Fwd: Review of Paper 061. Rehabilitation Works of Mined Forest Lands

From: Intl Conf Biodiv (biodiversitas@gmail.com)

To: triyono_sudarmadji@yahoo.com; wahyunihartati@yahoo.com

Date: Monday, February 22, 2016 at 08:29 AM GMT+8

Dear Pak Triyono n Bu Wahyuni,

Terlampir adalah komentar reviewer atas naskah anda.

Thank you,
Regards,

Ahmad Dwi Setyawan

Managing Editor,
- Biodiversitas, Journal of Biological Diversity (biodiversitas.mipa.uns.ac.id) (SCOPUS, DOAJ)
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International Conference on Biodiversity
- Yogyakarta, 19-20 March 2016; http://biodiversitas.mipa.uns.ac.id/S/2016/jogja/home.html or http://biosains.mipa.uns.ac.id/S/2016/jogja/home.html

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From: .....@ru.ac.za>
Date: Mon, Feb 22, 2016 at 7:23 AM
Subject: Re: Review of Paper 061. Rehabilitation Works of Mined Forest Lands
To: Intl Conf Biodiv <biodiversitas@gmail.com>
Cc: "r.lubke" <r.lubke@ru.ac.za>

Dear Dr. Ahmad Dwi Setyawan,

I arrived in Sydney, Australia yesterday. I have reviewed the Manuscript and am attaching my comments and also the corrected m/s with tracked changes.

I trust that you will find my review useful.

Regards

.....

Professor Roy Allen Lubke
Emeritus Associate Professor,

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QUALIFICATIONS

Botany & Zoology - B.Sc (Hons) Rhodes University
Science Education - M.Sc - Keele University (U.K.)
Quantitative Plant Taxonomy - Ph.D. University of Western Ontario (Canada)

ASSOCIATION AND SOCIETIES

South African Association for Advancement of Science (since 1962)
Canadian Botanical Association (1965 - 1968)
International Association of Plant Taxonomy (since 1966)
Association for the Taxonomic Study of the Flora of Tropical Africa (since 1970)
Society of Systematic Zoology (1966 - 1978)
Grassland Society of Southern Africa (1976 - 1978)
Botanical Society of Southern Africa (since 1975)
European Union for Coastal Conservation (since 1991)
Society for Restoration Ecology(since 2000)
International Association of Vegetation Science(since 1996)

PROFESSIONAL EXPERIENCE

1964 - 1968: University of Western Ontario - research and tutorial assistant
1970 - 1974: University of Witwatersrand - Lecturer
1975 - 1999: Rhodes University - Lecturer and Associate Professor (1984)
2000 - 2002: Head of Department of Botany, Rhodes University.
2003- present: Emeritus Associate Professor, Department of Botany, Rhodes University.

CURRENT RESEARCH ACTIVITIES

Ecological coastal research on dune systems and autecology's of dune plants.
Management of dune and coastal systems.
Grassland, savanna and thicket plant community studies, especially with respect to endangered species.
Rehabilitation of degraded landscapes, especially after mining.

CONSULTING EXPERIENCE

Environmental consulting under the name of Coastal and Environmental Services (formed in 1989 with Dr Ted Avis and Mr Peter Jackson).
Numerous consultancy reports produced within the field of expertise indicated above.
Specialist expertise in consulting:

- Coastal planning and EIA's.
- Environmental management and conservation.
- Plant ecology and plant biodiversity specialist studies.
- Dune ecology and dune stabilisation and management.
- Endangered plant surveys and sensitivity analysis.
- Restoration ecology and rehabilitation of disturbed landscapes.
* Alien eradication and subsequent rehabilitation of disturbed areas

.....

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Review RAL.docx
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The process of ~~R~~rehabilitation ~~works~~ of mined forest lands toward degraded forest ecosystem recovery in Kalimantan, Indonesia

Abstract

An overview of mined forest lands at East and Central Kalimantan Indonesia was conducted to determine most important influencing factors supporting degraded forest ecosystem recovery. Consecutive stages of rehabilitation ~~works~~processes consist of reclamation - *backfilling*, *re-contouring*, *re-shaping*, *topsoils spreading*, and revegetation - *land preparation*, *planting*, *maintenance* covering minimum topsoils spreading, soil acidity, plant hole size, soil improvement application (*dolomite*, *organic - anorganic fertilizers*), vegetation planting (*plant species selection - quality and site matching - verified plant material sources*, *hardening-off*, *planting techniques*), and land management implementation. The potential degraded forest ecosystem recovery was ~~indicated~~ shown by cover crops and fast growing species plant and undergrowths, survive primary species, decreasing surface run-off/overland flows following increasing soil infiltration capacities, decreasing soil erosion rate and it's erosion hazard, and an improved environments as habitat for ~~incoming~~invading wildlife~~s~~. The general characteristics of potential degraded forest ecosystem recovery after rehabilitation ~~works~~processes are: spread soil materials thickness > 70 cm, bulk density ± 1,2, soil acidity > 5,5, macro nutrients (N, P, K, Ca, Mg) - low to moderate, decreasing overland flow following increasing soil infiltration capacity - moderate to high, decreasing soil erosion rate - very low to moderate, decreasing erosion hazard - very slight to moderate, growing plants of fast growing species with significant layers and land cover, and growing interline planted primary species. Viewed from the ecological aspect, in the revegetated degraded forest lands wildlife such as ~~as of~~ insects, ~~aves~~birds, reptiles~~ia~~, ~~herpetofauna~~ amphibia and small mammals were found ~~for~~ feeding and also permanently living~~es~~ ~~for their~~resulting in ecosystem regeneration following gradual habitat improvement. The ecosytem status ~~has been~~was identified ~~to be~~as a ~~prospective~~ progression towards degraded forest ecosystem recovery.

Keywords: degraded forest, ecosystem, rehabilitation-process~~works~~, reclamation, revegetation

Introduction

Natural resources utilization and environmental management must be able to minimize the negative impacts and retain the quality and it's sustainability for peoples welfare. For this reason, coal mining companies have an obligation to observe - monitor and- manage ~~arised and~~ potential emerging environmental impacts along with their mining operation. It has been widely known that coal mining operation causes a significant impact to the environment (reference?). It is therefore environmental management must follow it's consecutive mining operation stages starting from ~~land~~ clearing of the vegetation,~~-~~ topsoils striping and stockpiling,~~-~~ mining waste treatment,~~s~~ ~~-~~the coal mining process,~~-~~ land reclamation and revegetation ~~works~~of the disturbed site. It is also very clear that ~~those~~ these activities determine an efficient and rational coal utilization as a non-renewable natural resource~~s~~. However, coal mining operations, as far as possible, must ~~produce a better energy to~~ enhance a better life ~~of~~ for mankind and ~~to~~ achieve a brighter future. Environmental disturbances, especialy forest land~~s~~ degradation, must be seriously considered for the next generation who will utilise this land.

Coal mining operations ~~affects various~~ contribute significant impacts both ~~of~~ on and off-sites to the environment ~~figurized as~~resulting in heavy degraded lands and massively altered forest ecosystems. General features of mined lands are ~~overburden~~ the dumping of overburden with disturbed soil ~~structures~~, fragmented rocks mixed with ~~fine coals~~coal fines without organic materials, bad water drainage, low soil water, compacted soils and with high soil temperatures. ~~; and therefore being~~Such disturbed soil and overburden sites are unable to perform the main soil~~s~~ function ~~as~~ to provide a plant growth media and ~~water~~ conservation of water. Moreover, degraded lands ~~is~~ are also characterized with ~~a~~ bad ~~lands~~ drainage and low water holding capacities and highly compacted soils. To ~~realize the spirit of doing~~ achieve~~a~~ good mining practices ~~related~~ along with the many rules for the coal mining operation, land rehabilitation ~~works~~ practices must be carried out in order to achieve recovery of ~~a~~ mined forest lands. ~~recovery which is~~These rehabilitated lands would also be expected to be ~~a~~ productive lands.

The open pit/cast method of coal mining operation which is commonly applied at Kalimantan Indonesia cause~~sing~~ ~~a~~ great and massive ~~lands form~~ changes to the landform ~~ing~~, and therefore they need rehabilitation ~~works~~ to recover and retain the environmental function capacity for supporting various ~~development programmes~~rehabilitated ecosystems. Specifically, minedout lands suffer~~ed~~ a drastic soil fertility ~~alteration~~ deficit and a ~~worse~~ poor microclimate, with a huge increase of ~~overland~~ water flow and runoff causing a significant ~~magnitude~~ increase ~~of~~ in soil erosion and sedimentation away from the disturbed site..

The ~~R~~rehabilitation process ~~works need~~ requires a specific knowledge~~s~~ and experience~~s~~ ~~in relation~~ with respect to soil ~~forming~~ formation and development, proper and practical techniques of mined land rehabilitation, plant species selection with appropriate ~~and~~ site matching, and also planting techniques

and vegetation maintenance after the rehabilitation process~~works~~. Degraded forest land~~s~~ rehabilitation ha~~s~~ve been carried out as an initial effort to restore altered ecosystems through reclamation activities of *backfilling*, *re-contouring*, *land* ~~*smoothing*~~*levelling*, *re-shaping* and *topsoil*~~*s*~~ *spreading*, ~~continued with~~followed by revegetation processes ~~works~~ such as ~~of~~ *land preparation*, *planting*, and *maintenance* of the rehabilitated lands.

The main objective of this study was to identify the characteristics of mined forest lands for potential recovery after rehabilitation ~~works~~ processes. ~~while t~~The expected results of the study were~~as~~ to develop and/or improve the design of land rehabilitation ~~works~~ processes ~~design~~ for enhancing degraded forest ecosystem recovery.

Materials and Methods

Observation and fieldwork~~s~~ focused on soil characteristics, ~~overland~~ water flow~~s~~ and infiltration, soil erosion and sedimentation, revegetation plants, wildlife~~s~~ (fauna), and ecosystem status ~~were conducted~~. The study sites were ~~6 (~~six~~)~~ rehabilitated forest lands of PT Berau Coal-BC, PT Kaltim Prima Coal-KPC, PT Trubaindo Coal Mining-TCM, PT Kitadin-KTD, PT Kideco Jaya Agung-KJA (East Kalimantan) and PT Multi Tambangjaya Utama-MTU (Central Kalimantan) concessions covering reclamation ~~works~~ processes (*backfilling*, *re-contouring*, *re-shaping*, *topsoils spreading*) and revegetation ~~works~~ processes (*land preparation*, *planting*, *maintenance*), taking into account the ~~processes of~~ consecutive stages of land rehabilitation ~~works~~.

Some minipits were ~~placed~~ selected as representatives of mined forest lands ~~in line with the~~of different ages of vegetation to asses and diagnose the physical and chemical soil characteristicts for indicating soil recovery and ~~it's pedological and edaphological~~ development ~~in relation~~ with respect to the assessment of overland water flow and infiltration capacity~~ies assessment~~.

~~Time series r~~Rainfall data ~~collection~~ and field observations of topographycal condition, ~~growing~~ vegetation ~~growth and it's undergrowth~~, land coverage density, soil and water conservation practices were used to estimate the potential soil erosion by using Universal Soil Loss Equation (USLE) approach. Secondary data of biodiversity and habitat improvement studies at the same sites was used to construct the scenario of degraded forest ecosystem recovery.

Results and Discussion

Rehabilitation of ~~Degraded Lands~~ Ecosystem Function~~ing of Degraded Lands~~

Forest succession ~~basically~~ is an ecosystem ~~element~~ process in which the ecosystem chang~~e~~~~ing~~ in the form of flora or fauna diversity is measured.~~changing~~ . Progressive succession is the normal sequential development of communities, from simple communities with few species and low

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productivity to the optimum sustainable in a given habitat or environment. ~~, while~~Conversely, retrogression is ~~termed as~~ a successional change usually from an existing climax community leading to a less diverse and less structurally complex community. ~~of wihich usually i~~It is usually triggered by an environmental factor. ~~Viewed from the earlier status of succession ,~~ pPrimary succession is a succession in an area without any previous vegetation~~. . On the other hand~~whereas, secondary succession is ~~a~~ succession that occurs in a degraded area with some remaining vegetation or an area where the ~~disturbed~~ vegetation has been disturbed~~ area. Concerning to the existing species changing,~~ ~~p~~Progresisve succession ~~means there were~~shows species increase ~~whether~~ whereasr species decrease ~~is~~ definesd retrogressive succession. In the forested or vegetated areas seriuously disturbed there might be complete failure in succession which means that the earlier condition or historical state could not be recovered.

One would expect the ~~R~~revegetation of mined-out lands ~~is expected~~ to accelerate ecological proccesses ~~to~~in achievcing the condition ~~as~~ of a pre-mining operation or ~~more~~ even better. ~~In this case,~~ ~~t~~The main consideration in~~of~~ plant species selection is based on not only having high tolerance to the extremely degraded soil conditions but also to the ~~catalisator plant~~ capacity of the plants ~~for~~ to recover~~ing~~ degraded ecosystem function~~ing~~. However, there ~~was~~ is a possibility that ~~those~~ the tree plant species selected could not fulfill such expectations. Some species are tollerantce ~~enough to~~of the extreme conditions but less ~~catalyst~~ favourable for~~to~~ enhancing ~~the~~ ecosystem recovery due to their intollerancy ~~incoming~~ invading ~~other~~ species and thus triggering a retrogressive succession. For these reason, it is ~~really~~ important to understand that the potential of the natural vegetation to alteratingon ~~the intensity~~ impact of~~due to~~ the coal mining operation and at the same time also increascing vegetation structure and ~~it's~~ composition following the rehabilitation process~~works~~.

Lands Rehabilitation ~~Works~~ Process

The process of ~~R~~rehabilitation ~~works~~ is studied in ~~a~~ consecutive activities of reclamation and revegetation ~~is determined~~in order to accelerate the recovery of degraded forest lands ~~recovery~~. Soils ~~function as~~provide a plants growth media ~~provides~~ with satisfactory aeration and drainage ~~assurance~~ to ensure the development of a root system ~~and activities gaining~~to absorb macro and micro nutrients ~~elements~~. In this ~~case~~rehabilitation study, reclamation ~~works~~ processes ~~provide~~ assure ~~an~~ a suffucient~~enough~~ thickness of soil ~~materials~~ through topsoils spreading and recontouring, in order ~~which is expected~~ to control exessive water drainages. In order to achieve the improvement of ~~S~~soil aeration ~~improvement was also done by adding~~ organic materials were added followed by immediate planting of land cover crops ~~planting immediately~~. Fig.1 shows the result of topsoil~~s~~ spreading at TCM, MTU and BC, while Fig.2 ~~explain~~ illustrates the initial planting at the same sites.

Commented [R2]: Need references here to definitions of succession in the literature.

Commented [R3]: Maybe include reference to Hobbs et al on Novel Ecosystems here?

Commented [R4]: I think that there needs to be more explanation in the text regarding these two series of figures.For example: at TCM (*fast growing species) – what DOES THIS MEAN?*

137

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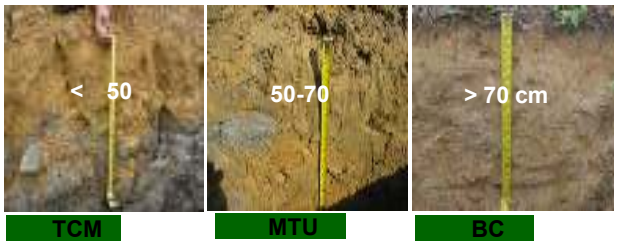

Fig.1. Land Preparation) at Mined-out Lands of TCM (<50 cm, MTU 50-70 cm, and BC (>70cm)

Fig.2. Planting after reclamation ~~works~~processes at TCM (*fast growing species*), BC (*land cover crops*), and MTU (*planting holes*)

Based on the results of observation, field work~~s~~ and laboratory analysis; the recovery processes of mined forest lands are highly dependent on the determining factors and steps of rehabilitation ~~works~~ which consist of reclamation and revegetation ~~works~~processes. Technically, the minimum standard ~~applied~~ required for mined land~~s~~ rehabilitation ~~efforts~~ are spreading of topsoils ~~spreading with~~ of a minimum of > 70 cm thickness, soil ~~acidity (pH)~~pH of > 5,5, planting holes with 40 ~~cm~~ x 40 ~~cm~~ x 40 cm in size~~s,~~ soil ~~ammandment~~ amelioration ~~of~~ with dolomite, organic and/or chemical fertilizer application, vegetation planting and followed by intensive rehabilitated land~~s~~ management. The summary of the general characteristics of mined forest lands potential recovery after rehabilitation ~~works~~processes is shown in Table 1.

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Table 1. General characteristics of mined forest lands potential recovery after rehabilitation ~~works~~processes

Component	Parameter	Description
Soil Physics	Soil materials thickness	≥ 70 cm
	Bulk density	± 1,2
Soil Chemistry	Soil acidity (pH)	> 5,5
	Macro nutrients	Macro nutrients (N, P, K, Ca, Mg : Low ~~–~~to Moderate
Hydrology	Overland water flow	Decreasing inline with the increase of soil infiltration capacity : no significant detention of water
Erosion	Rate	Decreasing soil erosion rate: Class Very low to Moderate, Hazard Very slight to Moderate
Revegetation	Plants	Fast growing spcies form land coverage both of trees and ~~undergrowth~~herbs or grasses, interline planted primary species grow well

Wildlife	Fauna	~~Incoming~~Invading insects, ~~aves~~birds, ~~herpetofauna, reptilia~~amphibia, reptiles, small mammals
Habitat	Improvement	Improved habitat : microclimate - air and soil temperature, relative humudity, solar radiation intensity, foods and plant surface coverages.
Ecosystem	Status	Prospective with cofficient of similarity 60 - 70%, completely developed foodweb, ~~incoming~~invading herbivores, carnivores, predators, but ~~not yet top~~no top predators as yet.

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The ecosystem function of mined forest lands after rehabilitation ~~works~~processes shows ~~a~~ positive trends to ~~be~~ recovery as visually shown in Fig.3 to Fig.8.

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Fig.3. Rehabilitated lands management at TCM (fast growing species - 4 years)

Fig.4. Rehabilitated lands management at BC (fast growing and primary species 10-12 years)

Fig.5. Rehabilitated lands management at MTU (fast growing species 4-5 years)

Fig.6. Rehabilitated lands management at KTD (fast growing and agriculture 1-2 years)

Fig.7. Rehabilitated lands Management at KPC (fast growing, primary species > 10 years)

Fig.8. Rehabilitated lands management at KJA (fast growing and primary species > 12 years)

Mined Forest Lands Recovery potential

Degraded lands intially ~~occured by~~showed soils disturbance especially that of soil structure and soil pore~~s~~ destruction. For this reason, degraded lands have to be ~~framed that~~assessed as recovery processes ~~and it's basic functions must be~~ based on ~~edaphological~~ a soil characteristic approach. Analysis of erosion potential dynamics as a simple indicator of mined lands revegetation showed that to reach the status of low (L) and very low (VL) erosion rate ~~needs~~ requires ~~arround~~ about 5 (five) years (Table 2).

Table 2. Potential soil erosion dynamics following land coverage development at three sites

Sites[1]	Classification of soil erosion rate (classes of ton/ha/yr)[2] at each site and ages							
	Open	<2Yr	2-4Yr	4-6Yr	6-8Yr	8-10Yr	>10Yr	Original
SMO	(VH)	(H)	(L)	(L)	(VL)	(VL)	(VL)	(VL)
BMO	(VH)	(M)	(L)	(L)	(VL)	(VL)	(VL)	(VL)
LMO	(VH)	(H)	(H)	(VL)	(VL)	(VL)	(VL)	(VL)

~~Note:~~ [1] SMO, BMO, LMO : Sambarata, Binungan, Lati,

[2] VR = Very Low (<15 Ton/Ha/Year), L = Low (15-60 Ton/Ha/Year), M = Moderate (60-180 Ton/Ha/year), H = High (180-480 Ton/Ha/Year), VH = Very High (>480 Ton/Ha/Tahun)

Vegetation is the first biological component which is very important as primary producer providing nutrients, ~~land~~ ground cover~~s~~, clean air and habitats for various other life forms. The vegetation life form ~~at land surfaces~~ is a real ~~figure~~ measure of the soil quality, and ~~logically~~ also ~~for~~ the quality of the wildlife ~~existence~~. Therefore, ~~it could be stated that~~ soils, vegetation and wildlife are ~~the~~ an ~~unseparable~~ inseparable and strongly inter-dependent ~~three~~ component~~s~~ of the rehabilitated habitat.

The seasonal emerging plant~~s of~~ creeper species have~~s~~ an important role as an undergrowth land cover and improve the~~support~~ microclimate ~~improvement~~, and also supply~~ing~~ organic matter and ~~trigger incoming~~enhance the return of mesofauna (~~a~~invertebrate~~s~~~~a~~). Mesofauna ~~itself~~ return is closely related ~~with~~ to vertebrate~~a~~ (~~reptilia~~reptiles and~~,~~ amphibians) recover, many as predators on the mesofauna. Therefore, revegetation ~~with~~s plants, whether planted or naturally emerging~~,ed~~ are very important in the mined forest land~~s~~ recovery process~~.es~~.

The individual ~~ammount and~~ presence and frequency ~~make~~ of birds ~~as~~ are an interesting and useful~~l~~ method of monitoring ~~object~~. Some ~~of bird species,~~ changing trends ~~of~~ in composition and ~~it's~~ population richness of bird species, can be used as a bio-indicator of environmental chang~~e~~~~ing~~. Similarly ~~with birds as bio-indicator of environment changing~~, other ~~fauna~~ animals such as ~~of~~ butterflies~~y~~, dragonflies~~y~~, bumble bees, reptiles~~ia~~ and amphibians ~~are also~~ can also be used as bio-indicators.

Soil erosion potential ~~was~~ is influenced by several factors ~~determining it's occurences and one of~~

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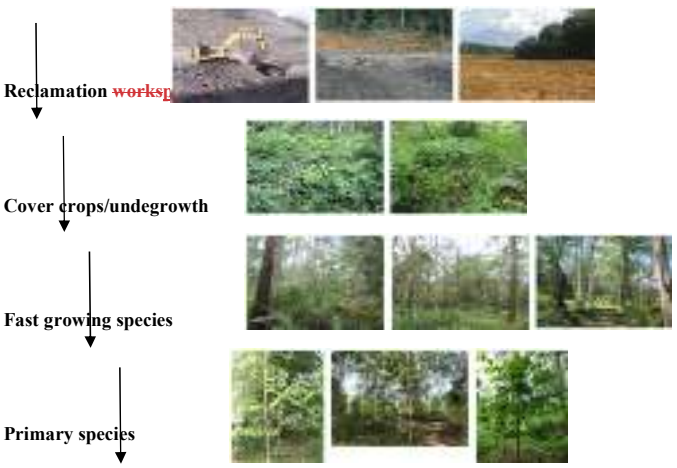
~~them is~~including vegetation development. ~~The~~ In order to decrease ~~of~~ the risk of soil erosion ~~hazard class means that~~ rehabilitated forest lands have to be intensively managed ~~at least~~ for at least the first 5 ~~(five)~~ years ~~period~~ especially in relation ~~with~~ to land preparation and the intensity of vegetation maintenance~~. intensity. This is due to l~~Land rehabilitation ~~works~~processes must initially ~~conducted~~ be introduced to control ~~overland~~ surface water flow~~. in order~~The plants ~~can~~ grow and ~~developing~~ provide ~~land~~ coverage to protect ~~land~~ soil surfaces form exessive ~~soil~~ erosion.

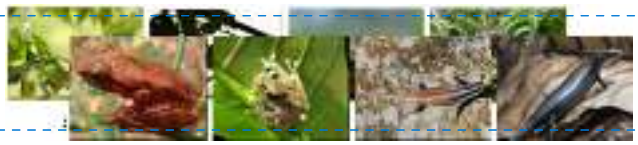
Ecological potential recovery of mined forest lands

~~Referring to~~With respect to the afore-mentioned ecological factors ~~mentioned~~, revegetated land recovery ~~processes~~ is ~~fully supported by~~made possible by the reclamation ~~works~~processes ~~that~~, namely, ~~was~~ land preparation to make the land function~~aling~~ as a medium~~a~~ for plant biomass production. Post mining revegetated land management, especially plant establishment~~s maintenance supports~~ results in vegetation development of both ~~of~~ both vertical and horizontal ~~forming vegetation~~ cover~~age upon revegetated lands~~.

In the early stages, ~~development~~ stabilisation of mined lands ~~coverage~~ by growing a cover crop~~vegetation~~ reduce~~d~~ soil erosion ~~potential~~ and gradually form~~s~~~~ing~~ a better microclimate ~~as of~~by decreasing air and soil temperatures and increasing air and soil humidities. The growth and development of vegetation ~~made organic materials~~ supplies~~y~~ organic materials into the soils ~~and~~ thus increasing soil fertility. ~~Following~~ In ~~the~~ time~~s~~, advance growth and development of vegetation contibute~~d~~ to the reduction of soil ~~the~~ erosion potential ~~reduction~~ and also ~~forming~~ forms a more ~~better~~ favourable microclimate~~. condition. Overall, t~~These conditions ~~invite~~ attract various animals (wildlife)~~s (fauna)~~ to feed~~ing at~~on rehabilitated mined lands, and more over liv~~inges~~ and ~~doing~~ enhancing the regeneration of the ecosystems (Figure 9).



~~Avifauna~~Birds



~~Herpetofauna~~Amphibians

Fig. 9. Steps ~~of~~ in the rehabilitation ~~works~~processes and ~~it's~~ the recovery processes, showing ~~indicator~~: land coverage by ~~growing~~ vegetation and ~~incoming~~ the invading wildlife~~s~~ ~~-~~ birds(avifauna) and amphibians(herpetofauna).

~~Naturally incoming~~The invading wildlife~~s~~ ~~is~~ can be potentially used as ~~a~~ bio-indicators for assessing the progress of ecological recovery of degraded lands. ~~processes of which ecologically being recovered.~~ More ~~S~~specifically, interline planting using primary species - dipterocarps species is a longterm investment to achieve more rapid recovery of mined lands ~~recovery~~. ~~Land c~~Cover crops and fast growing species planted in the early stages and rapidly reach~~inged~~ ~~their biological cycle~~flowering and fruiting ~~had completed task for~~ mak~~cing~~ an important contribution to bridging ~~to~~ the growth and developing of primary species ~~as~~ to the~~an~~ ultimate goal of degraded forest lands rehabilitation ~~works~~. A ~~more~~ higher diversity of ~~incoming~~invading wildlife~~s~~ to feed, liv~~cing~~ and regenerat~~cing~~ animal populations ~~indicate~~ shows a ~~more~~ clear direction and the steps of mined forest land~~s~~ recovery that is required (Fig.9).

Conclusions

The most important factors and ~~works~~ stages for land recovery are topsoil~~s~~ spreading (thickness and density), land preparation (planting hole, soil ammendment/amelioration materials), planting (plant materials, planting techniques), and rehabilitated mined forest lands management (replanting dead trees, maintenance, fertilization). The potential recovery of mined forest lands can be ~~indicated~~ shown by revegetation plants (land cover crop and fast growing species grow with undergrowth and interlayered crown, primary species are interline planted), decreasing soil erosion rate (soil erosion hazard class: very low to moderate, soil erosion hazard level: very slight to moderate, decreasing overland water flow in line with increasing soil infiltration capacities), and ~~incoming~~invading ~~-~~invading animals(wildlife) feeding, ~~playing~~ multiplying and ~~do~~ ecosystem regeneration. Mined forest land potential recovery could be ~~indicated~~ assessed through soil characteristics, overland water flow~~s~~, infiltration capacity, soil erosion and sedimentation, revegetation plants, ~~incoming~~ invading wildlife and ecosystem status; ~~As d~~Degraded lands are continuously recovering, the mined lands being ~~recover at least have been~~ on the

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right track to be recovery, as indicated by ~~appear~~ the interaction between ecosystem components of forest ~~land~~ ecosytems ~~of landscape~~, ~~hydro-orological~~hydrological conditions, ~~better~~ improved microclimate, and also ~~incoming~~ invading wildlife for regeneration of the ecosystems. The application of ~~R~~rehabilitation (*reclamation* and *revegetation*) ~~works~~processes has significantly ~~supported~~ enhanced the recovery of mined forest lands ~~recovery~~ and ~~was~~ were the most important basis for the improvement of degraded forest ecosystems.

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