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PREFACE

Continuing The 1st International Conference on Biodiversity in 2011 that was held in Solo, The Society For Indonesian Biodiversity proudly held The 2nd International Conference on Biodiversity which was focus on issues related to "Significance of Climate Change on Biodiversity in Sustaining The Globe. This conference has attracted significant numbers of participants from scientist, government agencies, NGO, and other experts from 5 different countries (Australia, New Zealand, United Sates of America, Malaysia, and Indonesia). This event was expected to promote innovations in the real research on biodiversity to tackle biodiversity loss that rapidly occured in our life.

The proceeding is the continuation of the 1st proceeding issued by the Society for Indonesian Biodiversity. The proceeding contain all oral and poster presented on the 2nd ICB 2012 in Lombok, Indonesia. Papers presented in this proceeding comprised wide ranges of issues regarding climate change impacts of agriculural and forestry biodiversity, fresh water, coastal and marine diversity, as well as economic and community biodiversity.

On behalf of The Society for Indonesian Biodiversity, we would like to thank to all authors, paper reviewers, editorial team, organizing commitee, local government, and sponsors for their contribution and involment in this conference.

Mataram, July 2013

Sutarno
Chairman of the Society for Indonesian Biodiversity

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POSTER :

THE RECOVERY OF PLANT SPECIES DIVERSITY IN 14 YEAR-OLD FOREST IN REHABILITATED MINED LAND IN CENTRAL BENGKULU

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ABSTRACT

Coal mining in Indonesia has not only caused carbon emission into the atmosphere, but also drastically changed forest ecosystems rich in biodiversity into degraded lands. The mining companies are required by the government to rehabilitate the degraded mined land. Most companies use fast growing species to revegetate the mined land, resulting in a single or few species forest stand. But if the rehabilitated land is left undisturbed, natural succession will finally return the vegetation into its original forest type. The objective of this study was to know the species composition of a 14-year-old vegetation growing in mined land revegetated with *Acacia mangium.* The results showed that after 14 years, the forest had 3 species of trees, 13 species of shrub and saplings, and 16 species of herbs and seedlings. The highest important values were *A. mangium* for trees, *Leea aequata* for saplings dan shrub, and *Wedelia trilobata* for herbs and seedlings. No saplings and seedlings of *A. mangium* were found, indicating that *A. mangium* failed to regenerate. Sorensen Index of similarity in species composition of shrub and trees between this14-year old forest and natural forest was only 6.4%, but the index was higher between this forest and the secondary forest, namely 38.7%. The results indicate that although the land was planted with a single species, *A. mangium*, natural succession has increased the plant diversity, and in the future *A. mangium* will be replaced by diverse native species, which are now in the stages of saplings and seedlings.

Keywords: mined soil reclamation, biodiversity recovery, succession, Central Bengkulu.

INTRODUCTION

As of 2011, Indonesia ranks 7th as the biggest coal producer in the world, with a total production of 176 million tons (World Coal Association, 2012). While it is a source of revenue to the nation, coal mining in Indonesia, however, has become an important environmental issue because it has converted a lot of forest areas into degraded ecosystems. Mined soil generally has physical, chemical and biological properties not suitable for plant growth (Bradshaw, 1997). The sulfur content in coal may result in acidification of soil, which in turn increases soluble Mn, Fe, Al, and Zn in soil which are toxic to plants (Lottermosser, 2010). The use of heavy equipments has caused soil compaction which results in decrease of soil porosity, permeability, and water holding capacity (Bussler et al, 1984). Mined land needs to be rehabilitated before the land can be used for end use (Bradshaw, 1997, Lottermosser, 2010).

The degraded forest ecosystem, theoretically, will return to its original condition through succession. In practice, however, human intervention must frequently be done to speed up the recovery of the damaged ecosystem. The more degraded an ecosystem, the more extensive intervention is needed (Hobbs and Cramer 2008). The ministry of energy and mineral resources of Republic of Indonesia has stipulated that mined lands must be reclaimed so that they can function adequately for the designated land use (Minister of Energy and Mineral Resources, 2008). When the mined land is in the forest area, the companies must also follow the guidance from the Ministry of Forestry on the reclamation of disturbed forest (Minister of Forestry, 2011). The Minister of Forestry guide for forest reclamation states that the degraded forest must initially be planted with cover crops to prevent erosion, followed by pioneer trees to improve soil nutrient. Finally, the forested land must be enriched with species of trees in accordance with the end use and the forest area category.

Both the Minister of Forestry's and the Minister of Energy and Mineral Sources' regulations, however, do not give specific criteria for the success of reclamation, especially from ecological point of view. Internationally, the Society of Ecological Restoration (SER) gives nine ecosystem attributes as the criteria of restoration success as follow (Clewell and Aronson, 2007): (1) The restored ecosystem must have similar diversity and community structure in comparison with reference sites; (2) Indigenous species must be present in the area; (3) It must have functional groups necessary for long-term stability; (4) It must have the capacity of the physical environment to sustain reproducing populations; (5) It must be able to function normally in accordance with its development; (6) It must be integrated with the landscape, enabling energy and nurrient flow with adjacent ecosystems; (7) It must be free from potential threats to the ecosystem health and integrity. (8) It must have high resilience to natural disturbances; and (9) It must be self-sustaining. Most studies on ecosystem restoration, however, did not measure all the nine criteria of the Society of Ecological Restoration (Ruiz-Jaen, and Aide, 2005). Most studies included at least one measure in each of three general categories of the ecosystem attributes: diversity, vegetation structure, and ecological processes.

Restoration ecologists have different opinions on the reference ecosystem toward which ecological restoration has to be directed (van Andel and Aronson, 2006). The practical approach is to use adjacent natural communities as the reference ecosystem. Comparison of species composition of the rehabilitated mined land and natural communities nearby can be done to evaluate the success of restoration (Herath *et al*, 2009).

The objectives of this study were to know the diversity of 14 year- old forest in rehabilitated mined land and to determine the similarity in species composition between the 14 year-old forest and natural forests.

MATERIALS AND METHODS

Site

The study was conducted in 14-year old forest growing in rehabilitated mined land under the management of PT Danau Mas Hitam, a coal mining company, in Taba Penanjung Village, Central Bengkulu District. The study site is 300-315 m above sea level. The topography of the study area was gently sloping, less than 10%. The site has wet climate with an average annual rainfall of 3,485 mm. The field work was done in January and February, 2011.

Sampling method

Vegetation was classified into three levels or categories. Tree was defined as any woody plant with diameter at breast height (130 cm) $\geq$ 10 cm, and height > 4m. Sapling and shrub was any woody plant with a diameter at breast height from 2.5 cm to 9 cm, and height from 2 to 4 m. Ground cover consisted of herbs and seedlings with height < 2m. The sizes of quadrats for tree, shrub and groundcover were 10m x 10 m, 4m x 4m and 1m x 1m respectively. Eleven lines of transect were made across contour lines. In each line two quadrats for trees were made, 20 m apart. Within each tree quadrat, a 4mx4m was made, and within this 4 m x 4 m quadrat, a 1 m x 1m plot was made. For tree and shrub categories, the names, diameter of each plant were recorded. For groundcover category, the name of each plant was recorded, and then every plant was cut separately for biomass measurement. The samples of groundcover were oven dried at a temperature of 105°C for several days to get constant weight.

Identification of plants was done at the Herbarium of University of Bengkulu. Unidentified species were sent to Indonesian Science Institute (Lembaga Ilmu Pengetahuan Indonesia, LIPI) for species determination. Secondary data of trees, saplings and shrubs of natural forest were taken from Ritonga (2009), while those of secondary forest were taken from Suhartoyo et al (2012). Secondary data of groundcover of natural forests were taken from Setiawan (1998).

From the study area two composite samples of soil from the depth of 1-20 cm were taken. The first sample was taken from the upper slope, and the second sample from the lower slope.

Data analyses

Plant data were analyzed to find the importance value index for each species, the Shannon-Wiener diversity index of the community, and Sorensen similarity indexes

between the 15-year-old forest and natural forest, and between the 15-year old forest and secondary forest. Formulae were taken from Müeler-Dombois and Ellernberg (1974).
Importance value index = relative frequency + relative density + relative dominance
For tree and shrub categories, dominance was determined using basal area, while for groundcover dominance was determined from biomass.
Shannon-Wiener diversity index:

$$H = -\sum_{i=1}^{s} (pi)(\log\ pi)$$

Where, H = diversity index
S = number of species
pi = Proportion of species i
pi = ni/N = (number of individual of species/total individual of all species).
Sørensen index of similarity

$$= IS_S = \frac{2c}{A+B} \times 100\ \%$$

c = common species (found in community A and community B)
A = number of all species found in communityA
B = number of all species found in B
Soil samples were analyzed for pH, N, P, K, C organic, particle density, porosity and texture.

RESULTS AND DISCUSSION

Diversity of plants

The species richness of plants was the highest at groundcover category, followed by shrub or sapling category and finally the tree category. At the tree category, only three species from two families were found (Table 1), and *Acacia mangium* was the most dominant because the mined land was deliberately planted with this species. *A. mangium* is one of the pioneer species used in Indonesia for mined land revegetation (Suhartoyo et al, 2012). Two other species were also found in the study area, namely *Acacaia auriculiformis* and *Mallotus paniculatus*. *Acacia auriculiformis* is not indigenous species, so it might be accidentally brought to this area during the plantation of *A. mangium*. *Mallotus paniculatus* is shrub or small tree, up to 10 m tall. It is a pioneer species found mostly in open or disturbed sites (http://www.asianplant.net/), but it can also be found in primary forest (Becker and van den Brink, 1963).

Thirteen species from nine families were found at shrubs or saplings level (Table 2). Four species with high importance values belong to Euphorbiaceae. Each of the other families had only one species. All species of shrubs or saplings grow naturally in the area. They are the pioneer species. *Leea aequata* had the highest importance value followed by *Mallotus paniculatus*. *Leea aequata* is a shrub or small tree which grows naturally in forest, hedges or village groves (Backer and van den Brink, 1965). The presence of indigenous species of saplings and shrub which eventually replace the *A mangium* species indicated that the second criterion of restoration success according to SER (Clewell and Aronson, 2007) was met.

Sixteen species from seven families of groundcover were found (Table 3). Asteraceae consisted of four species, Fabaceae three species and Poaceae also three species. *Wedelia trilobata* was the most dominant species of groundcover. Wedelia is an invasive alien species. It is distributed widely around the world and has become weed. Other species of groundcover are pioneer species that have ruderal strategy (Grime, 1979). These species are capable of invading open area and growing relatively fast. Prawito (2009) has found that *Wedelia trilobata, Melastoma malabathricum* can increase soil fertility in mined land in Central Bengkulu.

Table 1. The species composition of 14-year old forest in rehabilitated mined land and the importance value index (IVI) of each species at tree category.

Species	Family	Relative Dominance (%)	Relative Density (%)	Relative Frequency (%)	IVI
Acacia mangium Willd.	Fabaceae (Leguminosae)	98.84	97.47	91.67	287.98
Acacia auriculiformis Cunn. ex Benth.	Fabaceae (Leguminosae)	0.82	1.27	4.17	6.25
Mallotus paniculatus (Lam)M.A.	Euphorbiaceae	0.33	1.27	4.17	5.77

Table 4. Shannon-Wiener diversity index (H) of 14-year old forest in rehabilitated land at tree, sapling/shrub and ground cover categories.

Category	Diversity index (H)
Tree	0.06
Sapling or shrub	1.01
Ground cover	1.1

Species composition similarity with the reference sites and succession. The first of nine criteria for the success of restoration by SER is similarity in species composition between the restored site and the reference site (Clewell and Aronson, 2007). Compared with natural old forest nearby, the similarity indexes were still very low (<10%) both for groundcover as well as for shrub and tree category (Table 5). However the indexes increased when comparison was made between the study area and the secondary forest. At shrub and tree category, the index was 38.7%, meaning that almost 40% of the species composition between the two forests was the same. The similarity index shows that natural succession in this rehabilitated mined land has brought the originally single-species plantation forest closer to young secondary forest consisting of many species.

Table 5. Sørensen index of similarity (IS_S) between 14-year-old forest in rehabilitated land and natural old forest.

Category	ISs (%)
Tree and sapling/shrub	6,45
Ground cover	2,78

At this time, the first success criteria of SER (similarity in species composition with reference site) has not been met by the 14-year old forest stand, but as natural succession is still continuing, in the future, the first criteria will likely be met. Fourteen years old is too short for the mined land to return to its original species composition. In Western Australia, the species composition of vegetation after 14 years of rehabilitated bauxite mined site was still different from that of the unmined forest (Norman, et al., 2006). In South Sumatera, the tree composition of the 16-year old forest in rehabilitated coal mined land was not similar to the secondary forest nearby (Suhartoyo et al, 2012).

How long the rehabilitated mined land will return to its original species composition depends on the soil conditions, which vary from one mined land to another. If the mined land is severely degraded and the surface soil materials consist of overburden brought from material deep under the ground without any propagule in it, then succession in this extreme site is categorized as primary succession (Wali and Freeman, 1973), which proceeds very slowly. The primary succession pattern follows the Relay Floristic model of Egler (1954) or the Facilitation Model of Connel and Slatyer (1977). But, if the surface soil materials contain topsoil, are seeded and fertilized, then the succession in this less extreme site is categorized as secondary succession (Wali, 1987) which proceeds relatively faster. The secondary succession pattern follows the Initial Floristic Composition model of Egler (1954) or Tolerance model of Connel and Slatyer (1977). In rehabilitated bauxite mined land in Australia, the succession followed the Initial Floristic Composisiton model (Norman et al, 2006). In Texas, US, natural succession in coal mine spoils followed all models of succession (Skousen et al, 1988).

Because the conditions of mined land vary, the types of intervention do too. At the extreme site, fundamental human intervention is required, but at the less extreme site, only minor intervention is needed. Hobbs and Cramer (2008) and Prach and Hobbs (2008) suggested that, whenever possible, ecological restoration should rely on natural succession with little human intervention, because it is the cheapest method of restoration.

Table 6. Sørensen index of similarity between 14-year-old forest in rehabilitated land and young secondary forest.

Category	ISs (%)
Tree and sapling/shrub	38,71
Ground cover	20

Table 7. Soil properties of the 14-year old forest in rehabilitated mined land.

Samples	pH	C	N	P_2O_5	Exch-K	PD	BD		Texture	
	(H_20)	%	Ppm	meq/100g	g/cm^3	Sand (%)	Silt (%)		Clay (%)	
1	4.4	5.13	0.25	2.23	0.48	2.16	1.02	65.87	20.14	13[illegible]
2	4.2	5.07	0.2	4.02	0.63	2	0.93	72.43	15.77	11[illegible]
Mean	4.3	5.1	0.225	3.125	0.555	2.08	0.975	69.15	17.955	12.[illegible]

Note: Exch= exchangeable; PD = particle density; BD = bulk density

Soil properties

The success of terrestrial ecosystem restoration is based on the plant-soil interaction. Soil conditions affect plant performance and community species composition, while species composition can influence many aspects of soil structure and function (Eviner and Hawkis, 2008). Based on the results of soil tests (Table 7), the soil in the 14-year old forest was categorized as very acidic and had low phosphorus, medium nitrogen, medium to high carbon, and medium to high potassium (Landon, 1984). The site was not extremely poor in term of chemical properties. Some mine soils are extremely acidic and need to be ameliorated with lime before revegetation (Vogel, 1981; Bradshaw, 1997).

The soil texture was sandy loam and the particle density and bulk density (Table 7) were considered normal (Landon, 1984), meaning that the soil was not highly compacted. In some rehabilitated mine soils, the use of heavy machinery during the grading of soil to approximate original contour has caused compaction of soil which impedes the penetration of roots into the soil (Bussler et al, 1984; Powell et al, 1986; Bradshaw, 1997).

The result of soil tests for mine soil, however, must be interpreted cautiously. By definition, soil consist of decomposed rock material particles ≤ 2.0 mm in diameter, whereas the land surface material in mine land consist of a great fraction of particles larger than 2.0 mm in diameter. The particles that do not pass the 2.0-mm sieve are not tested. The soil tests, therefore, only reveals the soil properties of a portion of plant growth medium in mined land.

CONCLUSION

After 14 years, the originally homogenous *Acacia mangium* plantation in rehabilitated mined land has turned into heterogeneous forest composed of moderately diverse species especially at shrub, sapling and ground cover levels. Indigenous species have invaded the forest through natural succession. As the *Acacia mangium* fail to regenerate, in the future the forest will likely to return to its original species composition provided that it is not disturbed.

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