Final Project Report (to be submitted by 30th September 2016)

Instructions:

- Document length: maximum 10 pages, excluding this cover page and the last page on project tags.
- Start with an abstract (max 1 page).
- Final report text: Do not forget to mention your methodology; the people involved (who, how many, what organization they are from – if applicable); and the expected added value for biodiversity, society and the company. Finally, state whether the results of your project can be implemented at a later stage, and please mention the ideal timing and estimated costs of implementation.
- Annexes are allowed but will not be taken into account by the jury and must be sent separately.
- Word/PDF Final Report files must be less than 10 MB.
- If you choose to submit your final report in your local language, you are required to also upload your final report in English if you wish to take part in the international competition.
- To be validated, your file must be uploaded to the Quarry Life Award website before **30th September 2016** (midnight, Central European Time). To do so, please log in, click on 'My account'/ 'My Final report'.
- In case of questions, please liaise with your national coordinator.

1. Contestant profile

▪ Contestant name:	**Hafsah Ainu Zakhrof**
▪ Contestant occupation:	Indonesia
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▪ Number of people in your team:	**5**

2. Project overview

Title:	Study of Soil Arthropods and Earthworm Diversity as Bioindicator for Reclamation Success
Contest:	Indonesia
Quarry name:	Hambalang Quarry
Prize category: (select all appropriate)	☐Education and Raising Awareness ☒ Habitat and Species Research ☐Biodiversity Management ☐Student Project ☐Beyond Quarry Borders

Abstract

The process of mining causes the loss of biotic and abiotic components in a potential site containing mining materials. The goal of reclamation is to restore productivity and function of an ecosystem in a previously mined site. However, often times the success of reclamation is solely measured on the growth percentage of the planted vegetation. One of the important parameters that can indicate the success of reclamation is the occurrence and rise of habitat complexity indicated by two bio indicators, arthropods and earthworms. The purpose of this project is to analyze arthropod and earthworm diversity as a bio indicator for the rise of habitat complexity as a parameter for reclamation success in a mined site. Soil arthropods were sampled using pitfall traps placed proportionally in 19 sites categorized as four land uses (cassava fields, mixed forest, mahogany stands, rice paddies) located in seven reclaimed areas along with two reference sites. Meanwhile earthworms were sampled three times in each of the 19 sites by digging holes with dimensions of 30x 30x20 m3. Habitat complexity was measured in circular plots measuring 0,1 ha where parameters of vegetation structure was measured. Diversity was analyzed by using species richness, species abundance, and Shannon-Wiener’s index of diversity.. Sites categorized as mahogany stands and mixed forests had the highest levels of species abundance and species richness. More specifically the mahogany stand located in the 2004A reclamation site had the most complex habitat along with the highest levels of species richness and abundance. Spearman’s correlation test showed that there was a strong correlation between habitat complexity and species richness and abundance

Keywords : Soil arthropods, earthworm, habitat complexity, mining raclamation, sandy clay quarry

Introduction

Mining is considered to be responsible for major environmental degradation around the word, and despite being localized, mining is responsible for drastic changes in the landscape as a result of the exploration process (Ribas, et al., 2011). Soil arthropods represent a large portion of tropical biodiversity and hold important functions in the ecosystem, but little is known about the efficacy of different recovery strategies in facilitating their recovery in degraded habitats (Cole, Holl, Zahawi, Wickey, & Townsend, 2016). Arthropods occupy the widest diversity of microhabitats and niches, and play more ecological roles, than any other group of animals (Longcore, 2003). Their small size makes them efficient monitors of subtle yet important variations that may influence the quality of a habitat. Many researchers have assessed habitat quality and measured habitat differences using arthropods (e.g. Niemelä, *et al.*, 1993; Pollet & Grootaert, 1996; Gibb & Hochuli, 2002). Among the indicator organisms that provide useful information for monitoring rehabilitation practices, insects have been pointed out as potential bioindicators (McGoech, 1998) because they are very abundant and sensitive to environmental changes.

Single families, such as ants, have been identified as indicators of ecosystem recovery, and have been used extensively in the assessment of restoration and reclamation attempts (Majer, 1983; Majer, 1984; Parmenter, MacMahon, & Gilbert, 1991; Holl, 1995; Andersen A. N., 1997; Andersen & Sparling, 1997).

Relatively short generation of invertebrates allows them to respond rapidly to changes in the environment, whereas relatively poor ability to disperse generally hampers recolonization (Mattoni et al. 2000). These characteristics support soil invertebrates for use as indicators of an ecological disturbance such as mining.

Objective

To identify the correlation between soil arthropod and earthworm diversity with habitat complexity as an indicator for reclamation success in the sandy clay quarry of PT Indocement Tunggal Prakarsa

Material and Methods

3.1 Study Area

This study was carried out in the reclamation sites of the Hambalang Sandyclay Quarry. The quarry is located in Citereup, West Java province. The study site is located at heights of between 175-630 meters above sea level with an average anual rainfall of 290 mm/year with average temperatures of 21.31-30.76 degrees celsius.

The study was conducted in five different reclamation sites with variating sizes (Figure 3.1). These reclamation sites contained different land uses, among them were *Manihot esculenta* fields (ME), mixed forests (MF), *Swietenia mahagoni* stands (SM), and rice fields (RF). Studies were also conducted on two different reference sites which functioned as comparisons for the reclamation sites. The first reference site was a rubber plantation, *Hevea brasiliensis* planted during the 1960s (HB) and found outside of the quarry but assumed as part of the original ecosystem which was a primary rain forest. The second reference site was barren land (BS) found inside the quarry.

Reclamation techniques conducted by Indocement have changed considerably over the years as the tree species have also varied among different planting sites. Re-vegetation of post mined sites are predominantly planted by *Swietenia mahagoni*, but experimentation of other species have also been conducted with different planting distances. (Table 3.1).

3.2 Experimental design and site characteristics

Cover types could be categorized according to their potential to provide refuge, food, oviposition habitat, or some other ecological service (Fahrig, et al., 2011). The 2004 reclamation site was categorized into two different groups A and B (based on elevation) which consisted of cassava fields, mixed forests and mahogany stands. The 2005 reclamation site consisted of cassava fields, mixed forests, and mahogany stands. The 2006 reclamation site had the largest amount of land uses consisting of cassava fields, mixed forests, mahogany stands, and rice paddies. 2007 and 2009 reclamation sites consisted of just Mahogany stands. The 2008 reclamation site is located adjacent to the 2006 reclamation site and is composed of cassava fields and mahogany stand. Sampling in each site was proportionally placed based on the size of every landuse.

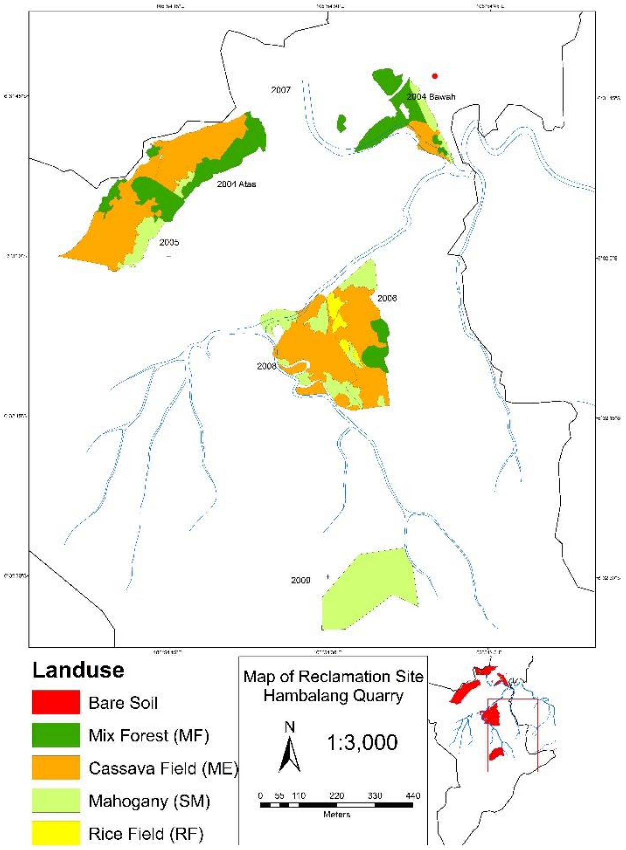

Figure 3. 1 Reclamation site of Quarry Hambalang

Table 3. 1 Vegetation Compotition Each Sites

Site	Age (yrs)	Area (m2)	Tree composition	Distance (m)
1960_HB	56		*Hevea brasiliensis*	3 x 3
2004A_ME	4*	104	*Manihot esculenta*	1 x 1
2004A_MF	12	64	*Acacia suratensis* *Dracaena surculosa* Lindl. *Erythrina cristagalli* *Erythrina glauca* *Ficus benjamina* *Leucaena leucocephala* *Mangifera indica* *Nerium oleander* *Plumeria* sp. *Polyantha longifolia*	3 x 4
2004A_SM	12	8	*Swietenia mahagoni*	5x5
2004B_ME	4*	24	*Manihot esculenta*	1x1
2004B_MF	12	72	*Acacia suratensis* *Bougainvillea sp.* *Delonix regia* *Dracaena surculosa Lindl.* *Plumeria sp.*	6x6
2004B_SM	12	16	*Swietenia mahagoni*	5x5
2005_ME	4*	136	*Manihot esculenta*	1x1
2005_MF	11	40	*Mangifera indica* *Cassuarina equisetifolia* *Syzigium aquatica* *Eugenia malaccensis* *Michelia campaka* *Parkia speciosa*	6 x 6
2005_SM	11	24	*Swietenia mahagoni*	6 X 6
2006_ME	4*	120	*Manihot esculenta*	1x1
2006_MF	10	26,92	*Samanea saman* *Spatodhea campanuliata* *Eugenia polyantha* *Terminalia cattapa* *Bauhinia purpurea* *Parkia speciosa* *Manihot esculenta*	6x6
2006_RF	3*	19,48	*Oryza sativa*	30x30*
2006_SM	10	40	*Swietenia mahagoni*	6 X 6
2007_SM	9	8	*Swietenia mahagoni*	6 x 6
2008_ME	4*	64	*Manihot esculenta*	6 x 6
2008_SM	8	32	*Swietenia mahagoni*	5x5
2009	7	32	*Swietenia mahagoni*	6 x 6
2013	3	24	-	

*= in month

3.3 Soil Arthropod Sampling

In this study, pitfall traps were used for measuring the relative abundance of soil arthropods. A trap consist of a 250 ml cup, 11 cm tall and 5 cm wide at the mouth, burried so that the top of the cup is level with the surface. Water and detergent are poured into the cup until filled up to a third of the cup's height. The detergent is used to reduce surface tension thus allowing the arthropods to sink to the bottom of the cup.

3.4 Earthworm sampling
Sampling of earthworms were conducted three times per site on plots measuring 30 x 30 cm with depths of 20 cm. The samples are then preserved with 70% ethanol and identified using Invertebrate Zoology (Kastner, 1968).

3.5 Abiotic measurements
At each site, a range of environmental attributes was recorded: soil temperature (˚C, at depth of 10 cm); soil moisture (%, at depth of 5 cm); air temperature (˚C, at height of 2 m); air moisture (%, at height of 2 m); light intensity (lux, at height of 2 m). Chemical soil properties of each site was measured by collecting samples of soil using an auger bore. One kilogram of soil is taken to a lab for further analysis of organic components in the soil. Soil bulk density was measured using a core sampler. The weight of the samples are measured and afterward inserted into the oven until dry and measured again

3.6 Structural Habitat Complexity Measurement
We assesed the structural habitat complexity using features and scores within a circular plot (Tongway & Hindley, 2001) (Table 3.3)

Table 3. 2 The feature and scores for the habitat complexity (Tongway and Hindley, 2001)

Structure	Score			
	0	1	2	3
Tree Canopy (%)	0	<30	30-70	>70
Shrub Canopy (%)	0	<30	30-70	>70
Ground Herbage	Sparse	Sparse	Dense	Dense
	<0.5 m	>0.5 m	<0.5 m	>0.5 m
Logs, rocks, debris, etc (%)	0	<30	30-70	>70
Soil Moisture	dry	moist	permanent water adjacent	water logged

Data Analysis
All soil arthropods were sorted and identified using the insect identification book (Borror, Triplehorn, & Johnson, 1989) to a morphospecies level. Species abundance were scaled with log (x) +1 to avoid data distortion causad by the common problem of numerous ants from a single colony falling into one or a few traps (Andersen A. , 1991). Species richness is measures on a morphospecies level. Species abundance and richness is measured per square meter to cope with different sampling sizes.
Species diversity index was calcuated to compare diversity among sampling areas. Species diversity was represented by the Shannon-Wiener diversity index (Ludwig & Reynolds, 1988) by :

$$H' = -\sum_{i=1}^{R} pi \ln pi$$

Where, *pi* is the proportion of individuals belonging to a species compared do the number of total individuals. Soil arthropods are also categorized into functional groups by classifying species into feeding guild group base on their food. The feeding guilds used in this research are phytophages, insect predators, scavengers, parasitoid, and ants. Richness of each guild is divided per square meter (feeding guild/m^2) and is compared with different landuse.
Correlation tests connected with habitat complexity was conducted using Spearman's correlation index using the IBM SPSS statistics vers.22 software.

Result
4.1 Soil Arthropods
4.1.1 Abundance of Soil Arthropods
10,468 individuals were collected during the sampling period. These individuals are from 154 morphospecies and 69 families. Among the study sites, mahogany stands had the highest abundance of arthropods (49.07%), followed by mixed forest (21.45 %), cassava fields (14.46 %), rubber plantation (7.21 %), rice fields (5.74 %) and bare soil (2.04 %). Abundance levels were highest in mahogany stands of the 2004A_SM reclamation site (Figure 4.1).

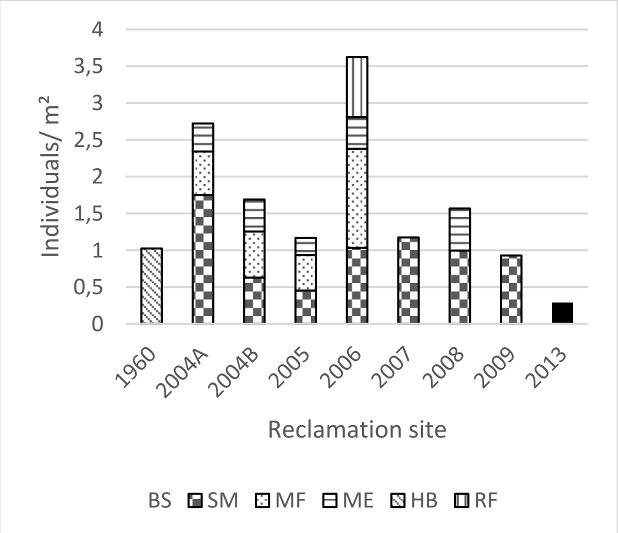

Figure 4. 1 Species abundance in all landuse type

4.1.2 Species richness of Soil Arthropods

A total of 154 morphospecies from 69 famili were collected during the study. The richest famili were Formicidae (20), Lycocidae (11), Acrididae (10), Gryllidae (10), Cicadidae (9), Blattidae (6), Blattelidae (5), Scarrabaeidae (4) and Pyrrhocoridae(4).

The site with the highest species richness was found in the mahogany stands in the 2004A reclamation site. This site contained 2.38 species per square meter. Meanwhile the bare soil site had the lowest species richness with 0.25 species per square meter (Figure 4.2)

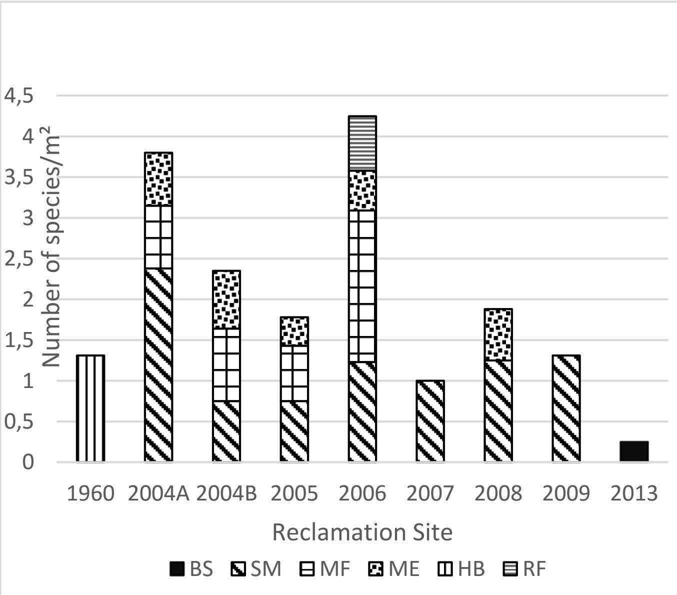

Figure 4. 2 Species richness in all landuse type

4.1.3 Diversity Index

The Shannon - Wiener index measured for the landuses showed that the cassava field landuse found in the 2006 reclamation site had the highest score of diversity while the bare soil landuse had the lowest score of diversity. Diversity scores measured in mahogany stands were generally lower than diversity scores measured in cassava fields and mixed forests (Figure 4.3).

4.1.4 Feeding Guild

Feeding guilds in every land use was composed uniquely (Figure 4.4). Mahogany stands and mixed forests had the most diverse quantities of feeding guilds compared to other land uses. All five feeding guilds used to categorize arthropods were found in all of the sites sampled. From the five categories of feeding guilds, ants and phytophagy were found in all landuses in all reclamation sites. Predators were not present in all sites but had the highest levels of species richness and abundance.

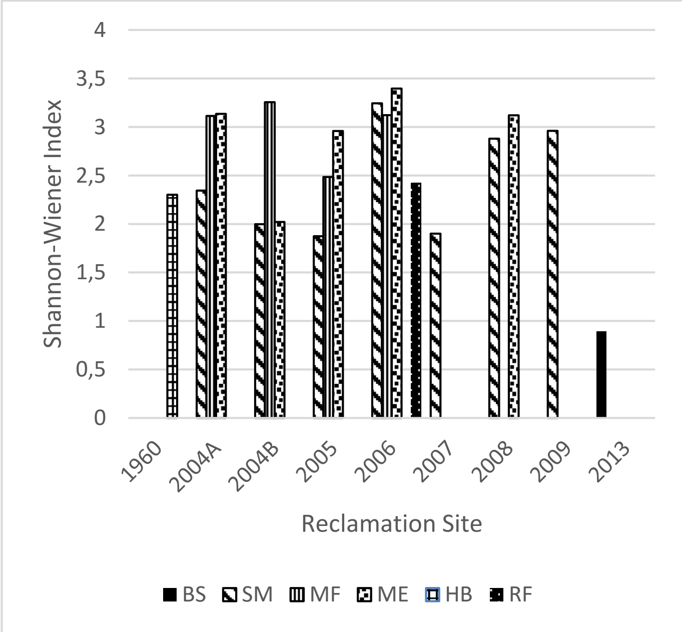

Figure 4. 3 Shannon-Wiener index in all landuse type

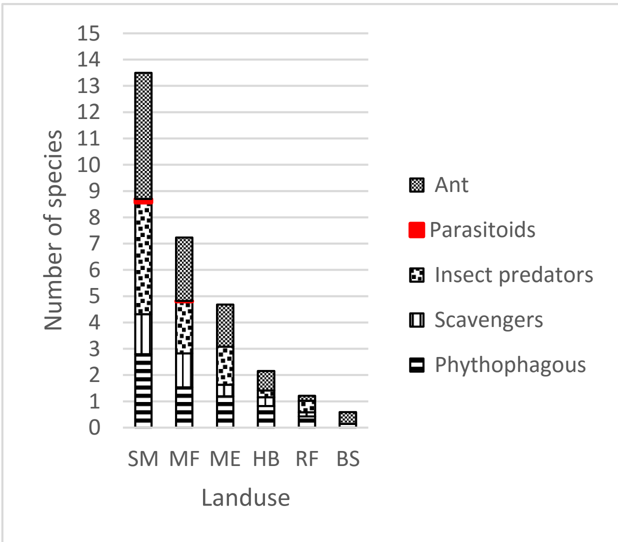

Figure 4. 3 Component of feeding guild in all landuse

4.2 Earthworm

4.2.1 Abundance of Earthworm

A total of 374 individuals were sampled from 7 reclamation sites and 2 reference sites. From these nine sites, earthworm abundance were the highest in the 2004A and 2005 reclamation sites where each site had a total of 90 and 89 respectively. In these two reclamation sites, earthworm abundance were highest in the mixed forest land use followed by the mahogany stands. Meanwhile the lowest levels of abundance was found on bare soil where no earthworms were found (Figure 4.5).

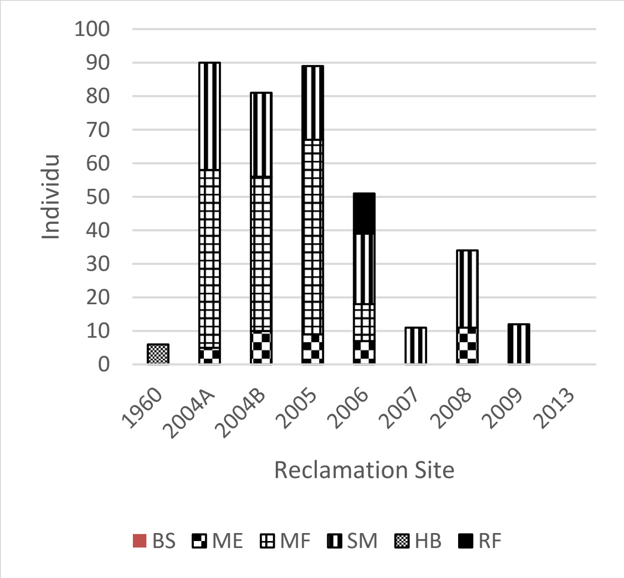

Figure 4. 4 Earthworm abundance in all site

4.2.2 Species Richness of Earthworm

A total of four species were identified from the samples collected in this study. Four locations had all 4 species in one land use, these were mixed forests found in the 2004 B and 2005 reclamation site and also mahogany stands found in the 2006 and 2008 reclamation sites. Meanwhile sites with the lowest species richness was found in bare soil with zero species and cassava fields of 2004b and 2005 reclamation sites with only one species (Figure 4.6).

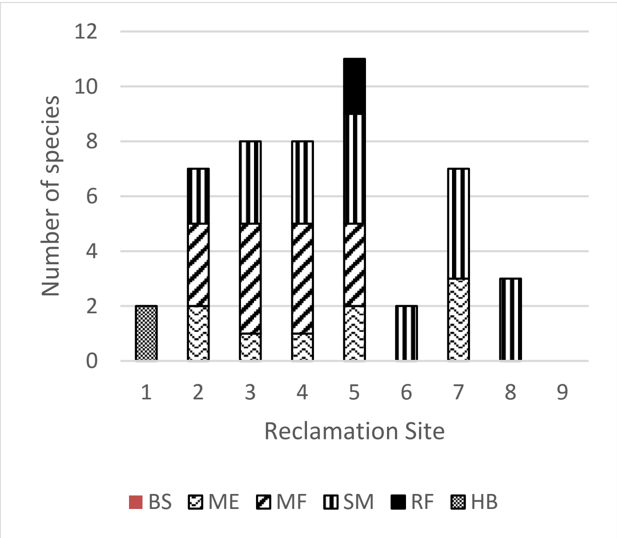

Figure 4. 5 Earthworm Species Richness in all site

4.2.3 Shannon-Wiener Diversity Index of Earthworm

The Shannon - Wiener index measured for the landuses showed that the mahagony landuse found in the 2005 reclamation site had the highest score of diversity while the mix forest landuse in the 2006 had the lowest score of diversity. Diversity scores measured in mahogany stands were generally higher than diversity scores measured in all landuse type (Figure 4.7).

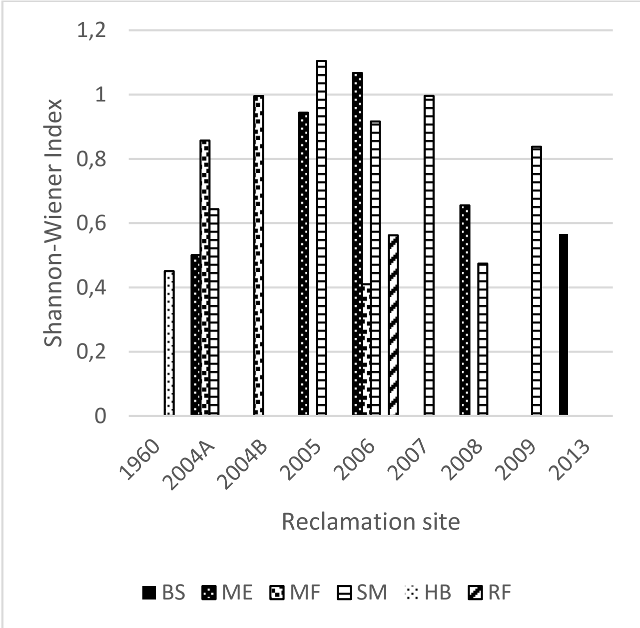

Figure 4. 6 Earthworm Shannon-WIener index in all site

Discusion

5.1 Soil Arthropods

Soil invertebrates are important components of any habitat and hold crucial roles in affecting structure and function of an ecosystem. Their role as nutrient recyclers, decomposers, herbivores, predators, and soil conditioners make their community assemblages sensitive to changes in ecosystem conditions (Giller 1996). Soil invertebrates also fill important niches in the environment because they influence nutrient flow, improve soil aeration and fertility, and alter plant community structure.

It is now recognized that many species interact with landscapes in more complex ways and use resources from different cover types, which implies the need to understand the effects of landscape structure on biodiversity (Fahrig, et al., 2011).

Levels of abundance, species richness, and habitat complexity was highest in the mahogany stand found in the 2004A reclamation site. But these values did not correlate with the Shannon-Wiener diversity index, where index values of diversity was higher in land uses such as cassava fields and mixed forest compared to mahogany stands. The Shannon wiener index is sensitive towards rare species with few individuals (Anderson & Davis, 2013), thus explaining the high scores of diversity measured in cassava fields and mixed forests where many species were found with only one individual. The bare soil land use had the lowest levels of species abundance, species richness, and habitat complexity.

Elements of landscape heterogeneity can influence a variety of ecological responses, including animal movement ((Fahring, 2007), population persistence (Fraterrigo, Pearson , & Turner, 2009) ,species interactions (Polis & Huxel, 2004) and ecosystem function (Lovett, Jones, Turner, & Weathers, 2005). These elements are parameters in the measurement of habitat complexity. Habitat complexity measured in reclamation sites had high positive correlations with individual abundance (r^2 Spermaen = 0,67; significant) (Figure 5.1) and species richness (r^2 Spermaen = 0,79; significant) (Figure 5.2). This correlation is supported by the data of landuses which had had values of habitat complexity extremes such as the mahogany stand of 2004 A and bare soil. Abundance and species richness decreases with the decrease of ground herbage coverage, this is shown by the low levels of abundance and richness found in cassava fields whose ground herbage are cleared regularly. Meanwhile factors such as tree canopy coverage, and soil moisture correlate positively with high levels of abundance and species richness, shown by mahogany stands and mixed forest.

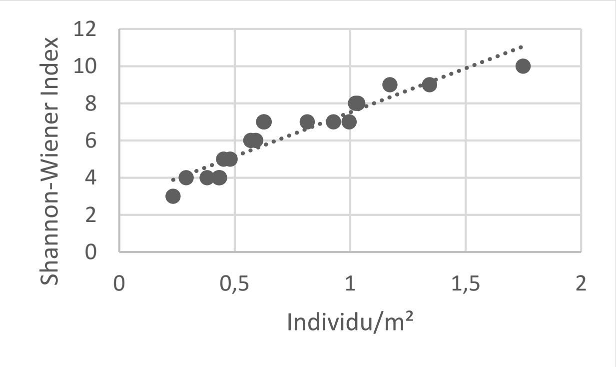

Figure 5. 1 Correlation between species abundance and habitat complexity

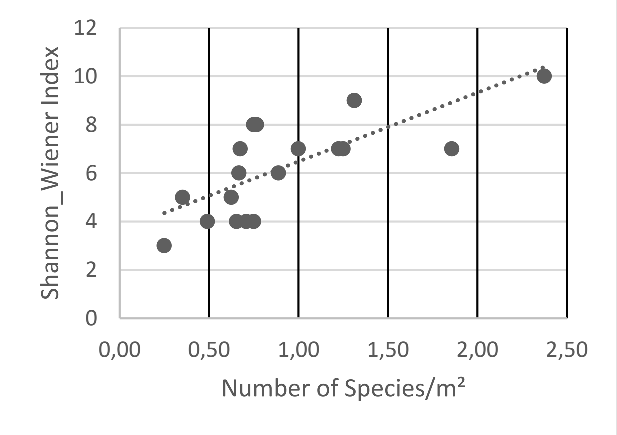

Figure 5. 2 Correlation between species richness and habitat complexity

Tree stands are structurally more complex and therefore creates larger amounts of niches. Other thant that, tree stands provide a more consistent resource compared to shrubs and herbs caused by a higher biomass productivity. This creates more feed for arthropods to consume and decompose and consequently increases leves of carbon in its ecosystem.

According to Moran and Southwood (1982) arthropods can be grouped by their method of obtaining food. Their role as nutrient cyclers decomposers, herbivores, and predators are correlated and therefore sensitive towards changer in the environment. High numbers of feeding guild groups shows that that an ecosystem provides diverse resources (Wardle, *et.al*, 2006). This diversity creates more complex interactions within an ecosystem. Higher levels of species richness shows that an ecosystem is capable of fulfilling various resources for large numbers of species.

Based on the abundance data of feeding guilds, the ant feeding guild is the most abundant in most land uses in all reclamation sites. According to Agus (2007), ants repre (Agus, 2007) sent insects that are capable of adapting to various types of terrestrial ecosystems. Through their activities such as tunneling, ants carry soil particles horizontally and verticaly thus affecting physical and chemical properties of the soil. Therefore ants affect the cycling of energy and nutrients in an ecosystem.

Results of this research show that the amounts of phytophagous in every land use is smaller compared to predators. Phytophagous act as herbivores and are prey for carnivorous insects. According to Root (1973) the abundance of arthropods, particularly phytophagous, are smaller in ecosystems with high levels of vegetative diversity. Based on the research's results, mixed forests had smaller abundance of phytophagous compared to mahogany stands. Phytophagous arthropods generally need specific types of vegetation to consume, therefore land uses with high levels of vegetative diversity reduces the abundance of certain vegetation that are important for the survival of a certain species. Meanwhile in higher trophic levels, predator possess a more flexible diet therefore leading to a more stable population. We found that arthropod abundance was not correlated with plant species richness or effective diversity, even when influences of environmental variables were taken into account (Perner, et al., 2005)

Scavengers hold an important role in degrading dead organic matter, therefore are an player in nutrient cycling. Scavengers feed on dead vegetation or fauna located on the surface of the forest and break down organic materials into simpler forms (Culliney, 2013). The presence of litter in a certain area affects the presence of organisms involved in decomposition such as certain arthropods (Swift et al, 1979). Land uses containing varieties in litter types provides a habitat for more diverse decomposers (Wardle et al. 2006).

Because of the magnitude of the areas converted into agricultural landscapes, any change in their capacity to accommodate more wild plants and animals and more complex interaction networks could produce important changes in biodiversity (Fahrig, et al., 2011).

5.2 Earthworm

Earthworms were found in all land uses of the reclamation sites. This indicates that the reclamation conducted increased the suitability of the substrate as a habitat for earthworms. Soil temperature, pH, C/N ratio, and organic properties of soil are factors that strongly influence the existance of earthworms in a given area (Qiao, Li, Peng, & Dong, 2003). Earthworms are capable of surviving in soil temperatures ranging from 20 to 30 C and soil moisture of 70-85% (Kaplan, et al., 1980). The optimal pH range for habitats of earthworms is between six to eight. (Jicong, et al., 2005). The optimal C/N ratio for earthworm habitats is 25 (Ndewa and Thompson (2000).

Based on the soil properties measured in this research compared to the optimal levels of soil characteristics needed for earthworm habitat, all sites studied are capable of being habitats for earthworms. This is supported by the fact that earthworms found in all reclamation sites.

The C/N ratio measured in all sites ranged from 8 to 12, but these levels are still low compared to the optimal C/N levels needed for an earthworm habitat. (Ndewa & Thompson, 2000). This explains the low levels of abundance and diversity for earthworm in the reclaimed sites. An ecosystem with low levels of diversity indicates a high level of ecological disturbance (Kooch, et al, 2012). This strengthens the fact that C/N levels are far from optimum.

Based on the data in figure 4.5, Shannon-Wieners's index of diversity measured for earthworms were highest in the mixed forest found in the 2005 reclamation site, followed by mahogany stands found in the same site. Abundance of earthworms meanwhile were highest in mixed forest of the 2005 and 2004 site, and mahogany stands in the 2006 and 2008 reclamation sites. This shows that these land uses are capable of providing resources needed for earthworms (Kooch, et al., 2012). Abundance and species richness data shows that the land use of mixed forest and mahogany stands found in the 2005 reclamation site are the most successful in terms of providing a habitat for earthworms.

Expected Added Value for biodiversity, society and company

As previously eplained, soil arthropods and earthworms are organisms that are very sensitive towards changes in an environment. Therefore, their presence or absence in an ecosystem can indicate the quality of that ecosystem. High levels of earthworm and soil arthropod diversity and abundance in an ecosystem also indicates the presence of other organisms, be it of a higher trophic level or a lower trophic level. Therefore Tongway and Hindley (2001) used both organisms as indicators for the rise of complexity in an ecosystem. Thereby, this research can be used as an input for PT Indocement Tunggal Prakarsa to monitor and evaluate faunal biodiversity in reclamation sites. Keepin in mind that monitoring and evaluation of biodiversity for all trophic levels is very time consuming and complex, monitoring and evaluation should be restricted to soil arthropods and earthworms asuming that high levels of soil arthropod and earthworm diversity will lead to the diversity of other faunas. This can also be educational for surrounding comminities, bearing in mind that no matter how small the organism, their roles in an ecosystem is irreplaceable and can be used as indicators for the quality of an ecosystem.

Conclusion

Correlations found between habitat complexity, species richness, and abundance, supported their use as parameters used for reclamation success. Meanwhile valuation of diversity using the Shannon-Wiener index was not appropriate because of the variation in sampling size and its sensitivity towards rare species which was found in several land uses. The mahogany stand found within the 2004A reclamation site can be used as a reference for future planning of reclamation because of its habitat complexity and high levels of species richness and abundance.

During the process of reclamation, parameters influencing habitat complexity should be strongly considered because of its effect on soil arthropod and earthworm presence, consequently affecting ecological functions such as nutrient cycling. Monitoring and evaluation should be conducted during the rainy and dry seasons to assess the differences in diversity. The presence of important families which could potentially be used as indicators, indicates an ecosystem's ability to provide habitat for these faunas and thus signaling success of the reclamation process.

The table below shows cost per hectares to implement this research study :

No.	Tools and Materials	Unit	Price	Quantity	Total
1	Pitfall glass	item	Rp.500,-	25	Rp. 12.500,-
2	Chopstick	item	Rp. 250,-	100	Rp. 25.000,-
3	Detergent	kg	Rp. 15.000,-	1	Rp. 15.000,-
4	Plastic bag 1 kg	*pack*	Rp. 15.000,-	2	Rp. 30.000,-
5	Raffia fiber	roll	Rp. 10.000,-	1	Rp. 10.000,-
6	Ethanol 70%	litre	Rp. 50.000,-	1	Rp. 50.000,-
7	Hand shovel	item	Rp. 25.000,-	4	Rp. 100.000,0
8	Large shovel	item	Rp. 50.000,-	2	Rp. 100.000,0
8	Plastic tray	item	Rp. 15.000,-	4	Rp. 60.000,
9	Siever	item	Rp. 5.000,-	4	Rp. 20.000,-
10	Pinset	item	Rp. 10.000,-	4	Rp. 40.000,-
11	Vial bottle	item	Rp. 2.000,-	25	Rp. 50.000,-
Total					Rp. 512.500.-

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Project tags (select all appropriate):

This will be use to classify your project in the project archive (that is also available online)

Project focus:

- ☐Biodiversity management
- ☐Cooperation programmes
- ☐Education and Raising awareness
- ☐Endangered and protected species
- ☐Invasive species
- ☐Landscape management - rehabilitation
- ☐Rehabilitation
- ☒Scientific research
- ☐Soil management
- ☐Urban ecology
- ☐Water management

Flora:

- ☐Conifers and cycads
- ☐Ferns
- ☐Flowering plants
- ☐Fungi
- ☐Mosses and liverworts

Fauna:

- ☐Amphibians
- ☐Birds
- ☐Dragonflies & Butterflies
- ☐Fish
- ☐Mammals
- ☐Reptiles
- ☒Spiders
- ☒Other insects
- ☐Other species

Habitat:

- ☐Cave
- ☐Cliffs
- ☐Fields - crops/culture
- ☐Forest
- ☒Grassland
- ☐Human settlement
- ☐Open areas of rocky grounds
- ☐Recreational areas
- ☐Screes
- ☐Shrubs & groves
- ☒Soil
- ☐Wander biotopes
- ☐Water bodies (flowing, standing)
- ☐Wetland

Stakeholders:

- ☒Authorities
- ☐Local community
- ☐NGOs
- ☐Schools
- ☐Universities