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The importance of in-situ conservation area in mining concession in preserving diversity, threatened and potential floras in East Kalimantan, Indonesia

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Abstract. *Fiqa AP, Fauziah, Lestari DA, Budiharta S. 2019. The importance of in-situ conservation area in mining concession in preserving diversity, threatened and potential floras in East Kalimantan, Indonesia. Biodiversitas 20: 198-210.* East Kalimantan is the most well-known province in Indonesia with high natural resources, particularly from the mining sector. While delivering benefits for economic development, coal mining operation negatively affects biodiversity. Effort to mitigate impacts on biodiversity is by establishing an in-situ conservation area inside the coal mining area. This area is preserved in the form of arboretum from existing natural forests. The aim of this research is to identify the importance of conservation area in a mining concession in East Kalimantan regarding its plants' diversity, conservation status, and utilization. The research was conducted by doing vegetation analysis and inventorying plant biodiversity inside the in-situ conservation area by using plot samples. The result showed that the in-situ conservation area protects at least 142 species with a high level of biodiversity on all vegetation phases, indicated by Shannon Wiener diversity indices in which all phase have an index higher than 3. It protects 22 species listed in IUCN Red List of threatened species and contains at least 90 potential plants utilized by traditional Dayak people in their daily life. This study highlights that the conservation area is an important part in mining management to protect biodiversity, and suggest that in-situ conservation area should be preserved by every mining concession.

Keywords: coal mining conservation area, conservation status, plant diversity, potential plant, vegetation structure

INTRODUCTION

Borneo is among the richest biodiversity regions in the world. In general, plant diversity in Borneo at a regional scale is found to be highest in the northeastern part and the central mountainous region of the island, and therefore these areas are considered as biodiversity hotspot (Myers et al. 2000; Slik et al. 2003; Sodhi et al. 2004; Budiharta and Meijaard 2014; de Bruyn et al. 2014). Besides its diversity, the Indonesian part of Borneo (i.e., Kalimantan), has been known as a region with many endemic species of flora. The most prominent endemic plant species in Kalimantan belong to Dipterocarpaceae family along with other flora, notably *Nephentes* spp., *Mangifera casturi*, and *Coelogyne pandurata* (Adam et al. 1992; Paoli et al. 2006).

Despite rich in biodiversity, a biodiversity hotspot in Kalimantan (i.e., East Kalimantan) is also endowed with high natural resources including from the mining sector (Mahrita et al.2016). Through mineral commodities, the mining sector has contributed to the competitiveness of East Kalimantan economy at a provincial level. The production of East Kalimantan mineral commodities, one of which is coal, also plays a major role for national economy and becomes supplier to the world (Yuwono 2012).

While the coal mining sector delivers benefit for economic development, it also negatively affects biodiversity and degrade environmental quality overall. Land clearing activities in mining operation is a form of deforestation which may wipe out flora and fauna living above ground. Many examples explain how land clearing activities can cause decline in plant species diversity and threaten many endemic species towards extinction. Moreover, this activity also causes habitat loss for many fauna species, such as birds and mammals (Curran et al. 2004; Fitzherbert et al. 2008; Vijay et al. 2016). In addition, coal mining activities also deteriorate soil quality including soil hydrology and its biological properties with the impacted areas have high soil bulk density and less fertile soil due to compaction processes of the pile of materials from underground layers and heavy equipment traffic during the mining operation. This condition is characterized by low organic material content, pH, water holding capacity, salinity, texture, nutrient, soil compaction and acceleration of erosion rate (Kumar and Pandey 2013).

Because of such negative impacts of coal mining activities, prudent environmental planning and management are therefore needed to minimize the impacts on environment (Sheoran et al. 2010). One of them is through the establishment of high conservation value area regarding the level of plant diversity and endemism in the area. The importance of conservation area in coal mining is a form of mitigation effort to minimize the environmental impacts of mining activities following the concept of mitigation hierarchy: avoid, minimize and offset the negative impacts of natural resource management (Kiesecker et al. 2009; Budiharta 2016).

The concept of conservation area in mining concession is the preservation of a tract of natural forest with good condition in which no extractive activities, such as timber cutting and land clearing, are allowed. Conservation area is one of the solutions to reduce the loss of biodiversity because in this area plant and animal can persist in their habitat. The presence of conservation area within the coal mining concession can serve as a reference site during post-mining reclamation as well as provide source of seeds and wildlings for reclamation activities. Trimanto and Sofiah (2018) said that the feasibility of a conservation area could be determined from its high diversity index, the availability of water in the region, the availability of feeding sources for animals, and free of human activity disturbance.

Besides the diversity of plants species, especially of local species, the importance of conservation area could also be related to the existence of some species with conservation concern indicated by the status of IUCN Red List and the use of such plant diversity for local people. Forests are important for the livelihoods of local people in Kalimantan, as they depend on forest resources for various products such as construction materials, medicine, and food. In addition, forest also supplies ecosystem services such as providing clean water, regulating local climate, and preventing flood and landslide (Abram et al. 2014).

The aims of this research was to assess the importance of conservation area in a mining concession in East Kalimantan on the basis of plant diversity, plants with conservation status of IUCN Red List as well as the potential uses of such plant diversity.

MATERIALS AND METHODS

Study area

Research was conducted in the conservation area of a mining concession located in Village of Muara Begai, Sub-district of Muara Lawa, District of West Kutai, East Kalimantan Province, Indonesia (Figure 1). The area is located in about 121-147 m asl with geographic position of S00°51’46,0”-S00°51’993” and E115°26’884”-E115°27’435”. The annual average rainfall is about 2000 mm/year with daily temperature range between 26.7 and 31.5°C. The area has 37.91 ha in extent and is crossed by a small river. The soil in area is classified as Podzolic soil, and has various soil textures including sand, clay, and dust with the dominant texture is sand which covers about 47% of conservation area.

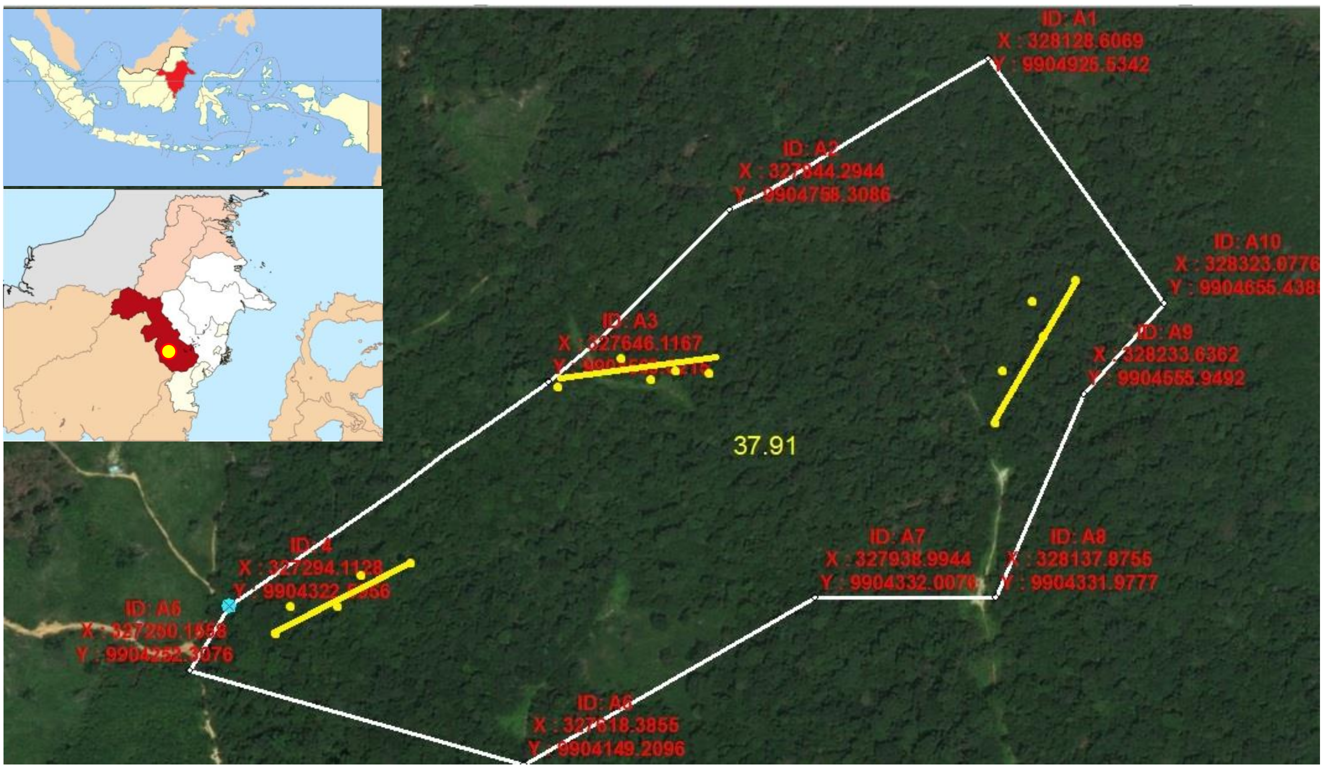

Figure 1. Study site location of conservation area in a mining concession in District of West Kutai, East Kalimantan, Indonesia, transect shown in yellow line and plot shown in yellow dots

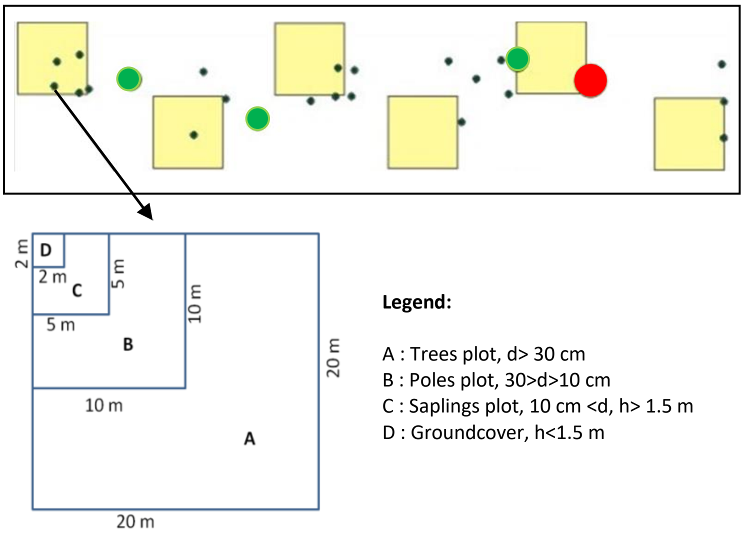

Figure 2. Observation plot on each transect on trees (*red spot*), poles and saplings (*green spot*), and groundcover (*black spot*)

Data collection

Vegetation analysis was carried out in the study area in three different transect directions to obtain represented data of the area (Figure 1). Vegetation inventory in the conservation area was done by making nested plots to record plants in four stages with 20x20 m plot is for tree (dbh ≥ 30 cm), 10x10 m plot is for pole (30>dbh>10), 5x5 m plot is for sapling (10>dbh and h>1.5 m) and 2x2 m plot is for ground cover (Indriyanto 2008). Observations of vegetation stages of four categories were done to determine the stability of the area through presence or absence of gaps in each phase of organism age. Each transect had five observation plots, totaling 60 plots for trees, poles, saplings and ground cover (Figure 2). Supporting data was documented including geographic coordinate and climatic factors (i.e. air temperature, relative humidity, altitude, light intensity, and soil pH).

Data analysis

Vegetation quality

Vegetation quality was determined based on the value of the Important Value Index of each species which is calculated based on the sum of relative density (RD) and relative frequency (RF) values with additional variable of relative coverage/dominance (RC) for trees, poles, and sapling. The quality of vegetation in the area was analyzed based on the Shannon-Wiener Diversity Index (H') formulated as:

$$H' = -\Sigma\, p_i \ln p_i;\; p_i = n_i/N,$$

pi = ratio of the number of individuals in each species to the total number of individuals

ni = number of the individual from species-i

N = total number of individual

Flora with conservation importance and potential uses

The conservation importance of all plants recorded inside the observations plots was evaluated based on the IUCN Red List (www.iucnredlist.org), to identify its status. The status of its protection is also assessed in regard to the Republic of Indonesia Government Regulation and related ministry decrees. The study of potential uses of plants inventoried in the conservation area was carried out through direct interviews with field guides who are local Dayak tribes and strengthened by literature studies.

RESULTS AND DISCUSSION

General description of the conservation area

The conservation area in the study site is established to preserve biological diversity in-situ within the concession area by reserving a block of remaining natural forest. This area also serves as reference site of the natural condition of typical East Kalimantan forest for the purpose of reclamation program after the mining activities are completed. This forest is also functioned to provide plant seeds and wildlings to be used during reclamation activities. Formerly, the conservation area was logged-over forest with selective logging system. Therefore, several large trees that had been cut down including *Eusideroxylon zwageri* and *Shorea* spp. which can be seen from the tree stumps found in the forest.

Forests in the conservation area are classified as wet lowland forest with an altitude of <200 m above sea level and daily air temperatures of 25-32ºC (Table 1). Observations carried out in the conservation area during the study show that as mentioned in Mabberley (1992), that in tropical forest areas, the value of the daily temperature will rarely reach 38°C, but will rarely fall below 20°C. In open area, the light intensity will be high, but in close canopy the light intensity entering the forest ground was low. The wide-ranging light intensity shows a typical of closed-canopy yet sunlight rich tropical forest. The humidity measured at the time of observation also depends on the tree canopy where the measure is undertaken. The denser is the canopy, the higher is the humidity. The soil pH of the area tend to be acidic (pH<7) (Wibowo 2009). However, the value ranges are higher compared to the average soil pH in the concession area reported in 2015 with only 4.5.

Plant diversity and vegetation structure

Result shows that total of 35 species of trees, 45 species of poles, 62 species of saplings and 56 species of ground cover within 60 plots. The result suggests that the vegetation in the conservation area is quite stable and ideal. Forest vegetation with ideal conditions is indicated by plants in the younger stages, namely poles, saplings and ground cover, having more species than trees (Wirakusumah 2003). This will ensure the forest regeneration will proceed well.

Based on the Shannon-Wiener Diversity Index in the study site, all vegetation stages have high diversity with H'>3 (Magurran 1988). Sapling is vegetation type with the highest H'of 3.8, while tree H' has the lowest H' with value of 3.3 (Figure 3). Due to the limited space and resources to support growth, plant diversity will decrease along with the increase in plant size. Forests in Kalimantan are among the highest in the world in term of diversity and density (Slik et al. 2015). For example, a sample plot in Central Kalimantan is reported to have Shannon-Wiener diversity index of 3.40 for secondary forest and 4.17 for the primary forest (Brearley et al. 2004). In line with that, Budiharta (2010) also found that the Shannon-Wiener diversity index in another part of Central Kalimantan forest is about 3.54 and 3.49 for trees and sapling respectively. In this research, the high vegetation quality indicates that the existence of conservation areas in a mining concession is very important to be preserved as an in-situ conservation strategy especially for endemic species as well as for reference site and source of seeds and wildlings post-mining reclamation program.

The forest of conservation area in this study which is dominated by Dipterocarpaceae family resembles the typical of tropical forest in Kalimantan often known as Dipterocarpaceae forest (Slik et al. 2003; Brearley et al. 2004; Wilkie et al. 2004), (Figure 4). Dipterocarpaceae family contributes 17 species which are evenly distributed across the stage of trees, poles, saplings, and groundcover with the latter in the form of seedlings. Whereas the Euphorbiaceae family consists of nine species, but there are no species in the tree stage. Lauraceae has 8 species in conservation area on tree and sapling vegetation stage. Some species belonging to the Dipterocarpaceae and Lauraceae families are species that have the potential as timber trees that have a high risk to be logged. As such their existence in each phase needs to be considered to maintain their presence in its natural habitat.

The highest Important Value Index (IVI) on tree vegetation stages is *Dipterocarpus cornutus* (kruwing; local names) with IVI value of 27.62%. It means that this species plays an important role in the ecosystem of the conservation area. This value is only slightly higher than *Shorea leprosula* (red meranti) and *Eusideroxylon zwageri* (Ulin; local names) with IVI value of 23.19% and 21.53% respectively. However, there are large gaps between IVI value of these three species compared to the other species which have IVI value less than 15% (Figure 5). This indicates that there is co-dominant of *Dipterocarpus cornutus*, *Shorea leprosula* and *Eusideroxylon zwageri* in the area. Some tree species in the conservation area are shown in Figure 5. Trees in this conservation area, have a fairly high density, reaching of 120 individuals/ha with a basal area of about 15 m^2. As such, this conservation area can be categorized as a secondary forest as the tree density and basal area is >30/ha and >10m^2 respectively (Pagiola et al. 2004). For comparison, a primary forest in East Kalimantan has tree density and basal area of 88 ind/ha and 22.93 m^2 respectively (Haryati et al. 2011).

Table 1. Environmental factors in forest conservation area

Abiotic factors	Value
Temperature (°C)	26.7-31.5
Humidity (%)	66-80
Light intensity (Lux)	253-7660
Soil pH	5.1-6.2
Altitude (m asl)	121-147

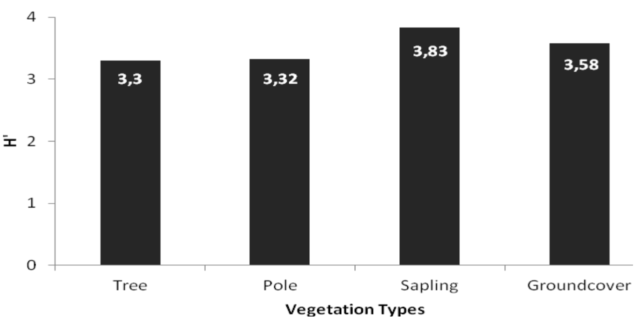

Figure 3. Shannon Wiener diversity index on each vegetation stages in the conservation area of the study site

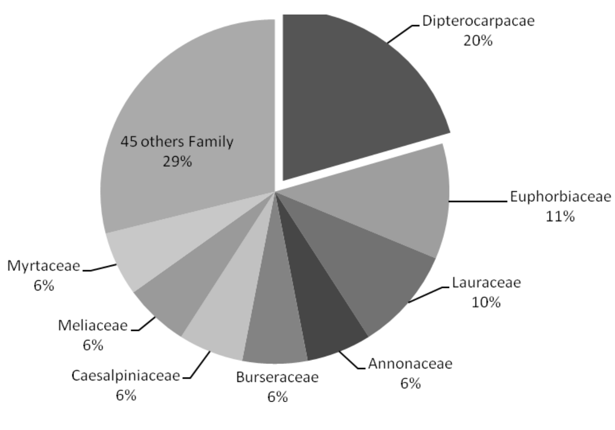

Figure 4. Distribution of each family in the conservation area of study site

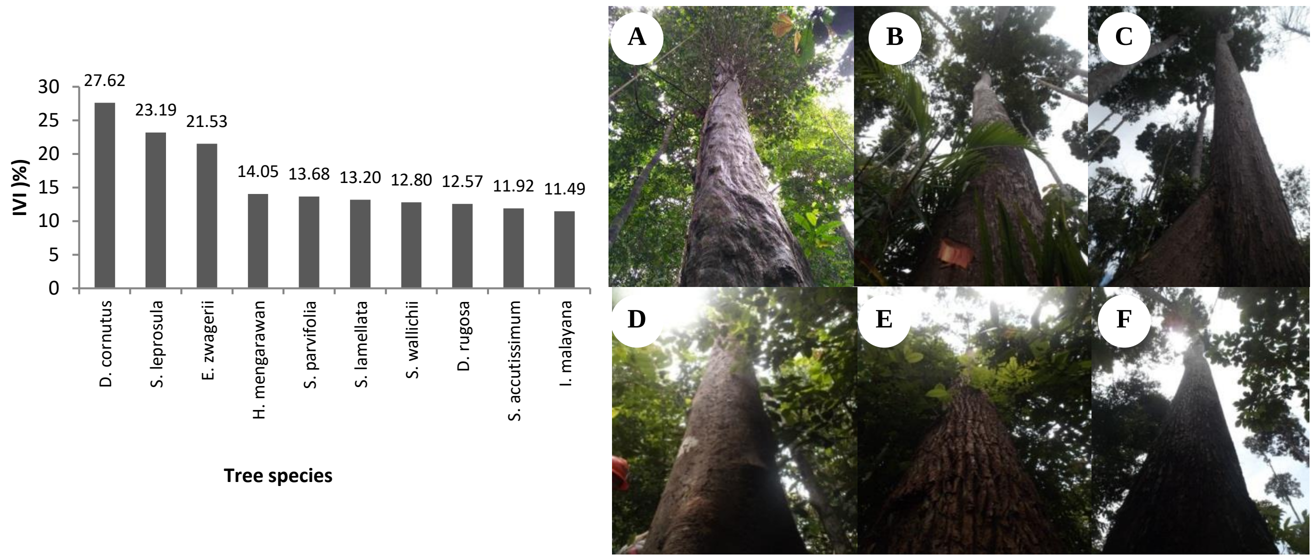

Figure 5. (Left) Five tree species with the greatest IVI (%), (Right) Tree species encountered in conservation area of study site; A. *Eusideroxylon zwageri*, B. *Shorea leprosula*, C. *Shorea parvifolia*, D. *Endiandra kingiana*, E. *Calophyllum pisiferum*, F. *Drypetes kikir*

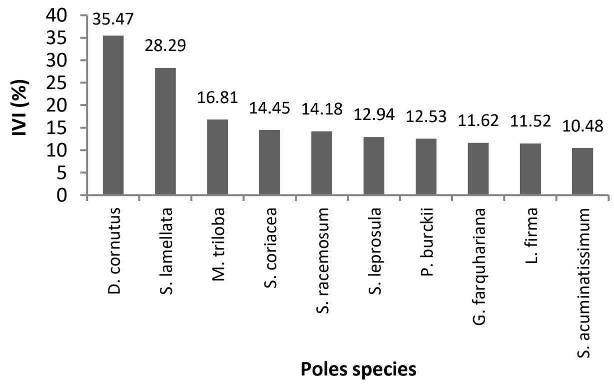

Figure 6. The greatest IVI value of ten plant species of pole

Poles are vegetation stage with diameter of breast high between 10 and 30 cm. In the conservation area, poles have relatively similar H' to tree, which is3.32 (Figure 6). The species recorded in the plots are relatively similar with the species inventoried at the trees stage. Two most important species at poles stage are also ranked as important at trees stage, namely *Dipterocarpus cornutus* and *Shorea lamellata*. Some species of *Shorea* in the conservation area have been in strata A according to forest stratification system because they have height of more than 40 m although their diameter has not reached 30 cm. The existence of *D. cornutus* and *S. lamellata* confirms that these species could proceed from poles stage to trees as long as no extreme condition occurred. In contrast, *E. zwageri*, an endemic species to Kalimantan which is found in quite large number at trees stage, is hard to find in lower stages. In fact, at the poles stage, *M. triloba* becomes the third most important species with IVI of 16.81%. This species is known as primary species that grow in disturbed secondary forests favoring opening gaps (Slik et al. 2003). This result indicates that the conservation area is secondary forest that has been disturbed, presumably by previous logging activities.

At sapling vegetation stage, two species from the genus of *Macaranga* are noted as important species with *M. Triloba* has the highest IVI. Beside *M. triloba*, *M. gigantea* is also recorded as species with high IVI. The occurrence of these *Macaranga* species is the typical characteristic of secondary forests during vegetation succession which is potential as pioneer plants in post-mining reclamation. Sapling vegetation in the conservation area shows more varying families and species than at the trees and poles stages. Plant species at sapling vegetation stage in the conservation area is shown in Figure 7.

Ground cover plants in the conservation area are dominated by *Maranta lietzei* and followed by *Hedychium borneense* (Figure 8). *M. lietzei* is a non-native plant and originated from America tropics. This plant grows well in moist forests with good shade (Perera et al. 2009). The occurrence of non-native species indicates that the forest area is disturbed because ground cover is the simple measure of ecosystem disturbance (Sutomo and Fardila 2013). However, since *M. lietzei* requires shade and high humidity for its growth, it can be concluded that forest canopy is still largely closed.

Beside of *M. lietzei* and *H. borneense*, *Melastoma malabathricum* becomes ground cover plant species that have high IVI value. *H. borneense* and *M. malabathricum* are the native species commonly found in Indonesia. Similar with *Macaranga*, *M. malabathricum* is an indication that the area has been disturbed. Some of the ground cover species in the conservation area is shown in Figure 8.

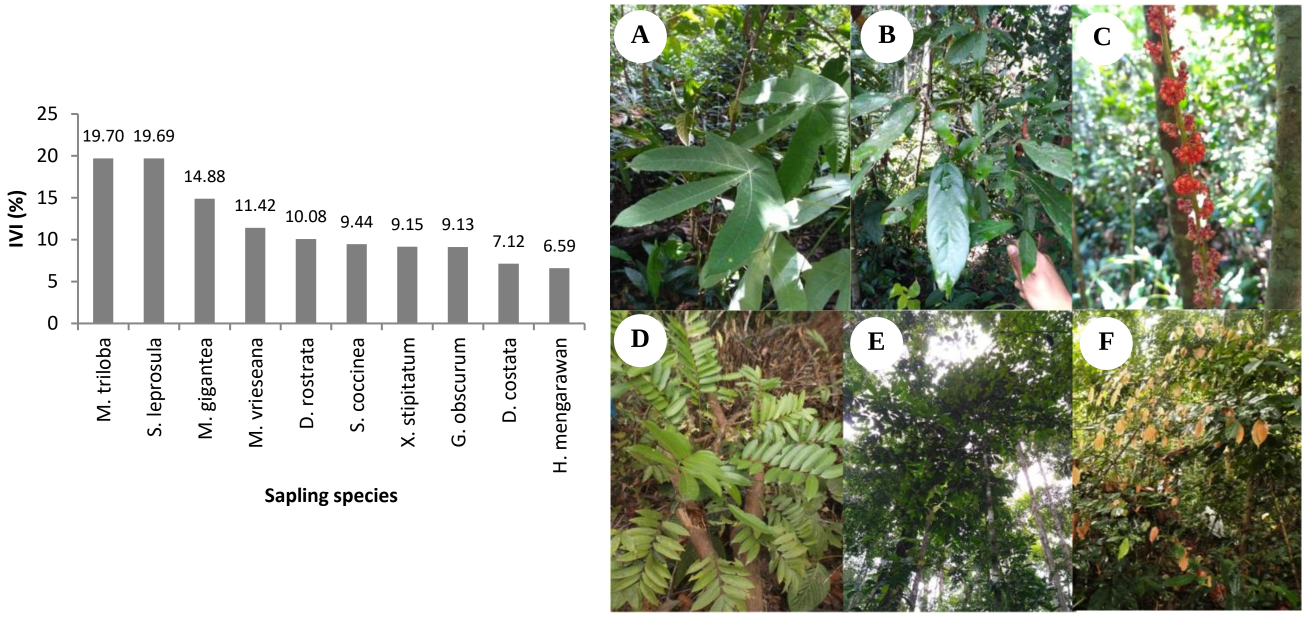

Figure 7. The greatest IVI value of ten plant species of sapling (*left*)*;* Sapling plant species encountered in the conservation area of study site (*right*); A. *Macaranga triloba*, B. *Koilodepas brevipes*, C. *Sarcotheca diversifolia*, D. *Eurycoma longifolia*, E. *Mitrephora polypyrena*, F. *Orophea hexandra*

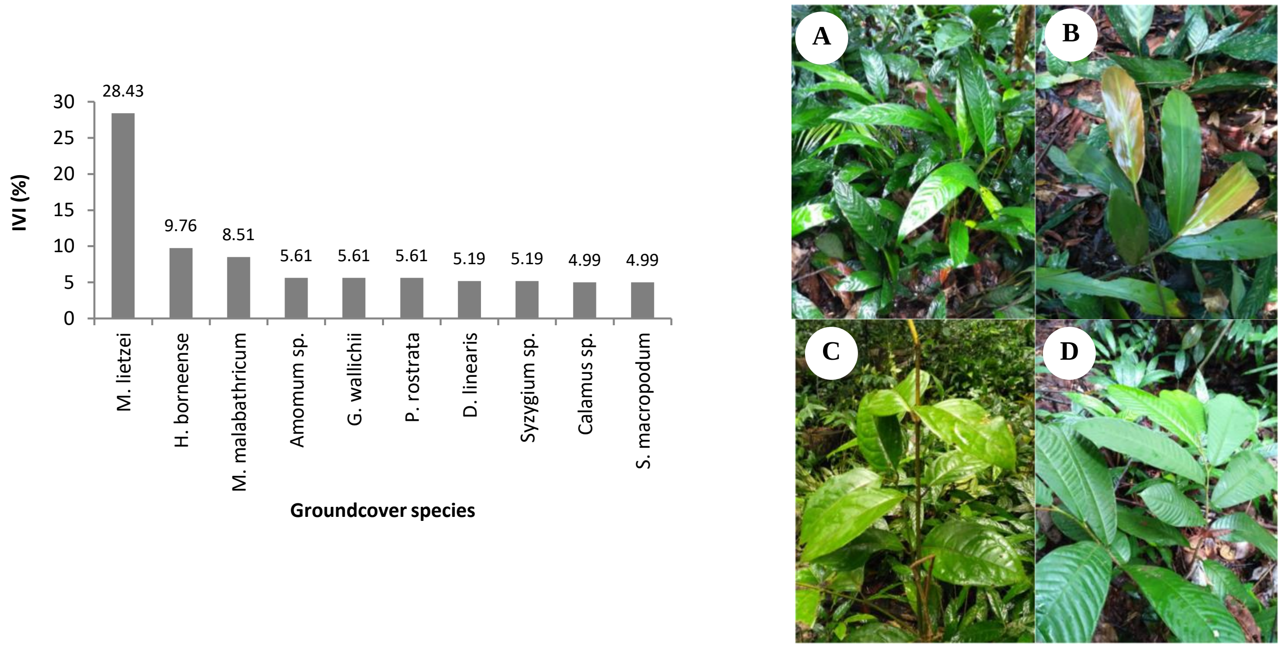

Figure 8. The greatest IVI value of ten plant species of ground cover (*left*); Ground cover plant species (*right*); A. *Maranta lietzei*, B.*Haedychium borneense*, C.*Ficus racemosa*, D. *Goniothalamus macrophyllus*

The existence of conservation area in this natural habitat has conserved plant biodiversity of Kalimantan as well as its various endemic species. Unfortunately, the presence of conservation area could not save many orchid species. In 2010 (Trimanto and Sofiah 2018; Sofiah et al. 2018), 53 orchid species have been recorded living in the Bersiq Bermai forest, near the conservation area. However, none of them has been noted in the observation plots of this study. Although the existence of the area has not been optimal in conserving native orchids of Kalimantan, yet this secondary forest can serve as refugia for other plant species and as reference site for the implementation of mining reclamation activities.

Table 2. Plant species in the conservation area of study site which is listed in IUCN

Species	Family	Conservation status based on IUCN
Dipterocarpus cornutus	Dipterocarpaceae	CE ver 2.2
Shorea lamellata	Dipterocarpaceae	CE ver 2.2
Shorea smithiana	Dipterocarpaceae	CE ver 2.2
Dipterocarpus tempehes	Dipterocarpaceae	CE ver 2.3
Hopea mengarawan	Dipterocarpaceae	CE ver 2.3
Shorea seminis	Dipterocarpaceae	CE ver 2.3
Dryobalanops beccarii	Dipterocarpaceae	EN ver 2.2
Dryobalanops lanceolata	Dipterocarpaceae	EN ver 2.3
Cyperus elatus	Poaceae	LC ver 3.1
Koompassia excelsa	Caesalpiniaceae	LR ver 2.2
Aglaia argentea	Meliacceae	LR/lcver 2.3
Calophyllum pisiferum	Clusiaceae	LR/lcver 2.3
Cratoxylum formosum	Hypericaceae	LR/lcver 2.3
Dacryodes costata	Burseraceae	LR/lcver 2.3
Dacryodes rostrata	Burseraceae	LR/lcver 2.3
Irvingia malayana	Simaroubaceae	LR/lcver 2.3
Knema latifolia	Myristicaceae	LR/lcver 2.3
Scaphium macropodum	Sterculiaceae	LR/lcver 2.3
Shorea leprosula	Dipterocarpaceae	NT ver 3.0
Durio acutifolius	Bombacaceae	VUL er 2.3
Eusideroxylon zwageri	Lauraceae	VUL ver 2.2
Psydrax dicoccos	Rubiaceae	VUL ver 2.3

Note: CE: Critically Endangered, EN: Endangered, VUL: Vulnerable; NT: Near Threatened; LR: Lower Risk; LR/lc: Lower Risk/least concern

Table 3. Plant species in conservation area of study site which is included in government regulation

Species	Family	Government regulation
Koompassia excelsa	Leguminosae	Permen LHK No. P.20/2018
Eusideroxylon zwageri	Lauraceae	SK Mentan No. 54/Kpts/Um/2/1972; Permen LHK No. P.20/MENLHK/ SETJEN/KUM.1/6/2 018

Conservation status

Conservation status of plant species in the conservation area was determined based on The International Union for Conservation of Nature (IUCN) list (Table 2) and government regulation (Table 3). The results show that most plant species found in the conservation area and listed in IUCN Red List and government regulation belong to the Dipterocarpaceae family.

Durio cornutus as tree species with the highest IVI is listed as Critically Endangered. In the conservation area, this species has density of 15 trees per ha and is found at the stages of trees, poles, and sapling. *Shorea smithiana* is also listed as Critically Endangered yet it only has density of 3 trees per ha and is found in the tree and poles stage only. Despite *E. zwageri* is stated as Vulnerable species, this species is only encountered at trees and poles stages with small number. *E. zwageri* in the past was commonly found in a large number and contributed greatly to the basal area (Riswan et al. 1985). *Shorea leprosula* is the only species which has complete vegetation stages in the conservation area and it is stated as Near Threatened. *D. acutifolius*, an endemic species from Kalimantan and only found in the phase of groundcover as a seedling is listed as Vulnerable.

Indonesian government regulations also control some species that potential to be cut down as timber. *Koompassia excelsa* listed as a Lower Risk by IUCN is also protected by the Indonesian government regulation. *Eusideroxylon zwageri* listed as Vulnerable species by the IUCN is still permitted being able to cut down for the tree with minimum diameter at breast high of 60 cm.

Serving as habitat of more than 20 species listed as threatened species, the conservation area holds another important role for biodiversity conservation. This list of threatened species in the conservation areas could be used as reference in enrichment planting during reclamation activities by planting such threatened species and could be considered as one of indicators of the successful restoration programs. As they are mostly endemic species, the presence of this species will conserve biodiversity even to the level of genetic (Trimanto and Sofiah 2018). .

Potential uses of plant

Many species in the conservation area of the study site are used by local people living nearby the mining concession (Table 4). Local people use various products from intact and highly degraded forests. The benefits of forest to local people include sources of foods, building materials, tools, craft, and medicinal plants as well as for cultural and spiritual purposes (Abram et al. 2014). Based on Meijaard et al. (2013), local people in Kalimantan also have high awareness of negative environmental impacts of deforestation on ecosystem services such as air pollution, hotter temperature, and loss of clean water sources. Dayak people in Kalimantan using their indigenous knowledge to conserve their traditionally managed forest called Simpukng. This simpukng provide their daily needs such as food, medicine, cooking wood and also other product for traditional ceremony (Mulyoutami et al. 2009).

Most of species found in the conservation area were potential for timber either for major or minor timber. Species from Dipterocarpaceae family is the most widely used for timber, consisting 27% of a total of 63 species of potential plant for timber trees. In total, there are 25 families recorded the conservation area which has potential use for timber. While most timber trees have already been in literature, some species are rarely mentioned such as *Goniothalamus macrophyllus, Tetracera scandens, Shorea parviflora, Baccaurea pyriformis,* and *Psydrax dicoccos*. People use the trunk to build traditional house, make household tools or create handicraft.

Table 4. Potential uses of plant species in conservation area of the study site

Species	Family	Uses	References
Timber, household material and handcraft			
Ryparosa hullettii	Achariaceae	Timber	Nasution (1998a)
Ryparosa javanica	Achariaceae	Timber	Nasution (1998b)
Dracontomelon dao	Anacardiaceae	Household appliances and craft materials	Heyne (1987b); Verheij and Coronel (1992b)
Gluta wallichii	Anacardiaceae	Household appliances and craft materials	Boer et al. (1995a)
Koordersiodendron pinnatum	Anacardiaceae	Timber	Boer et al. (1995b)
Goniothalamus macrophyllus	Annonaceae	Timber, furniture material plant	-
Mitrephora polypyrena	Annonaceae	Timber	Boer and Sosef (1998c)
Orophea hexandra	Annonaceae	Timber	Boer and Sosef (1998d)
Calamus sp.	Arecaceae	Household appliances and craft materials	Heyne (1987a); Anon (1994a)
Daemonorops sp.	Arecaceae	Household appliances and craft materials	Heyne (1987a); Anon (1994b)
Dacryodes rugosa	Burseraceae	Timber	Kochummen (1998c)
Dacryodes costata	Burseraceae	Timber	Kochummen (1998a)
Dacryodes rostrata	Burseraceae	Timber	Kochummen (1998b)
Santiria oblongifolia	Burseraceae	Timber	Kochummenet al. (1995)
Sindora leiocarpa	Caesalpiniaceae	Timber	Heyne (1987b); Sambas et al. (1994a)
Sindora wallichii	Caesalpiniaceae	Timber	Heyne (1987b);Sambas et al. (1994b)
Koompasia excelsa	Caesalpiniaceae	Timber	Razali and Sudo (1994)
Cyperus elatus	Cyperaceae	Craft material plants	Dasuki (2003)
Dillenia ovata	Dilleniaceae	Timber	Rugayah et al. (1995a)
Dillenia reticulata	Dilleniaceae	Timber	Rugayah et al. (1995b)
Tetracera scandens	Dilleniaceae	Craft material plants	-
Hopea mengarawan	Dipterocarpaceae	Timber	Heyne (1987c); Kochummen et al. (1994a)
Shorea coriacea	Dipterocarpaceae	Timber	Kochummen et al. (1994b)
Shorea lamellata	Dipterocarpaceae	Timber	Kochummen et al. (1994c)
Shorea leprosula	Dipterocarpaceae	Timber	Heyne (1987c); Kochummen et al. (1994d)
Shorea ovalis	Dipterocarpaceae	Timber	Kochummen et al. (1994e)
Shorea parviflora	Dipterocarpaceae	Timber	-
Shorea parvifolia	Dipterocarpaceae	Timber	Heyne (1987c); Kochummen et al. (1994f)
Shorea pinanga	Dipterocarpaceae	Timber	Kochummen et al. (1994g)
Shorea seminis	Dipterocarpaceae	Timber	Kochummen et al. (1994h)
Shorea smithiana	Dipterocarpaceae	Timber	Kochummen et al. (1994i)
Vatica oblongifolia	Dipterocarpaceae	Timber	Lemmens et al. (1994)
Dryobalanops aromatica	Dipterocarpaceae	Timber	Lee et al. (1994a)
Dipterocarpus cornutus	Dipterocarpaceae	Timber	Smitinand et al. (1994a)
Dipterocarpus tempehes	Dipterocarpaceae	Timber	Smitinand et al. (1994b)
Dryobalanops beccarii	Dipterocarpaceae	Timber	Lee et al. (1994b)
Dryobalanops lanceolata	Dipterocarpaceae	Timber	Lee et al. (1994c)
Diospyros andamanica	Ebenaceae	Timber	Soerianegara et al. (1995a)
Diospyros macrophylla	Ebenaceae	Timber	Soerianegara et al. (1995b)
Baccaurea pyriformis	Euphorbiaceae	Timber	-
Castanopsis buruana	Fagaceae	Timber	Sunarno et al. (1995)
Cratoxylum formosum	Hypericaceae	Timber	Kartasubrata et al. (1994a)
Cratoxylum sumatranum	Hypericaceae	Timber	Kartasubrata et al. (1994b)
Actinodaphne borneensis	Lauraceae	Timber	Slik (2009)
Dehaasia caesia	Lauraceae	Timber	Wiselius (1998a)
Dehaasia cuneata	Lauraceae	Timber	Wiselius (1998b)
Endiandra kingiana	Lauraceae	Timber	Wiselius and Sosef (1998)
Eusideroxylon zwageri	Lauraceae	Timber	Kostermans et al. (1994a)
Litsea firma	Lauraceae	Timber	Lemmens et al. (1995)
Fagraea racemosa	Loganiaceae	Timber	Hildebrand et al. (1995)
Magnolia vrieseana	Magnoliaceae	Timber	-
Pternandra galeata	Melastomataceae	Timber	Boer and Sosef (1998e)
Pternandra rostrata	Melastomataceae	Timber	Boer and Sosef (1998f)
Aglaia argentea	Meliaceae	Timber	Ba et al. (1995)
Walsura pinnata	Meliaceae	Timber	Boer and Sosef (1998g)

Artocarpus anisophyllus	Moraceae	Household appliances materials	Djarwaningsih et al. (1995)
Knema latifolia	Myristicaceae	Timber	Sambas and Sosef (1998)
Phyllanthus emblica	Myrsinaceae	Timber	van Schaik and van Banning (1992)
Syzygium racemosum	Myrtaceae	Timber	Haron et al. (1995b)
Syzygium rugosa	Myrtaceae	Timber	Haron et al. (1995c)
Syzygium polycephaloides	Myrtaceae	Timber	Haron et al. (1995a)
Ochanostachys amentacea	Oleaceae	Timber	Boer et al. (1995c)
Sarcotheca diversifolia	Oxalidaceae	Timber	Chung (1998)
Drypetes kikir	Putranjivaceae	Timber	Boer and Sosef (1998a)
Carallia borneense	Rhizoporaceae	Timber	Hou (1998)
Psydrax dicoccos	Rubiaceae	Timber	-
Melicope latifolia	Rutaceae	Traditional house material building	Boer and Sosef (1998b)
Nephelium cuspidatum	Sapindaceae	Timber	Uji (1998)
Tristiropsis acutangula	Sapindaceae	Timber	van Welzen (1998)
Palaquium burckii	Sapotaceae	Timber	Kartasubrata et al. (1994c)
Palaquium rostratum	Sapotaceae	Timber	Kartasubrata et al. (1994e)
Palaquium gutta	Sapotaceae	Timber	Kartasubrata et al. (1994d)
Irvingia malayana	Simaroubaceae	Timber	Yusuf (1998)
Scaphium macropodum	Sterculiaceae	Timber	Kostermans et al. (1994b)
Gonystylus velutinus	Thymelaeaceae	Timber	Soerianegara et al. (1995c)
Edible fruit, vegetable, ingredients and animal feed			
Dracontomelon dao	Anacardiaceae	Edible fruit, vegetable,	Verheij and Coronel (1992b)
Koordersiodendron pinnatum	Anacardiaceae	Edible fruit, beverage ingredients	-
Blechnum orientale	Blechnaceae	Vegetable plants	Kumar et al. (2015)
Durio acutifolius	Bombacaceae	Edible fruit	Yap et al. (1995)
Dacryodes rugosa	Burseraceae	Edible fruit	Kochummen (1998c)
Garcinia parviflora	Clusiaceae	Edible fruit	-
Dillenia ovata	Dilleniaceae	Animal feed plants	Rugayah et al. (1995a)
Dillenia reticulata	Dilleniaceae	Animal feed plants	Rugayah et al. (1995b)
Baccaurea pyriformis	Euphorbiaceae	Edible fruit	Verheij and Coronel (1992a); Matius et al. (2018)
Artocarpus anisophyllus	Moraceae	Edible fruit	Djarwaningsih et al. (1995)
Gymnacranthera farquhariana	Myristicaceae	Animal feed plants	-
Phyllanthus emblica	Myrsinaceae	Edible fruit	van Schaik and van Banning (1992)
Syzygium polycephaloides	Myrtaceae	Edible fruit	Haron et al. (1995a)
Sarcotheca diversifolia	Oxalidaceae	Edible fruit	-
Fordia splendidissima	Papilionaceae	Vegetable plants	-
Nephelium cuspidatum	Sapindaceae	Animal feeds plants	-
Hedychium borneense	Zingiberaceae	Edible tuber	-
Dryobalanops aromatica	Dipterocarpaceae	Edible nut	Lee et al. (1994a)
Ochanostachys amentacea	Oleaceae	Edible fruit	Boer et al. (1995c)
Medicinal, poisonous and essential oils plants			
Dracontomelon dao	Anacardiaceae	Medicinal plants	Verheij and Coronel (1992b)
Gluta wallichii	Anacardiaceae	Medicinal plants	Boer et al. (1995a)
Goniothalamus macrophyllus	Annonaceae	Medicinal plants	Shaari (2002)
Blechnum orientale	Blechnaceae	Medicinal plants	Kumar et al. (2015)
Koompasia excelsa	Caesalpiniaceae	Medicinal plants	Razali and Sudo (1994)
Sindora leiocarpa	Caesalpiniaceae	Medicinal plants	Heyne (1987b); Sambas et al. (1994a)
Sindora wallichii	Caesalpiniaceae	Medicinal plants	Heyne (1987b); Sambas et al. (1994b)
Mapania cuspidata	Cyperaceae	Medicinal plants	Lemmens (2002)
Tetracera scandens	Dilleniaceae	Medicinal plants	Heyne (1987c); Tawan (2002)
Dryobalanops aromatica	Dipterocarpaceae	Medicinal plants	Lee et al. (1994a)
Koilodepas brevipes	Euphorbiaceae	Medicinal plants	-
Fagraea racemosa	Loganiaceae	Medicinal plants	Hildebrand et al. (1995)
Melastoma malabathricum	Melastomataceae	Medicinal plants	van Velkenburg and Bunyapraphatsara (2002)
Heynea trijuga	Meliaceae	Leaves for insecticides, poison dart	Brotonegoro and Wiharti (2003)
Ochanostachys amentacea	Oleaceae	Medicinal plants	Boer et al. (1995c)
Carallia borneense	Rhizoporaceae	Medicinal plants	Hou (1998)
Luvunga scandens	Rutaceae	Medicinal plants	Mutiatikum (2003)
Palaquium gutta	Sapotaceae	Medicinal plants	Kartasubrata et al. (1994d)
Smilax excelsa	Smilacaceae	Medicinal plants	Ozsoy et al. (2008)
Scaphium macropodum	Sterculiaceae	Medicinal plants	Kostermans et al. (1994b)
Hedychium borneense	Zingiberaceae	Essential oil plants	-

Dye materials			
Phyllanthus emblica	Myrsinaceae	Dye materials	van Schaik and van Banning (1992)
Syzygium racemosum	Myrtaceae	Dye materials	Haron et al. (1995b)
Koordersiodendron pinnatum	Anacardiaceae	Dye materials	Boer et al. (1995b)
Traditional ceremony plants			
Mitrephora polypyrena	Annonaceae	Traditional ceremony plants	-
Orophea hexandra	Annonaceae	Traditional ceremony plants	-
Ornamental plants			
Alocasia longiloba	Araceae	Ornamental plants	Yuzammi and Rahardjo (2006)
Fagraea racemosa	Loganiaceae	Ornamental plants	Hildebrand et al. (1995)
Maranta lietzei	Maranthaceae	Ornamental plants	-
Nephrolepis radicans	Nephrolepidaceae	Ornamental plants	-
Dillenia ovata	Dilleniaceae	Ornamental plants	Rugayah et al. (1995a)
Dillenia reticulata	Dilleniaceae	Ornamental plants	Rugayah et al. (1995b)
Cratoxylum formosum	Hypericaceae	Ornamental plants	Kartasubrata et al. (1994a)
Magnolia vrieseana	Magnoliaceae	Ornamental plants	-

Some edible flora recorded from the interviews is also rarely discussed existing literature as well. Local people around the study site traditionally consume such lesser-known species for vegetables such as *Fordisia splendidissima*; for fruits such as *Koordersiodendron pinnatum* and *Garcinia parviflora*; tuber for carbohydrate such as *Hedychium borneense*; and animal feedings such as *Nephelium cuspidatum* and *Gymnacranthera farquhariana*. *Hedychium borneense* is not only known as potential source of carbohydrate but also can be used for aromatherapy. *Mitrephora polypyrena* and *Orophea hexandra* are known as plants for traditional ceremony while *Koilodepas brevipes*is is believed by traditional people to cure cancer.

Contribution to conservation

Based on the results of this study, the conservation area plays an important role for in-situ conservation. This is indicated by its high diversity index value (H>3) in all vegetation stages. The area also hosts some Bornean endemic species as well as species with conservation concern as listed in the IUCN Red List. Differ with Besiq Bermai forest area located nearby the mining concession in which the trees and sapling stages dominated by *Dillenia excelsa* and *Macaranga triloba* (Sofiah et al. 2018), the conservation area in this study is dominated by *D. cornutus*, a species listed as Critically Endangered by the IUCN. Trimanto and Sofiah (2018) also reported that in Besiq Bermai forest there are 20 species listed in the IUCN Red List, while the conservation area in this study protects 22 species by such list. In addition, the diversity of plant species in the conservation various potential uses for local people which help conserve traditional wisdom and culture. People in Borneo stated that forest is important for them, especially for the health, cultural and spiritual benefits (Meijaard et al. 2013). This study implies that each mining concession, especially in the area of biodiversity hotspots, should preserve a conservation area for in-situ conservation strategy and as a reference area for post-mining reclamation activities.

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