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Vegetation development in post-gold mining revegetation area in Minahasa, North Sulawesi, Indonesia

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Abstract. *Lestari KG, Budi SW, Suryaningtyas DT, Yudhiman E. 2022. Vegetation development in post-gold mining revegetation area in Minahasa, North Sulawesi, Indonesia. Biodiversitas 23: 3224-3233.* Gold mining activities in Indonesia, in many areas, have a negative impact on the environment. Activities that can improve the quality of post-mining land include revegetation activities, which are included in post-mining land reclamation activities. The purpose of this study was to analyze the development of vegetation in post-gold mining revegetation areas. Vegetation data were collected using the plotted line method (natural forest) and the Systematic Sampling method with Random Start (revegetation area). The analysis found that the vegetation structure in the post-gold mining revegetation area aged 3 to 10 years has complete vegetation levels (saplings, saplings, poles, and trees). Compared to natural forest, which only includes 30 tree species and 7 herbaceous, this revegetation region has a greater diversity of species, with 66 tree species and 16 herbaceous. The longer the age of revegetation is not followed by an increase in species and an increase in the value of the species diversity index. However, it is still better than the revegetation at a young age and is closer to the condition of a natural forest. The revegetation area aged 8 and 7 years has a higher number of species than natural forests and other revegetation areas.

Keywords: Post gold mining, reclamation, revegetation, species diversity, vegetation development

INTRODUCTION

Gold mining is a mining business activity that produces gold in a certain area. Indonesia is in the seventh position as the world's largest gold producer, with a total volume mined in 2018 of 4.42 million troy ounces (Idris 2020). Although gold mining is profitable for the country, this activity has a detrimental impact on the environment. Gold mining activities, in many cases, occur in Indonesia; several research reports indicate environmental damage due to water pollution by mercury used in gold mining (Soemarwoto and Ellen 2010). The mining sector also contributes to forest destruction in Indonesia, which reaches 10% and reaches 2 million ha per year (Setyowati et al. 2018). Land recovery at gold mining sites will be slower and more difficult since the influence alters not just vegetation but also soil properties (Chambi-Legoas et al. 2021; Ekyastuti et al. 2016; Kalamandeen et al. 2020; Rohitashav and Jaipal 2020). To overcome the damage to the ex-mining land, it is necessary to reclaim the ex-mining land. Natural regeneration alone is ineffective for recovering abandoned mining sites because the nutrient loss significantly impacts the ability to recover after mining (Kalamandeen et al. 2020). Within post-mining settings, certain species can also play an essential role in phytoremediation (Ritchie and Raina 2016).

Reclamation is an activity that aims to improve or organize disturbed land due to mining business activities so that it can function and be efficient according to its designation (Suprapto 2008). Reclamation success requires basic knowledge about the biotic and abiotic environment and the processes that occur in the environment at each level. Things that need to be considered and carried out in the rehabilitation/reclamation of ex-mining land are the impact of changes from mining activities, soil reconstruction, revegetation, prevention of acid mine drainage, drainage arrangements, and post-mining land use (Suprapto 2008). One of the reclamation efforts is revegetation activities or planting adaptive plant species. Revegetation on post-mining land is certainly very influential in forming the vegetation profile, both in composition and structure.

Revegetation activities that are included in post-mining land reclamation activities are activities that can improve the quality of post-mining land. This activity can shape the structure and composition of the stand and can improve soil quality. The success of revegetation can be evaluated by determining the plant's growth performance (Istomo et al. 2013). In addition to requiring maintenance, revegetation activities require monitoring activities to determine their success of a revegetation activity. Activity monitoring after existence planting in the land is very important for doing. Activity monitoring aims to know the development condition of planted plants. According to the Decree of the Minister of Energy and Resources Mineral Resources No.1806 K/30/MEM/2018 About Guidelines Implementation Preparation, Evaluation, Approval Plan Work and Budget Costs, As well as Reports on Mineral and Coal Mining Business Activities that activity monitoring in the revegetation area including to in mandatory activities enter in plan and mandatory realized in the field.

The success of these revegetation activities will show the success of reclamation activities in the post-mining area. PT Tambang Tondano Nusajaya is a gold mining company that has carried out revegetation activities. However, this company has not carried out monitoring activities, so vegetation development in this post-mining revegetation area is not yet known. Research on the analysis of vegetation development in post-mining revegetation areas is very important so that land reclamation activities are maximized and can provide recommendations for policies and further actions that need to be taken by the company. The purpose of this study was to analyze the development of vegetation in the revegetation area of post-mining land and to compare the condition of vegetation in various revegetation age classes with the condition of vegetation in natural forests.

MATERIALS AND METHODS

The research was carried out from September 2021 to November 2021. The research location is in ex-mining land that has been revegetated and in natural forest, PT Tambang Tondano Nusajaya, North Sulawesi (Figure 1). The tools used are stationery, laptop, and Microsoft Excel application. The material used is primary data on vegetation in the revegetation area and natural forest.

Data collection

Vegetation data were collected on revegetation plants with planting years from 2011 to 2019, which meant they were 2, 3, 4, 5, 6, 7, 8, 9, and 10 years old and in natural forests. Vegetation data collection for forest areas uses a combination of the path method with the plotted line method with 25 squared plots (20x20 m) (Figure 2). The revegetation plants assessment was carried out using a sampling technique using the Systematic Sampling with Random Start method (Figure 3). The observed area of the revegetation area is 56.26 hectares, and the number of plots observed is 33 plots (40x25 m).

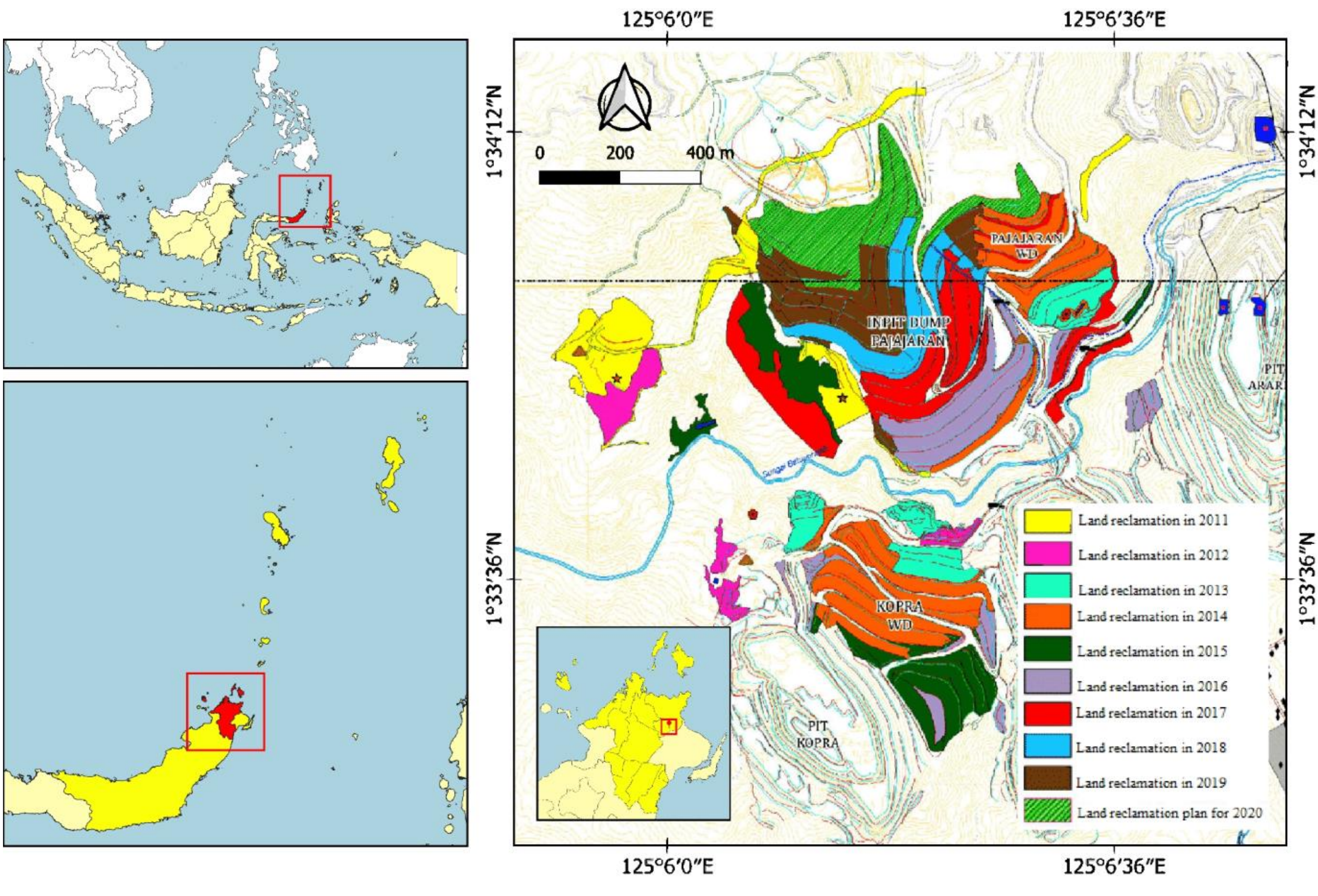

Figure 1. A map of the research site's observation locations

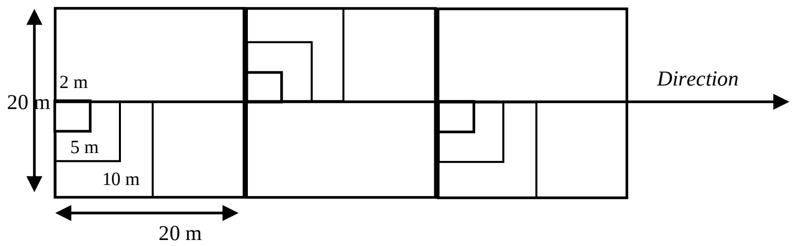

Figure 2. Design of observation plots in natural forest

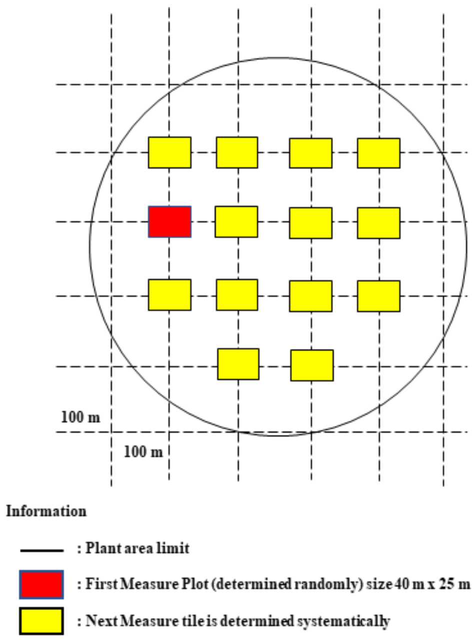

Figure 3. Design of observation plots in the revegetation area on a planting map of 1:10000 scale. Source: Permenhut No. P. 60/Menhut-II/2009

Data analysis

The vegetation data obtained were analyzed quantitatively by calculating the Important Value Index for each species found.

Density (K) $: \frac{\text{Number of individual species}}{\text{The total area of the sample plot}}$

Relative Density (KR) $: \frac{\text{species specific density}}{\text{All species density}} \times 100\%$

Dominance (D):
$$\frac{\text{Total area of the base area of a particular species}}{\text{Area of the entire sample plot}}$$

Relative Dominance (DR):
$$\frac{\text{Dominance of a particular species}}{\text{Dominance of all species}} \times 100\%$$

Frequency (F):
$$\frac{\text{Number of sample plots found of a particular species}}{\text{Number of all sample plots}}$$

Relative Frequency (FR): $\frac{\text{Specific frequency}}{\text{All species frequency}} \times 100\%$

Important Value Index (IVI):
IVI = KR + FR (for seedlings and saplings)
IVI = KR + FR + DR (for trees)

Significant value is obtained from the sum of relative density, relative frequency, and relative dominance, which produces values between 0 - 300 (Mueller-Dombois and Ellenberg 1974). Meanwhile, for undergrowth and seedlings, the important value was obtained from the relative density and frequency sum, so the maximum significant value was 200.

Species Diversity Index/ Shannon-Wiener Index (H')

The diversity of plant species was determined using *the Shannon-Wiener Diversity Index* (H') (Ludwig and Reynolds 1988) with the formula:

$$H' = \sum_{i=1}^{s} pi \ln pi, pi = \frac{ni}{N}$$

Information:
H': Species Diversity Index
ni: The significance value of the i-th species
N: Total importance of all species

The larger the H' of a community, the better the community. H' is maximum when all species have the same number of individuals and show a perfectly distributed abundance (Ludwig and Reynolds 1988). There are three criteria for analyzing the species diversity index: if the value of H' < 2, then the value of species diversity is included in the low category. If the value of 2 < H' < 3, then it is included in the medium category, and if the value of H' > 3, then the value is classified as high (Magurran 1988).

RESULTS AND DISCUSSION

Vegetation structure in the revegetation area and natural forest

The vegetation development analysis results are seen from the development of the vegetation structure in the post- gold mining revegetation area aged 3 to 10 years (2011-2018). Natural forests have complete vegetation levels, namely from regeneration (seedlings, saplings, poles) to tree level but in post-gold mining revegetation areas aged 2 years 2019 only have seedlings, saplings, and poles (Figure 4). The completeness of the vegetation level in the post-mining land revegetation area aged 3 to 10 years (2011-2018) means that it is close to the actual forest structure except in the post-mining land revegetation area of 2 years (2019) because this area has not been found any tree-level vegetation. Many biotic and abiotic elements influence the formation of vegetation structure (Jaˇcka et al. 2021; Walmsley et al. 2017). The beginning of pile processing and the main woody plant species are significant environmental elements that influence community growth (Vachova et al. 2022; Walmsley et al. 2017).

Index of vegetation significance in revegetation areas and natural forests

Vegetation analysis by looking at the IVI value of vegetation types resulted in different IVI values. The difference in IVI values is influenced by the density, frequency, and dominance of each species. Figures 5 and 6 show the IVI values for all species in the revegetation area and natural forest. Overall conditions in this revegetation area have a more diverse number of species, namely 66 tree species and 16 herbaceous, compared to the natural forest, which only has 30 tree species and 7 herbaceous.

In the revegetation area of the understorey category, there were 16 species with *Mikania micrantha* Kunth., which was found to have the highest IVI value. *Mikania micrantha* is an annual weed that grows to creep and can invade its growing habitat quickly (Sankaran 2008). Due to the nature of the invasion, this species is found not only in one revegetation area, so it has the highest IVI value. Meanwhile, for the woody plant category, *Falcataria moluccana* (Miq.) Barneby & JW Grimes, which has IVI dominates in several revegetation areas, not only in one area at the pole and tree level, so the IVI value is higher than other types. *Falcataria moluccana* species are stapled vegetation resistant to sunlight or intolerant (Simbolon 2016). *Falcataria moluccana* is one of the recommended species and has often been planted for post-mining rehabilitation activities. The rehabilitation project in the post-coal mining area was conducted by planting ten local tree species in East Kalimantan, Indonesia (Adman and Yassir 2016; Adman et al. 2020).

The flower wood species have the largest IVI for the woody plant category in a natural forest, and the *Salvinia molesta* D.S. Mitch. species has the largest IVI for the herbaceous plant category. Research by Tallei et al. (2016) produced data that *Spathodea campanulata* Beauv. had the highest IVI compared to other types at the pole and tree level. This is because *S. campanulata* is an invasive plant originating from Africa and has a very fast growth so that it can dominate an ecosystem.

Table 1 compares tree species diversity between post-mining revegetation areas and natural forests. The natural forest has a diversity of tree species, as many as 31 species. Meanwhile, for the diversity of tree species in the post-mining revegetation area, 25 species were aged at 10 years, 35 species at 9 years old, 33 species at 8 years old, 35 species at 7 years old, 23 species at 6 years old, 28 years at 5 years old. Species, age 4 years, as many as 11 species, age 3 years, as many as 22 species, and age 2 years, as many as 19 species. The diversity of tree species that have approached and even exceeded the number of species in natural forests are vegetation stands aged 9 years (2012), 8 years (2013), and 7 years (2014). The diversity of tree species in the post-mining revegetation area fluctuates at various ages. With species that appear in all areas, namely *Macaranga tanarius* (L.) Müll.Arg. Several plants in the reclamation area that grow and develop naturally were identified in a previous study, including *M. tanarius*, *Syzygium aqueum*, and *Vitex pinnata* (Komara et al. 2016; Nugroho et al. 2021).

Table 2 compares the diversity of herbaceous species between post-mining revegetation areas and natural forests. The natural forest has a diversity of 7 types of herbs. As for the diversity of herbaceous species in the post-mining revegetation area, 3 species were 10 years old, 6 species aged 9 years old, 8 years old 8 species, 7 years old 9 species, 6 years old 9 species, 5 years old 9 species. Types, 4 years old, as many as 4 types, age 3 years, as many as 4 types, and age 2 years, as many as 7 species. The diversity of herbaceous species in post-mining revegetation areas tends to increase in middle age. The diversity of herbaceous species that has even exceeded the number of species in natural forests is vegetation stands aged 8 years (2013), 7 years (2014), 6 years (2015), and 2 years (2019).

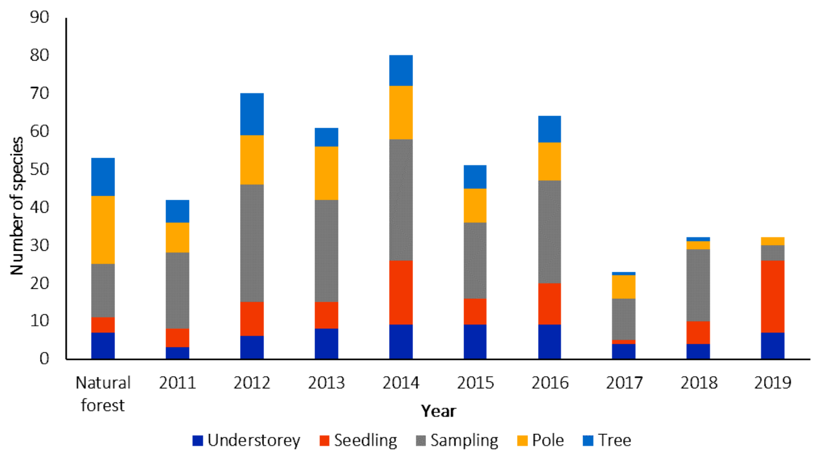

Figure 4. Amount type seen from level structure vegetation

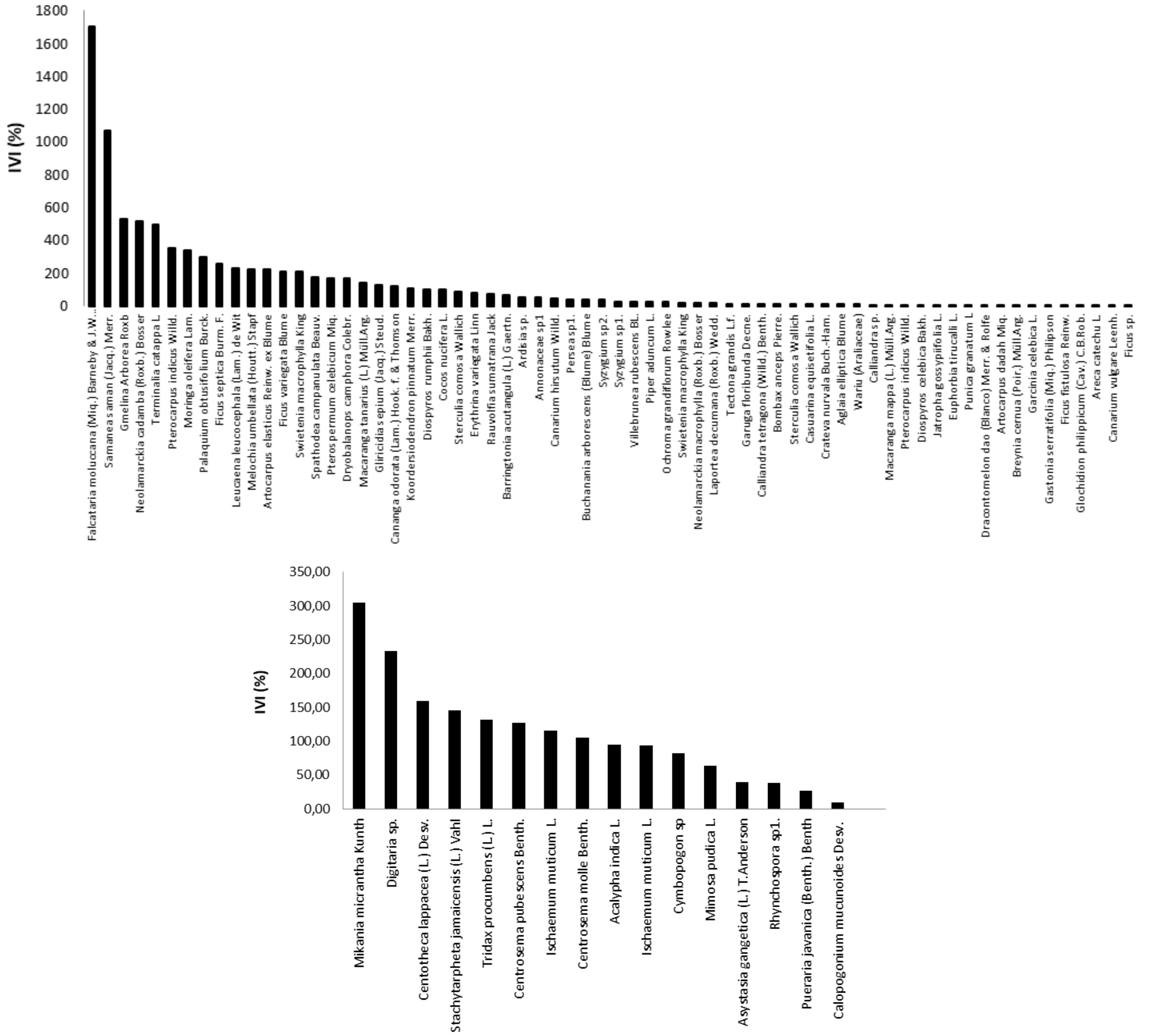

Figure 5. The importance value indices (IVI) of 66 species of tree species (A) and 16 species of herbaceous plants (B) in the revegetation area

With the dominant species appearing, namely *Mikania micrantha*. *Mikania micrantha*, a severe weed, is known as a mile a minute due to its fast and furious growth. Seedlings grow swiftly with a high seed germination rate, and the juvenile period is short, so the time between sowing and reproduction is short. *Mikania micrantha*, for example, has a robust vegetative reproductive potential and can grow into plants from plant remnants of underground rhizomes (Cui et al. 2022). The presence of a soil seed bank, rock concentration, and topsoil composition, proximity to native forest stands that serve as seed sources, availability of seed dispersal animals, tree spacing, age of stands, understorey management, and protection against fire and other nuisance agents are all factors that influence the rate of herbaceous colonization (MacDonald et al. 2015; Nero 2021).

In normal conditions, the long age of revegetation will make the land condition better with an increase in the number of species. But in this study, it was found that those with the highest number of species were 7 years old (2014) instead of the 10-year-old revegetation area (2011). This can occur due to several factors inhibiting the growth site and also other factors so that the diversity of species is not proportional straight with age revegetation. Several factors are the availability of ingredients in organic soil, soil pH conditions, moisture soil, temperature, and intensity of light in each area (Wijana 2014). Besides that, the existence of type tree dominant, the spread of seeds by animals, and man's activities could influence species diversity in each area. The post-mining revegetation area, which has an age of 2 to 10 years, has been planted with 41 types of main vegetation, 7 types of insertion vegetation, and 26 types of vegetation that grow naturally (Table 3). The presence of these new species is certainly greatly influenced by the dispersion of seeds and species adaptation in the revegetation area (Rozendaal et al. 2019). The seed is dispersed to other areas after the seeds or the seedlings are transported by an abiotic component such as wind and water. The plants whose seeds are dispersed by wind are Mikania, Saccharum, and Eleocharis dulcis (LRC 2013; Mani 2013; Tripathi et al. 2012). Natural plants can be affected by the topsoil restoration treatment in this post-gold mining area. Plant species can grow slowly as the topsoil returns to the former coal mine area. If the environment is supportive, they will form a complete individual and even become a forest ecosystem simultaneously (Soendjoto et al. 2015).

Vegetation diversity index in revegetation areas and natural forests

Vegetation analysis through species diversity index, species evenness index, species richness index, and species dominance index in post-mining revegetation areas at 2 years (2019). The tree level does not have an index value because no tree level is found in the area. So the index discussion will explain only the revegetation area at the understorey level to the tree level for the revegetation area aged 3 to 10 years (2011 to 2018), while the index discussion in the revegetation area in 2019 is the understorey level up to the pole level. Altitude, humidity, nutrient availability, lighting, geography, and soil type influence plant diversity and composition (Sofiah et al. 2018).

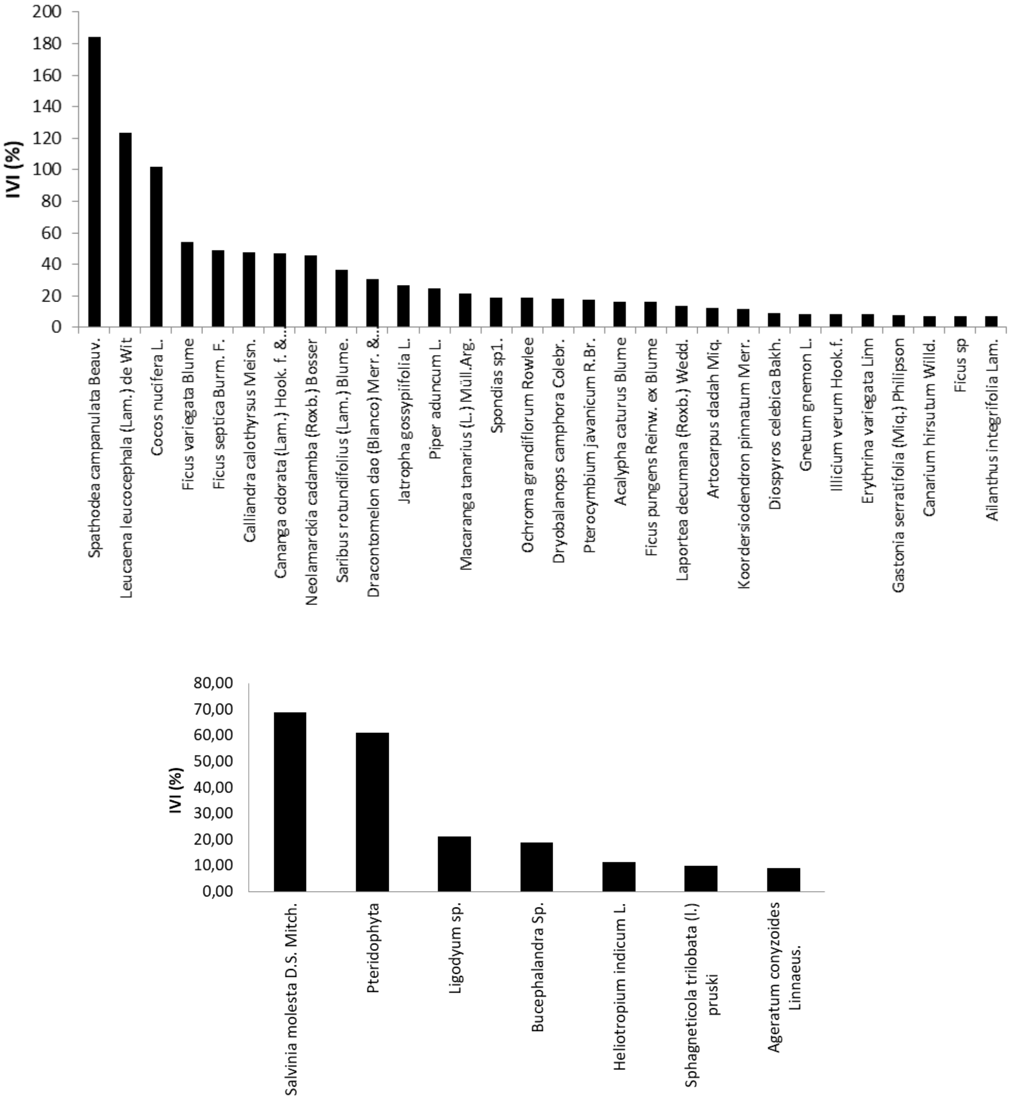

Figure 6. The importance value indices (IVI) of 30 species of tree species (A) and 7 species of herbaceous plants (B) in natural forest

Table 1. Diversity of tree species in natural forest and revegetation area (√ for present or × for absent)

Tree species	Natural forest	Age of revegetation area (year)								
		10	**9**	**8**	**7**	**6**	**5**	**4**	**3**	**2**
Acalypha caturus Blume	√	x	x	x	x	x	x	x	x	x
Annonaceae sp1	x	x	x	√	x	x	x	x	√	x
Jatropha gossypiifolia L.	√	x	x	x	√	x	√	x	x	x
Ardisia sp.	x	√	x	x	x	x	x	x	x	x
Artocarpus dadah Miq.	√	x	√	x	x	x	x	x	x	x
Artocarpus elasticus Reinw. ex Blume	x	x	√	x	x	x	√	√	x	x
Ochroma grandiflorum Rowlee	√	√	√	√	√	x	x	x	√	x
Barringtonia acutangula (L.) Gaertn.	x	√	√	√	x	x	x	x	√	x
Bombax anceps Pierre.	x	x	x	x	√	√	x	x	x	x
Breynia cernua (Poir.) Müll.Arg.	x	x	√	x	x	x	x	x	x	x
Buchanania arborescens (Blume) Blume	x	√	x	x	x	x	x	x	x	x
Calliandra calothyrsus Meisn.	√	x	x	x	x	x	x	x	x	x
Calliandra sp.	x	√	x	x	x	x	x	x	x	x
Calliandra tetragona (Willd.) Benth.	x	x	x	√	√	x	x	x	x	x
Cananga odorata (Lam.) Hook. f. & Thomson	√	√	√	√	√	x	√	√	√	√
Canarium hirsutum Willd.	√	√	x	x	√	x	x	x	x	x
Canarium vulgare Leenh.	x	x	x	x	√	x	x	x	x	x
Cocos nucifera L.	√	x	x	x	x	x	x	x	x	x
Crateva nurvala Buch.-Ham.	x	√	√	x	x	x	x	x	x	x
Diospyros celebica Bakh.	√	x	√	x	x	x	√	x	x	x
Diospyros rumphii Bakh.	x	x	x	x	√	√	x	x	x	x
Dracontomelon dao (Blanco) Merr. & Rolfe	√	x	x	x	x	x	x	x	x	x
Dryobalanops camphora Colebr.	√	√	√	√	√	√	√	x	√	x
Erythrina variegata Linn	√	x	√	x	√	√	x	x	x	x
Euphorbia tirucalli L.	x	x	x	x	x	√	x	x	x	x
Falcataria moluccana (Miq.) Barneby & J.W. Grimes	x	√	√	√	√	√	√	x	√	√
Ficus fistulosa Reinw.	x	x	x	x	x	x	√	x	x	x
Ficus pungens Reinw. ex Blume	√	x	x	x	x	x	x	x	x	x
Ficus septica Burm. F.	√	√	√	√	√	√	√	√	√	x
Ficus sp.	√	x	x	x	√	x	x	x	x	x
Ficus variegata Blume	√	√	√	x	√	√	√	√	√	√
Garcinia celebica L.	x	x	√	x	x	x	x	x	x	x
Garuga floribunda Decne.	x	x	x	√	x	x	x	x	√	√
Gastonia serratifolia (Miq.) Philipson	√	x	√	x	x	x	x	x	x	x
Gliricidia sepium (Jacq.) Steud.	x	x	x	√	√	√	x	x	√	x
Glochidion philippicum (Cav.) C.B.Rob.	x	x	x	x	x	x	√	x	x	x
Gmelina Arborea Roxb	x	x	√	√	√	x	√	√	√	√
Gnetum gnemon L.	√	x	x	x	x	x	x	x	x	x
Illicium verum Hook.f.	√	x	x	x	x	x	x	x	x	x
Spathodea campanulata Beauv.	√	√	√	√	√	√	√	x	√	√
Koordersiodendron pinnatum Merr.	√	√	x	x	√	x	x	x	√	√
Laportea decumana (Roxb.) Wedd.	√	x	√	x	x	x	x	x	x	x
Leucaena leucocephala (Lam.) de Wit	√	√	√	√	√	√	√	x	√	√
Macaranga mappa (L.) Müll.Arg.	x	√	x	x	x	x	x	x	x	x
Macaranga tanarius (L.) Müll.Arg.	√	√	√	√	√	√	√	√	√	√
Cocos nucifera L.	x	x	√	√	√	√	√	x	x	√
Melochia umbellata (Houtt.) Stapf	x	x	√	√	√	√	√	√	√	√
Casuarina equisetifolia L.	x	x	√	√	x	√	x	x	x	x
Areca catechu L.	x	x	x	x	x	x	√	x	x	x
Neolamarckia cadamba (Roxb.) Bosser	√	x	√	√	√	√	√	√	√	√
Neolamarckia macrophylla (Roxb.) Bosser	x	x	x	√	√	x	√	x	x	x
Palaquium obtusifolium Burck.	x	√	√	√	x	√	√	x	√	√
Aglaia elliptica Blume	x	x	x	x	x	x	x	x	√	x
Persea sp1.	x	√	√	x	√	√	√	x	x	x
Piper aduncum L.	√	√	√	√	√	x	√	x	x	x
Punica granatum L	x	x	x	x	x	√	x	x	x	x
Pterocarpus indicus Willd.	x	x	√	√	√	√	√	√	√	√
Pterocymbium javanicum R.Br.	√	x	x	x	x	x	x	x	x	x
Pterospermum celebicum Miq.	x	x	√	√	√	x	√	√	x	√
Dracontomelon dao (Blanco) Merr. & Rolfe)	√	x	x	√	x	x	x	x	x	x
Rauvolfia sumatrana Jack	x	√	x	√	√	x	√	x	x	√
Moringa oleifera Lam.	x	√	x	√	√	√	√	x	√	x
Samanea saman (Jacq.) Merr.	x	x	√	x	√	√	√	√	x	√
Saribus rotundifolius (Lam.) Blume.	√	x	x	x	x	x	x	x	x	x
Pterocarpus indicus Willd.	x	x	x	√	√	x	x	x	x	x
Spondias sp1.	√	x	x	x	x	x	x	x	x	x
Sterculia comosa Wallich	x	√	√	√	√	x	x	x	x	x
Swietenia macrophylla King	x	√	√	√	√	x	x	x	x	x
Syzygium sp1.	x	x	√	x	x	x	x	x	x	x
Syzygium sp2.	x	x	x	√	x	x	x	x	x	x
Tectona grandis L.f.	x	x	x	√	x	x	x	x	x	x
Terminalia catappa L.	x	√	√	√	√	√	√	x	√	√
Villebrunea rubescens BL.	x	x	x	√	x	x	x	x	x	x
Ailanthus integrifolia Lam.	√	x	√	x	x	x	x	x	x	√
Total	31	25	35	33	35	23	28	11	22	19

Table 2. Diversity of herbaceous in natural forest and revegetation area (√ for present or × for absent)

Herbaceous	Natural forest	Age of revegetation area (year)								
		10	**9**	**8**	**7**	**6**	**5**	**4**	**3**	**2**
Acalypha indica L.	x	x	x	√	x	x	x	x	√	x
Asystasia gangetica (L.) T.Anderson	x	x	x	√	√	√	x	x	x	x
Calopogonium mucunoides Desv.	x	x	x	x	√	x	x	x	x	x
Centotheca lappacea (L.) Desv.	x	√	√	x	√	x	x	x	x	x
Centrosema molle Benth.	x	x	√	√	x	√	√	x	x	√
Centrosema pubescens Benth.	x	x	√	x	√	√	√	x	x	√
Cymbopogon sp.	x	x	x	x	x	x	x	x	√	x
Digitaria sp.	x	x	√	√	√	√	√	√	x	√
Heliotropium indicum L.	√	x	x	x	x	x	x	x	x	x
Ischaemum muticum L.	x	√	x	x	x	√	√	x	x	x
Ligodyum sp.	√	x	x	x	x	x	x	x	x	x
Mikania micrantha Kunth	x	√	√	√	√	√	√	√	x	√
Mimosa pudica L.	x	x	x	√	√	√	x	x	x	√
Pteridophyta	√	x	x	x	x	x	x	x	x	x
Pueraria javanica (Benth.) Benth	x	x	x	√	x	x	x	x	x	x
Salvinia molesta D.S. Mitch.	√	x	x	x	x	x	x	x	x	x
Rhynchospora sp1.	x	x	x	x	x	x	x	x	√	x
Ageratum conyzoides Linnaeus.	√	x	x	x	x	x	x	x	x	x
Bucephalandra Sp.	√	x	x	x	x	x	x	x	x	x
Sphagneticola trilobata (l.) pruski	√	x	x	x	x	x	x	x	x	x
Stachytarpheta jamaicensis (L.) Vahl	x	x	x	√	√	√	√	√	√	√
Tridax procumbens (L.) L.	x	x	√	x	√	√	√	√	x	√
Total	7	3	6	8	9	9	7	4	4	7

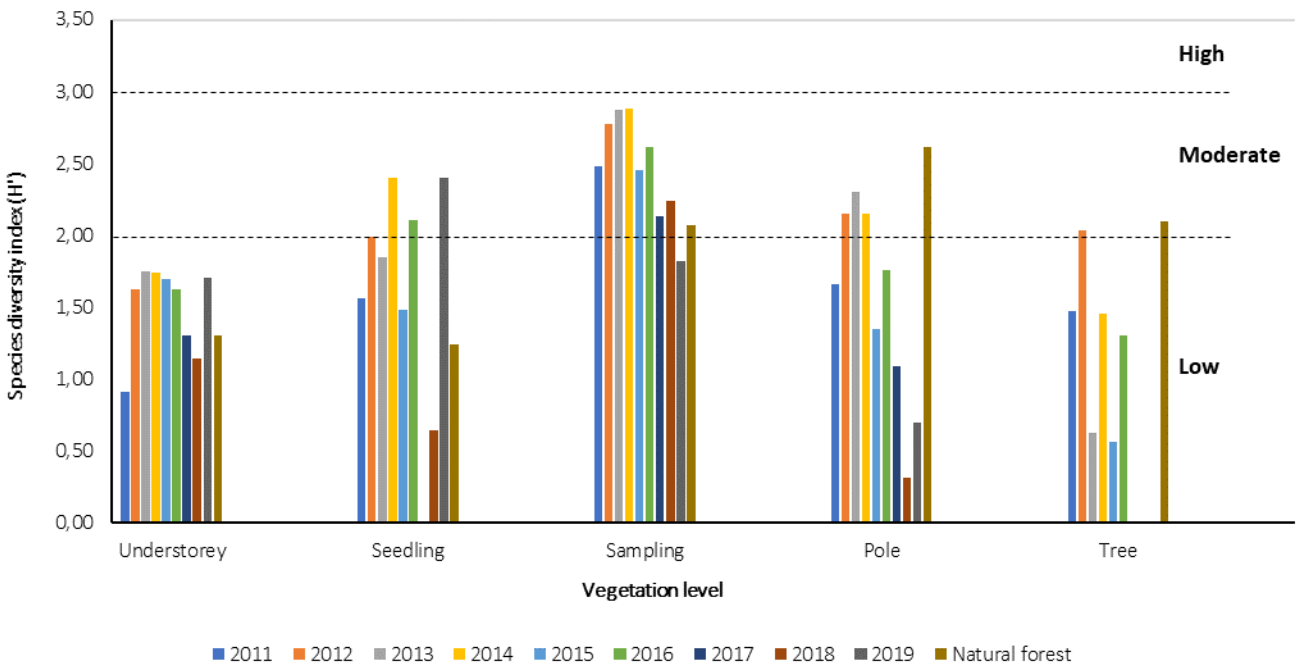

Figure 7. Chart Index Diversity Types of (H') Vegetation in various revegetation levels and areas 2011 to 2019 and the forest natural

Species diversity can measure community stability, namely the ability of a community to keep itself stable despite disturbances to its components. Species diversity in the revegetation area and natural forest has an index value classified as low to moderate. At the sapling level, almost all areas have a moderate category. These results can mean that species diversity occurs at the sapling level. The area with species diversity is close to a natural forest, namely the 9-year-old post-mining revegetation area (2012). The longer the revegetation age is not followed, the greater the value of the species diversity index, but the 8 and 7 years revegetation age has a higher index than the vegetation in other revegetation areas; this is especially evident at the sapling level (Figure 7). The large value of this species diversity index indicates that the stability of the community is getting better. The diversity positively impacts better microclimate and improves soil quality (Yuningsih et al. 2021).

Table 3. Main, natural, and intercropped vegetation data in various revegetation areas from 2011 to 2019

Scientific name	Local name
Natural vegetation	
Jatropha gossypiifolia L.	Arang merah
Glochidion philippicum (Cav.) C.B.Rob.	Arang putih
Ardisia sp.	Ardisia
Ochroma grandiflorum Rowlee	Balawirang
Crateva nurvala Buch.-Ham.	Balontang
Macaranga mappa (L.) Müll.Arg.	Binunga besar
Macaranga tanarius (L.) Müll.Arg.	Binunga kecil
Ficus sp.	Ficus
Illicium verum Hook.f.	Kalawatan
Calliandra sp.	Kaliandra
Ficus racemosa L.	Kayu ara
Melochia umbellata (Houtt.) Stapf	Kayu bintang
Spathodea campanulata Beauv.	Kayu bunga
Dryobalanops camphora Colebr.	Kayu kapur
Leucaena leucocephala (Lam.) de Wit	Lamtoro
Cocos nucifera L.	Mapanget
Casuarina equisetifolia L.	Monalawiran
Areca catechu L.	Monang
Aglaia elliptica Blume	Paopao
Euphorbia tirucalli L.	Patah tulang
Punica granatum L	Pomas
Moringa oleifera Lam.	Rupu
Villebrunea rubescens BL.	Sasoro
Pterocarpus indicus Willd.	Soso
Laportea decumana (Roxb.) Wedd.	Sosoro
Gastonia serratifolia (Miq.) Philipson	Titolang
Main vegetation	
Pterocarpus indicus Willd.	Angsana
Syzygium sp1.	Bombongan
Buchanania arborescens (Blume) Blume	Popohan
Koordersiodendron pinnatum Merr.	Bugis
Ficus variegata Blume	Coro
Gliricidia sepium (Jacq.) Steud.	Gamal
Gmelina Arborea Roxb	Gmelina
Syzygium sp2.	Gora hutan
Neolamarckia macrophylla (Roxb.) Bosser	Jabon merah
Neolamarckia cadamba (Roxb.) Bosser	Jabon putih
Tectona grandis L.f.	Jati
Calliandra tetragona (Willd.) Benth.	Kaliandra putih
Bombax anceps Pierre.	Kapuk hutan
Diospyros celebica Bakh.	Kayu arang
Melochia umbellata (Houtt.) Stapf	Kayu bintang
Diospyros rumphii Bakh.	Kayu hitam
Garuga floribunda Decne.	Kayu kambing
Piper aduncum L.	Kayu sirih
Rauvolfia sumatrana Jack	Kayu telur
Cananga odorata (Lam.) Hook. f. & Thomson	Kenanga
Canarium hirsutum Willd.	Kenari
Canarium vulgare Leenh.	Kenari hutan
Terminalia catappa L.	Ketapang
Leucaena leucocephala (Lam.) de Wit	Lamtoro
Swietenia macrophylla King	Mahoni
Garcinia celebica L.	Manggis hutan
Artocarpus dadah Miq.	Maumbi
Sterculia comosa Wallich	Momas
Breynia cernua (Poir.) Müll.Arg.	Nanamuhang
Palaquium obtusifolium Burck.	Nantu
Persea sp1.	Pemuli
Dracontomelon dao (Blanco) Merr. & Rolfe	Rao
Barringtonia acutangula (L.) Gaertn.	Salengse
Falcataria moluccana (Miq.) Barneby & J.W. Grimes	Sengon
Ficus septica Burm. F.	Tagalolo
Artocarpus elasticus Reinw. ex Blume	Teep
Samanea saman (Jacq.) Merr.	Trembesi
Annonaceae sp1	Wakan
Erythrina variegata Linn	Walantakan
Ailanthus integrifolia Lam.	Wariu
Pterospermum celebicum Miq.	Wolo
Insertion vegetation	
Ficus variegata Blume	Coro
Cananga odorata (Lam.) Hook. f. & Thomson	Kenanga
Terminalia catappa L.	Ketapang
Swietenia macrophylla King	Mahoni
Sterculia comosa Wallich	Momas
Palaquium obtusifolium Burck.	Nantu
Ficus septica Burm. F.	Tagalolo

The results of the analysis show that the vegetation structure in the post-gold mining revegetation area aged 3 to 10 years (2011 to 2018) has complete vegetation levels (saplings, saplings, poles, and trees); stands in the post-mining land revegetation area of 2 years (2019) tree-level vegetation has not been found. Overall conditions in this revegetation area have a more diverse number of species, namely 66 woody plant species, and 16 herbaceous plants, compared to the natural forest, which only has 30 woody plant species and 7 herbaceous plant species. The longer the age of revegetation is not followed by an increase in species and an increase in the value of species diversity. However, it is still better than revegetation at a young age and has approached the condition of natural forest. The revegetation area aged 9, 8, and 7 years (2013 and 2014) has a higher number of species than natural forest and other revegetation areas.

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