified wildlife includes aves and non-aves (mammals and reptiles), meanwhile, the identification of the aves fauna (Table 5) showed that there is a change in its presence and diversity which is significantly high within an increase in the understorey. The classification of species presence and diversity index in the observation of one month after cleaning activities were 3 species with an index of 0.90 (H'=low), while 26 were observed one year after cleaning activities with an index of 3.35 (H'=high). According to Casas et al. (2016), the presence and diversity of birds are strongly influenced by the composition and structure of vegetation. Similarly, changes in the structure of vegetation which include understorey, saplings, poles, and trees affect the presence of animals. The existence of food sources and habitat suitability attract animals' migration to the reclamation area until the reclaimed plants become a climax. A previous study (Boer 2009) showed that in the area of land reclamation and rehabilitation, the presence of avifauna (fauna aves) changes continuously towards the common composition in natural forests.

Birds are the most practical group of animals and are often used to detect and respond quickly to environmental changes (Wong & Candolin 2015). During observation after the understorey cleaning activities, the habitat of birds and other animals changes, which leads to migration to an undisturbed area. According to (Liang et al. 2021), the community of bird species declines and migrates due to a decrease in suitable habitat. Meanwhile, habitat is improved through the process of succession of the understorey in the reclamation area by allowing it to grow and develop for one year without disturbance. Also, the presence of understorey increases to show high diversity, which makes the bird community reappear until it reaches a high classification index. A previous study by (Swab et al. 2017) showed that the initial success of reclamation areas in form of grass contributed to the increase in songbird populations. The development of bird and other animal species evolve gradually with the succession of plants, therefore, the use of mining land reclamation methods to create biodiversity determines the rate of presence and composition of bird species (Al-Reza et al. 2016)

The aves fauna in the reclamation area after one year of understorey cleaning activities were approximately 7.70% and categorized as water birds, such as *Todiramphus Chloris*, *Actitis hypoleucos.* Out of the 92.30% of the water birds, as described by Ducks Unlimited New Zealand (2017), there are 8 families on the west coast and 34 in the world, and 33 as described by Wetlands International (2020). The presence of waterbirds in the reclamation area is due to the availability of former mining pit water sources close to the area.

Not only does wildlife depend on plants, the presence and condition of plants are also influenced animals because vegetation requires birds, mammals, or other animals for pollination (Ratto et al. 2018). Meanwhile, many species of birds often forage and make nests in the stratum of understorey such as *Orthotomus ruficeps*, *Prinia flaviventris*, *Centropus bengalensis, Rhipidura javanica, Lanius schach*, *Lonchura punctulata,* etc. The diversity of understorey and high density isi a good habitat for various animals to grow and develop (Valladares et al. 2016)v. Birds or small animals, such as *Orthotomus ruficeps and Prinia flaviventris*, hide from predators in thickets of leaves/shrubs. Similarly, *Centropus bengalensis* likes short trees with thick understorey for foraging, playing, sheltering, and nesting (Rajpar & Zakaria 2011).

Table 5. Presence and diversity of aves fauna in the reclamation area during observations one month and one year after understorey cleaning

No.	Species	Family	First observation			Second observation		
			L-1	L-2	L-3	L-1	L-2	L-3
1	*Gerygone sulphurea*	Acanthizidae				✓		✓
2	*Aegithina tiphia*	Aegithinidae				✓		✓
3	*Todiramphus chloris*	Alcedinidae				✓		
4	*Artamus leucoryn*	Artamidae	✓					✓
5	*Caprimulgus affinis*	Caprimulgidae				✓		
6	*Orthotomus ruficepsf*	Cisticolidae				✓	✓	✓
7	*Prinia flaviventris*	Cisticolidae				✓	✓	✓
8	*Geopelia striata*	Columbidae				✓		✓
9	*Spilopelia chinensis*	Columbidae	✓	✓	✓	✓		
10	*Centropus bengalensis*	Cuculidae						✓
11	*Dicaeum trochileum*	Dicaeidae				✓	✓	
12	*Dicaeum trigonostigma*	Dicaeidae				✓		
13	*Lonchura punctulata*	Estrildidae				✓	✓	✓
14	*Hirundinidae*	Estrildidae						
15	*Hirundo rustica*	Estrildidae					✓	✓
16	*Hirundo tahitica*	Estrildidae				✓		✓
17	*Lanius schach*	Laniidae						✓
18	*Meropidae*	Laniidae						
19	*Merops viridis*	Laniidae					✓	✓
20	*Nectariniidae*	Laniidae						
21	*Anthreptes malacensis*	Laniidae				✓	✓	
22	*Cinnyris jugularis*	Laniidae					✓	
23	*Dendrocopos moluccensis*	Picidae				✓	✓	✓
24	*Pycnonotidae*	Picidae						
25	*Pycnonotus aurigaster*	Picidae				✓	✓	✓
26	*Pycnonotus goiavier*	Picidae	✓	✓	✓	✓	✓	
27	*Rhipiduridae*	Picidae						
28	*Rhipidura javanica*	Picidae				✓	✓	
29	*Actitis hypoleucos*	Scolopacidae						✓
30	*Sturnidae*	Scolopacidae						
31	*Acridotheres javanicus*	Scolopacidae				✓	✓	✓
32	*Vangidae*	Scolopacidae						
33	*Hemipus hirundinaceus*	Scolopacidae				✓	✓	✓
	H' of each observation site		**0,69**	**0,64**	**0,64**	**2,90**	**2,69**	**2,77**
	H' of entire reclamation site			**0.90**			**3.17**	

Table 6. Presence and diversity of non-aves fauna in the reclamation area during observations one month and one year after cleaning the understory

No	Species	Family	First observation	Second observatio
1	*Bronchocela jubata*	Agamidae	✓	✓
2	*Eutropis multifasciata*	Scincidae	✓	✓
3	*Callosciurus notatus*	Sciuridae	✓	
4	*Varanus salvator*	Varanidae		✓
	H' of entire reclamation site		**1.10**	**1.10**

Clean puddles are a habitat for animals to breed and also a source of food, hence, the pool at the reclamation area is a place for animals to drink and find food, especially the waterbird *Todiramphus chloris*. In a puddle, dragonfly larvae develop, and after adulthood is food for Merops Viridis birds and other species that consume flying insects (Arbeiter et al. 2014).

There are 3 species of non-aves fauna in the reclamation area as shown by the observation of one month after the understorey cleaning activities, namely *Eutropis multifasciata*, *Bronchocela jubata*, and *Callosciurus notatus*. Meanwhile, one year after the understorey cleaning, *Eutropis multifasciata*, *Bronchocela jubata*, and *Varanus Salvator* were discovered (Table 6).

The non-aves fauna species identified as 1 species of mammal was Callosciurus notatus, while 3 reptiles, namely *Bronchocela jubata*, *Eutropis multifasciata*, and *Varanus Salvator*, were obtained by the direct encounter. Meanwhile, the recovery of the presence of non-aves fauna species in the reclamation land was slower than the avian fauna species. The factor of stand density and the availability of food sources significantly influenced the encounter of this mammal species. In the rehabilitated ex-coal mining area with a plant age of up to 10 years in a dense understorey condition, 15 species of mammals were discovered (Soendjoto et al. 2015). Hence, the establishment of a micro-climate under the stands and suitable atmosphere with a variety of plants as a source of food is required for animals to find food, rest, play, hide from predators, sing, and breed.

Based on these results, the increase in the diversity of understorey in the reclamation area attracts the presence of fauna, especially the aves. The development of understorey and woody plants to resemble natural forest habitats makes aves and non-aves fauna migrate to the reclamation area. Therefore, the presence of understorey provides is a place for animals to rest, hide, shelter, nest, find food, make sounds, and breed.

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