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The sufficiency of existed protected areas in conserving the habitat of proboscis monkey (*Nasalis larvatus*)

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Abstract. *Wardatutthoyyibah, Pudyatmoko S, Subrata SA, Imron MA. 2019. The sufficiency of existed protected areas in conserving the habitat of proboscis monkey (*Nasalis larvatus*). Biodiversitas 20: 1-10.* Proboscis monkey *(Nasalis larvatus)* is an endemic species on the island of Borneo. Their population size progressively decreased because they are very sensitive to any habitat destruction and human activity. The population of proboscis monkey in 2008 was estimated at only approximately 25,000 in total, of which only 5,000 within the conservation areas. However so, the continuation of habitat degradation is hardly prevented in non-protected areas. To solve the problem, the Indonesian government commits to increase the population of the proboscis monkey, particularly outside the protected areas. To support this goal, the distribution data of *N. larvatus* for conservation planning has become necessary. This study aims to build predictive models of the *N. larvatus* in Kalimantan and to measure how big the overlap between the habitat and the land use activity (protected areas, concession areas, plantation, and agriculture areas). The study used the *Species Distribution Modelling* (SDM) approach and *Maximum Entropy* (MaxEnt) software. We collected recent data from *N. larvatus* and a number of environmental variables. The result shows that only 5% of the total of Kalimantan area is suitable for their habitat. The overlap between *N. larvatus* distribution, land use, and land cover map reveals that only 9% of the distribution lies in protected areas, while 37% lies in concession areas and 27% lies in agriculture and plantations areas. We discuss the spatial distribution of the model and current situation of the land use policy in Kalimantan to provide scientific guidance for the Indonesian government to make a master plan for conserving endangered species *N. larvatus*.

Keywords: Concession areas, endemic species, land use, Maxent, Proboscis Monkey (Nasalis Larvatus), protected areas

INTRODUCTION

Proboscis monkey (*Nasalis larvatus*) is an endemic species to the island of Borneo covering the territories of Indonesia, Malaysia, and Brunei. The distribution of the species is limited to specific habitats which include the mangrove forest, swamp forest, and riverine forest. Some small populations can also be found in rubber forest and swamp forest dominated by *glam* (*Melaleuca cajuputi*) (Sha 2006; Soendjoto 2004).

Wetlands such as riverbanks as the habitats of *N. larvatus* are very susceptible to land degradation and conversion since they have high economic value. These locations are usually used for public transport routes and are usually used for cultivation, settlement, ponds, and plantations. Of the 29,500 km² of *N. larvatus* habitat, there was a decrease of about 40% and only 4.1% was included in the conservation areas (McNelly et al. 1990). Meijard and Nijman (2000) reported that there was a habitat degradation of 20 to 88% of the six *N. larvatus* habitats. In addition, the habitat is also reported to decrease by 2% per year. The existence of logging in natural forest and industrial tree plantation concession licenses also exacerbate the declining rate of their habitat.

Habitat limitations have a serious impact on the *N. larvatus* population. Their populations are estimated in a total of 250,000 (MacKinnon 1986) and of 25,000 in conservation areas. However, Yeager and Blondal (1992) reported that the number of *N. larvatus* in conservation areas is less than 5,000. In 2012, the Director General of PHKA reported that the population of *N. larvatus* is estimated to be only around 25,000, of which 5,000 exist in conservation areas. This shows that within 22 years (1986-2008), the population of *N. larvatus* has significantly decreased which leads to remain only 10% of its initial population. *N. larvatus* is even predicted to become extinct within 27 years if improvement of their habitat management is not being made (Stark et al. 2012).

However, the continued habitat degradation is hardly prevented in the non-protected areas. A large gap between the number of population of *N. larvatus* inside and outside the conservation areas has become a major challenge in managing the population. Thus, this calls for special attention to the habitats outside the conservation area in order to prevent further declined rate. In an attempt to overcome this problem, the Indonesian government commits to increase the population of *N. larvatus*. The commitment is as evidenced by the Directorate General of Natural Resources and Ecosystem Conservation Decree concerning the determination of twenty-five endangered species of priority (No.180/IV-KKH/2015). Through this decree, the Indonesian government aims to increase the population of *N. larvatus* in natural habitats by 10% for the period of the year 2015-2019. To achieve these objectives, a more developed or even new knowledge on the distribution of proboscis in Kalimantan is required. But until now, the latest knowledge concerning its distribution remains inadequate.

Field surveys with broad coverage to determine the dispersion of *N. larvatus* in Kalimantan have limitations as they require huge cost and lack time efficiency. Therefore, modeling is the ways that are more feasible to take. Recently, the use of species distribution modeling in predicting animal presence has been widely practiced. It can be a practical guide for animal conservation. This modeling enables the data collection of *N. larvatus* in Borneo to be focused on specific locations that correspond to the predicted results. This result will help in establishing better conservation area design and management program.

The objectives of this research are: (i) to provide updated information on the potential distribution of the *N. larvatus*, (ii) to identify potential habitats of *N. larvatus* in conservation areas, concession areas, agriculture and plantation areas, (iii) to determine the low and high risk of potential conservation sites.

MATERIALS AND METHODS

Occurrence

The occurrence data of *N. larvatus* in Kalimantan was compiled from field studies, literature, field survey data in Danau Sentarum National Park and Tanjung Puting National Park, WWF field survey data, communication with researchers, and citizen scientist through the distribution of online questionnaires. We selected the occurrence data for our final model by taking only one point for every 10 km distance to avoid autocorrelation spatial occurrence (Phillips et al. 2006) and by utilizing SDM toolbox extension. There are 250 occurrence data of *N. larvatus* in Kalimantan for the span of the year 2011 to 2016 which have been used in the final modeling process. We assume that over a 5-year span (2011 to 2016) the proboscis remains present in that location.

Environmental layer

We used 11 variables that are considered important for *N. larvatus* based on knowledge (Table 1). Meanwhile, we acquire topographic layers such as altitude and slope from the *Digital Elevation Model (*DEM) SRTM 1 Arc-Second Global available from USGS (https://earthexplorer.usgs.gov/) in raster format. We extracted climate data (annual precipitation and annual mean temperature) from WorldClim database version 1.4 for the bioclimatic variable in raster format (Hijmans et al. 2005; http://www.worldclim.org).

We also used distance variables to build models; we utilized the distance variable from the river in our model because *N. larvatus* depends heavily on the riverbank habitat (related to its resting site). We created a map of its distance from the river by using the year 2014 Rupa Bumi Indonesia (RBI) river network map which uses 1:50.000 scale. Since *N. larvatus* is an animal that is sensitive to human activities, we deliberately created distance to block any disturbance coming from roads, populated areas, plantation areas, agriculture areas, and fish ponds areas to enter. This distance was mapped by using the 2014 RBI 1:50,000 scale. To attain the distribution map of plantations, agriculture, and fish ponds, we clipped it from the land cover map that we obtained from the National Spatial Planning Agency (BAPLAN) of Ministry of Forestry with 1:250.000 scale, the year 2015. All distance variables were then processed using distance extension in ArcGIS 10.1. We resampled and rescaled all variables in building our models to ~1 km² resolution (0.008333 decimal degrees) with WGS84 geographical coordinate system. We used all variables without multicollinearity test because MaxEnt is not affected by highly correlated variables (Elith et al. 2011).

Model development and evaluation

We used the maximum entropy algorithm in the MaxEnt program version 3.4.0k (Phillips et al. 2004; Phillips. 2008) to build the prediction distribution of *N. larvatus* in Kalimantan. MaxEnt is the best approach in making predictions of species distribution compared to other approaches (Baldwin 2009). MaxEnt runs using data-only presence and environmental variables with ASC ESRI format that processed the Arc Map software ver 10.1. We used 75% of the occurrence data of *N. larvatus* as training data and 25% occurrence data to test the model. We ran the models to function steadily by setting the default of the software parameter (Phillips et al. 2006). We used *Receiver Operating Characteristic* (ROC), which is measured by calculating the *Area Under the Curve* (AUC), which has been widely used to evaluate the performance of the model (Fielding and Bell 1997). AUC values ranged from 0.5 to 1 is used to identify the possibility of species presence, where the presence location is ranked higher than a random background location (Phillips et al. 2006). The AUC values of 0.5 - 0.7 are considered low, while the values of 0.7 to 0.9 indicate useful model performance and the values above 0.9 indicate high-level accuracy in measuring the presence and absence factors (Manel et al. 2001). Jackknife test was also applied to determine the contribution percentage of each variable to the model (Elith et al. 2011).

Distributions under land using policy and land cover type

To determine how big is the overlap between *N. larvatus* distribution, land use types and conservation areas, we overlaid *N. larvatus* distribution map with protected areas and concession areas in Kalimantan map. The concession areas in this study include the *Industrial Oil Palm Plantations* (IOPP), *Industrial Tree Plantation* (ITP), logging in natural forests, and *Ecosystem Restoration Concessions* (ERCs). Even though mining concession is often overlaid with proboscis habitat, we did not use them due to data unavailability. To that end, we clipped the agricultural and plantation features from the land cover map to identify proboscis distribution that intersects with agriculture or plantations outside the concession and protected areas.

Table 1. Variables used in building the model

Variable	Source	Format
Land Cover	The national spatial planning agency (BAPLAN) of the Ministry of Forestry	Shapefile
Altitude	DEM SRTM 1 Arc-Second (https://earthexplorer.usgs.gov/)	Shapefile
Slope	Generated from elevation DEM	Raster
Annual Temperature	WorldClim database (http://www.worldclim.org)	Raster
Annual Precipitation	WorldClim database (http://www.worldclim.org)	Raster
Distance to the river	Generated from RBI map	Raster
Distance to the road	Generated from RBI map	Raster
Distance to the populated area	Generated from RBI map	Raster
Distance to the plantation	Generated from the land cover map	Raster
Distance to the agriculture	Generated from the land cover map	Raster
Distance to the fish ponds	Generated from the land cover map	Raster

Table 2. Classification of patches of habitat quality based on low risk, medium or high risk. Ratings show patches of habitat suitability to support viable Populations of *Nasalis larvatus*

Measure	Low risk	Medium risk	High risk
Size of forest patch	> 40 km²	> 20 km²	> 10 km²
Distance to protected area	Within 20 km²	Within 20-30 km²	Within 30-40km²
Distance to populated area	> 20 km	> 10 km	Adjacent
Distance to roads	> 20 km	> 10 km	Adjacent
Distance to agriculture	> 10 km	> 5 km	Adjacent
Distance to plantation	> 10 km	> 5 km	Adjacent
Connectivity	Connected	Particularly connected	Isolated

We obtained conservation area data from *World Database on Protected Areas* (WDPA) (https://www.protectedplanet.net/). This covers the data of national park, nature reserve, wildlife reserve, nature recreation park, and grand forest park, while the forest protection data were excluded from our analysis. The WDPA is the most comprehensive global database on terrestrial and marine protected areas. Whereas, we collected the concession areas map from the *National Spatial Planning Agency* (BAPLAN) of the Ministry of Forestry, with a 1:250.000 scale in shapefile format. We obtained the West, East, and North Kalimantan industrial oil palm plantation concessions maps in 2012 while for the Central and South Kalimantan in 2016. The data of industrial tree plantation concessions map and logging in natural forest concessions was obtained in 2011, while the map of ecosystem restoration concessions was obtained in 2012.

Anthropogenic risk assessment

We used logistic 10 percentile training presence threshold to create a map of the potential *N. larvatus* distribution. Habitat classified with three classifications as Low Risk (LR), Medium Risk (MR), and High Risk (HR). Variables with LR criteria are given score 1, MR scores 2 and HR score 3 which we processed in ArcGIS. The classification determined with scoring to locate conservation priority areas.

We made recommendations for the potential sites of *N. larvatus* conservation which have never been done before. The recommendations of additional protected areas based on the location with a low to medium level of risk areas classified in Table 2.

RESULTS AND DISCUSSION

Performance and variable model responses

The average result of the replicated running AUC test which was produced by our model was 0.936 (SD = ± 0.015). This value indicates that the model is very effective in measuring the presence and absence of *N. larvatus* (Fielding and Bell 1997; Manel et al. 2001). The high value of AUC on the model can be explained by the fact that AUC value is higher for species with small range size (Phillips et al. 2006; Elith et al. 2011) like the *N. larvatus* (Meijaard and Nijman 2000). The five of most important variables in a fit model for *N. larvatus* are altitude, distance to the fish ponds, annual precipitation, land cover and distance to the agriculture. In this study, altitude variable has the highest contribution to the relative contribution of environmental variables (22.1%), followed by annual precipitation (15.5%), distance to the fish ponds (15.1%), land cover (8.7%) and distance to the agriculture (8.5%).

We used the jackknife test to identify the important variable. The environmental variable with the highest gain when being used in isolation is the annual mean temperature, which therefore showing the most useful information. The environmental variable which decreases the gain the most when it is being omitted is the distance to the fish pond, which therefore appears as the most information that isn't present in the other variables (Figure 1).

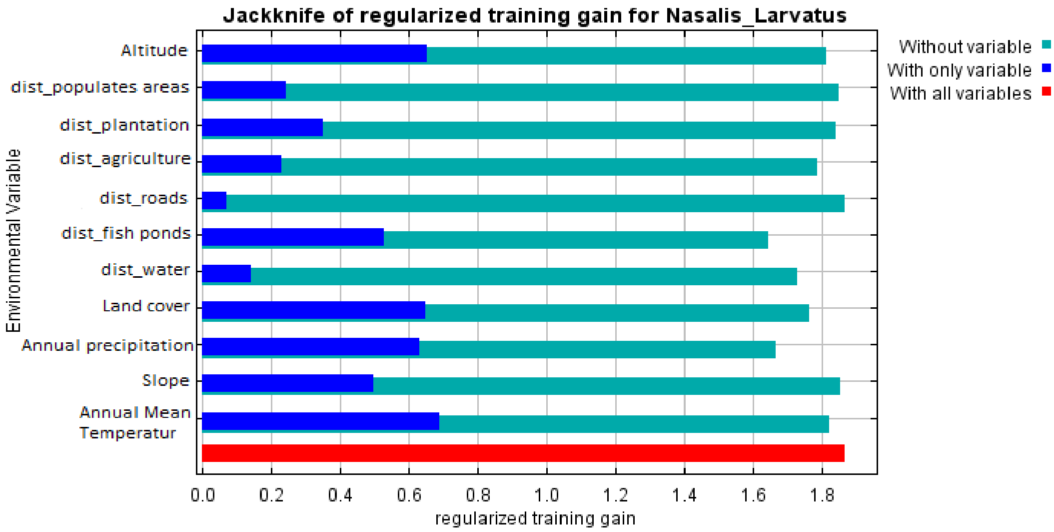


Figure 1. The result of Jackknife test of regularized training gain for the *Nasalis larvatus*

Table 3. Variable contribution to the *Nasalis larvatus* distribution

Variable	**% contribution**
Altitude	22.1
Annual precipitation	15.5
Distance from fish ponds	15.1
Land cover	8.7
Distance to the agriculture	8.5
Annual mean temperature	7.7
Distance to the plantations	7.4
Distance to the river	7
Slope	6.6
Distance to the populated area	1.2
Distance to the roads	0.3

Nasalis larvatus distribution in Kalimantan

We present the latest knowledge about the distribution of *N. larvatus* in Kalimantan. Although the distribution of *N. larvatus* was already reported by Meijard (2000), the survey was conducted and based on only field surveys which gives the possibilities of the unrecorded presence of *N. larvatus* in a certain location to most likely occur. In addition, the high level of land cover change causes the distribution map to be irrelevant for current use. The results of this study provide potential field surveys areas such as locations with low risk and high-risk habitat for *N. larvatus* population. It could be used as a guide in governmental efforts to increase the *N. larvatus* population, prevent high degradation in locations considered potential to wildlife habitat, as well as to support effective land-use decision making.

The study covers 524,610 km² of Kalimantan, and it is estimated that only 5% (± 26,661 km²) of the total area corresponds to the habitat of the *N. larvatus*. The distribution is uniform and dominant along the rear of the island or near the coastal area. As Meijard and Nijman (2000) reported, about 58% of the population is located on a coastal area about 50 km from the coast, 16% between 50-100 km, and 18% between 100 and 200 km. The largest potential distribution is in West Kalimantan, followed by sequentially smaller in Central, South East, and North Kalimantan. This tendency arises since the lowlands in the first three locations are more varied. This is related to the contribution percentage of the highest altitude variable compared to the other variables (Table 3). *N. larvatus* is known to spread over the lowlands with an altitude of fewer than 200 meters and is reported to have been found at an altitude of 350 meters.

Nevertheless, as in any modeling, commission and omission errors in predicting the presence and absence of species are inevitable (Rondinini et al. 2006). There are 25 points of occurrence excluded from the model. However, this may be due to the high level of habitat destruction, so the *N. larvatus* population is forced to be away from the suitable habitats; this point can be further seen from the 25 points of presence excluded from the suitable habitat list in sour model, where 19 of which are spread in several districts of South Kalimantan province. Research conducted in South Kalimantan found that *N. larvatus* can adapt in rubber forest and limestone hill forests (Soendjoto and Nazzaruddin 2012), whereas these habitats are actually not suitable as *N.larvatus* habitat. In addition, the threats to the habitat can be identified in the form of land conversions and wildfires. Our results show that the potentially suitable habitat of *N. larvatus* is in Bukit Soeharto Grand Forest Park, Tanjung Keluang-Teluk Keluang Nature Recreation Park, and Mandor Nature Reserve, but there has been no report yet of the presence of *N. larvatus* at this sites. The reason we think that the areas may be suitable is there is a possibility of the existence of mixed forest of lowland Dipterocarpaceae and coastal forest there, although its presence has still not yet discovered.

Distribution of *Nasalis larvatus* under forest management and protected areas

Protected area

The *N. larvatus* habitat that is situated within the conservation area is actually only a small fraction of its total area in Kalimantan. This distribution is spread out over 15 protected areas, including Danau Sentarum National Park (Strak et al. 2012), Tanjung Puting National Park, Kutai National Park, Gunung Palung National Park, Muara Kendawangan Nature Reserve (Manangsang et al. 2005), Teluk Adang Nature Reserve, Muara Kaman Sedulang Nature Reserve (Meijaard and Nijman 2000), Sebangau National Park (Husson et al. 2018), Lamandau Wildlife Reserve (Friends of the National Parks Foundation 2012), Teluk Kelumpang, Selat Laut and Selat Sebuku Nature Reserve, Pulau Kembang Nature Recreation Park, Pulau Bakut Nature Recreation Park, Sultan Adam Grand Forest Park, Pleihari Tanah Laut Wildlife Reserve, Kuala Lupak Wildlife Reserve (BKSDA Kalsel 2008).

Protected areas provide a higher chance of survival because there are prohibitions on land conversion, illegal logging, hunting, and other human activities that can disrupt the *N. larvatus* population. This is important for its survival in the long run. However, although "protected", violation of land conversion prohibition can still be found there; activities to converse the area into agricultural land can still be found and any effective action to prevent it has still not taken any place yet. In addition, illegal logging and hunting have also been reported in these conservation areas. Protected areas, for examples, Danau Sentarum National Park, Sebangau National Park, Tanjung Puting National Park, and Kutai National Park are reportedly still vulnerable to illegal logging, human activities which disrupting the population and forest fires (Yeager 1992; Robins 2008; Stark et al. 2012). Other evidence of activities that disturb the habitat is shown in several studies which reported land conversion, illegal logging, hunting, mining poisoning, and forest fires occur in the protected area as the habitat of the *N. larvatus* (Yeager and Blondal 1992; Yeager 1998; Robins 2008). Conservation failures in some protected areas such as Kutai National Park, Tanjung Puting Nature Reserve, and Kendawangan Nature Reserve have also been reported by Meijard and Nijman (2000). Therefore, management improvement is strongly needed to happen in order to increase the population of the *N. larvatus*.

In line with the goal to build more protected areas, maximizing the connectivity between protected areas and creating a habitat corridor adjacent to the protected area might be deemed as an efficient solution. The construction of connectivity between protected areas for primate arboreal such as *N. larvatus* is important because the pattern of adaptation of its behavior will not terrestrially cover long distances (Nekaris and Bearder 2007). Since *N. larvatus* lives on the riverbank, the creation of the *N. larvatus* corridor along the river can be an alternative to save its habitat and to avoid habitat fragmentation in the conservation areas. Apart from that, we also recommend adding another conservation area in North Kalimantan since by far it exists only one protected area which is in "*Kawasan Konservasi Mangrove dan Bekantan"* (KKMB). To note, even though the previously mentioned area is a protected one, it is not included in our protected area map.

Concession areas

More than one-third of the monkey's habitat can be found in the concession area (37%). This indicates that special attention to the habitat of *N. larvatus* in the concession area needs to be paid. Special planning needs to be made considering that land clearing or clear-cutting activities as the real threats to the habitat take place in such concession sites such as ITP and IOPP.

Concessions area in natural forest and ecosystem restoration concessions

Distribution of *N. larvatus* in logging concessions is only 4%. This percentage is small because there are currently not many logging concessions on wetlands. Many logging concessions that were closed in the 1990s. In spite of the small percentage, it is important to consider the various types of concessions that include the habitat of the monkeys considering its increasingly limited habitat. From a total of 953 km² of wildlife habitat in the logging concession, it is mostly spread in eastern Kalimantan, particularly in Gunung Sari village, Berau district and in some villages in Kutai Barat and Kutai Timur districts. In addition, the habitat of *N. larvatus* in logging concessions is also found with fewer numbers in Kapuas Hulu and Kuburaya districts of West Kalimantan as well as in Bulungan and Nunukan districts in North Kalimantan. Those locations are actually a potential habitat for the monkey, yet several logging concessions permits can be found here. Their presence at these locations is also most likely unreported. Although some management is done by means of selective logging, the ongoing activities in the concessions still the main factor which affect the number of population of the proboscis. *N. larvatus* is an animal that is known to be easily stressed when there are human disturbances such as logging happening in their surrounding. This can reduce its reproduction rate which leads to a continuous decline of its population. Several studies have been reported that even with a low logging rate of 3.3%, a serious effect on the primates' quality of life can still be found (Johns 1983). In addition, the primate populations are also known to decrease after logging and in some cases, the populations become very low, especially in the long run.

Actually, logging concessions have an important role in the conservation of the monkeys. This method is proven to give effect to reducing the rate of land conversion in the area. However, good management is still a crucial thing to ensure that wildlife conservation works. This is the basis for changing our perception of concession area as one of the important components in the conservation of the *N. larvatus*. Harvesting systems that do not address environmental sustainability actually causes more damage to the habitat of the *N. larvatus*. Therefore, the application of certification systems such as Timber Legality Assurance System (TLAS) and Forest Steward Council (FSC) is important to ensure the sustainability of wildlife habitat.

However, the high cost to obtain FSC certification has become also a factor that makes many of logging concessions do not bother to take it a separate challenge for the companies.

Ecosystem Restoration Concessions (ERCs)

About 5% of *N. larvatus* distribution lies in the ERCs. In Kalimantan, there are two companies that have already received permission, namely PT. Ekosistem Khatulistiwa Lestari and PT. Rimba Raya Conservation, while four other companies are still in the application process. For example, there is *N. larvatus* habitat in the ERCs that borders directly with the protected areas. Those ERCs are PT. Rimba Raya Conservation which is directly adjacent to Taman Nasional Tanjung Puting, and PT. Pencadangan RE Pulang Pisau which is directly adjacent to Taman Nasional Sebangau.

Although still relatively new and the experiences of ERCs are still limited, but the ecosystem restoration concessions can be seen as an important part of the in-site *N. larvatus* conservation plan. The ERCs concept was significantly built and promoted by the organization of conservation such as RSPB, Birdlife International, and Burung Indonesia (Buergin 2016). Therefore, logging will not be carried out before the ecosystem is stable. The licensee is responsible for not only restoring the forest but also the wildlife habitat. The implementation of this will greatly assist the maintenance of the habitat of *N. larvatus* beyond the protected area. The concept of ERC which also embraces the community in its management indirectly has awakened the public about the importance of the *N. larvatus* conservation. This is related to the perception of the locals that *N. larvatus* is a pest animal. With this system, the public is invited to prevent hunting and take part in wildlife conservation.

We consider this new concept as the fresh air in the conservation of *N. larvatus*. The main challenges of this concept, however, are the uncertainty in setting up the boundaries, the disputes between the parties involved, and the costly and complexity of the required licensing process. Entrepreneurs are expected to pay substantial fees in order to obtain permits and implement the ERCs. They often need to seek to fund from additional projects coming from national and international conservation foundations. Therefore, the government's commitment to simplify the licensing process and focus on the conservation of *N. larvatus* in this concession is essential in order to enable the habitat outside the conservation area restored. In addition, the commitment of license holders to conserve in their sites and do regular monitoring or evaluation of wildlife and it is also urgently and strongly needed.

ITP concessions and industrial oil palm plantations concessions

A total of 28% of *N. larvatus* distributions are predicted to be found in industrial forest area and oil palm plantation concessions. There is a large quantity of evidence indicating that industrial tree plantations and industrial oil palm plantations can play important roles in the conservation of *N. larvatus* populations. In Kalimantan, to obtain local revenue, the licensing for palm oil plantation and industrial tree plantations is widely granted by local governments to replace landforms such as forests into oil palm, *Acacia mangium,* and *eucalyptus* plantations. In fact, in West Kalimantan, the extent of ITP, IOPP, mining and logging concessions licensing granted by the provincial government reached 67% of the area, and half of them are permits for ITP and IOPP concessions. The high granting of licenses to both types of land use has given a great impact on the habitat of *N. larvatus*. This is because more than 70% of the *N. larvatus* habitats in these two types of concessions are located in West Kalimantan. The provincial government of West Kalimantan surely needs to pay more attention to the habitat of *N. larvatus* in the industrial tree plantation and industrial oil palm plantations.

To date, specific research on the impact of land use policy on the behavior of *N. larvatus*, particularly the industrial tree plantations and industrial oil palm plantations impact is still limited. However, the logging pattern that uses a clear-cutting system greatly affects the *N. larvatus* population due to the disappearance of their habitat. The disappeared habitats which take place in industrial oil palm plantations and industrial tree plantation concessions directly reduce the survival rate of the proboscis population due to the limited home range which makes the monkey unable to exit from the deforested area. The consequence of this is the remaining *N. larvatus* would most likely migrate to the remaining forest areas such as the High Conservation Value (HCV) areas. The impact is increased competition for the monkeys to survive as in this area resources are more difficult to obtain and the monkeys' capacity to carry them is also being limited.

N. larvatus is highly depending on the riverbank habitat. Therefore, more attention needs to be a pain in the area of the riverbank. The government policies that concessions should not be situated less than 100 meters away from the riverbank should remain valid. We recommend a thorough assessment of the rivers that are known as the habitat takes place in order to precisely determine areas as the corridor of *N. larvatus*. The vegetation on this corridor should be maintained at least 500 meters from the riverside; therefore the source of food and sleeping site remain intact.

Plantation, agriculture and other land cover types

The habitat of *N. larvatus* also intersects with agricultural and plantation areas. About 27% of the monkey's habitat can be found in plantation and agriculture areas. This indicates that the threat to its habitat in the form of land conversion into agricultural and plantation area has been very alarming. The highest threat is in South Kalimantan province. Of the total 7,158 km² of *N. larvatus* distribution is located on plantation and agricultural land, of which more than half is situated in South Kalimantan. It has also been widely reported in several studies. In Balangan districts, for example, it was reported that land conversion was a threat to the population of *N. larvatus* (Soendjoto and Nazaruddin 2012). In addition, land preparation patterns for agriculture and plantations are often done by deforestation activities. Forest fires then give also a further impact of land conversion that threatens the *N. larvatus* population.

N. larvatus is wildlife that becomes the mascot of South Kalimantan in 1990 ; therefore it is imperative then to give proper attention to its distribution. Research and comprehensive survey of *N. larvatus* distribution, habitat types and threats have been conducted in 6 out of 13 districts in South Kalimantan (Soendjoto et al. 2014). This shows the overall seriousness and concern of the locals to prevent the *N. larvatus* population from declining and to give more efforts in its conservation planning. Another serious effort is the frequent reporting done by the locals on hunting activities in the province.

The overlap between *N. larvatus* habitats with people's agricultural and plantation areas occur in South, Central, West, and East Kalimantan. However, research on *N. larvatus* appearance in the local farms and plantations situation in this cities is still rarely conducted, unlike in South Kalimantan. It is strongly suggested that the other provincial governments follow South Kalimantan government's step in conducting such research in order to give more efforts on the conservation of the monkeys. As reported in Pulau Kaget, the *N. larvatus* is already extinct due to an insufficient amount of carrying capacity versus the population number (Meijaard and Nijman 2000). The main reason for this extinction lies in the 90% usage of Pulau Kaget as an agricultural area.

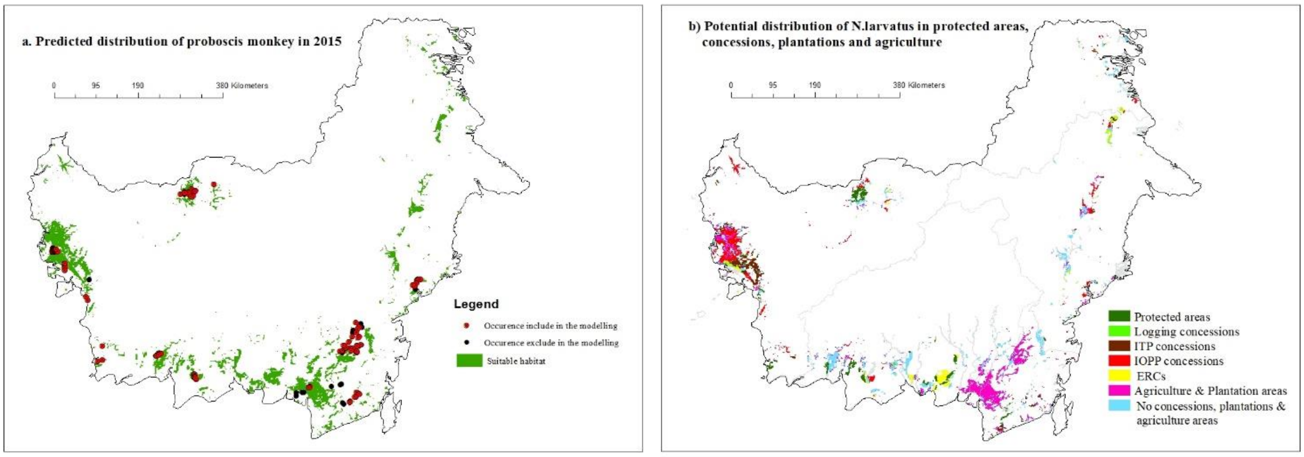
When the supposed habitat area being converted into agricultural and plantation areas, the monkey flees to the locals' farm and plantations. This condition creates inevitable conflict between human and the monkey which is considered a pest animal. Therefore, socialization of awareness of the importance of *N. larvatus* conservation is important to take place. This way as well, the locals would feel being allowed to participate in the wildlife conservation. In addition, it is also seen imperative to do local approach to the leader of the region of Hulu Tengah, South Kalimantan. There, the village chief is the one who makes the regulation of not killing or hunting *N. larvatus* species, and the locals respect their chief. Therefore, this approach is considered very effective in preventing the *N. larvatus* population to keep declining

It is known that approximately 28% of *N. larvatus* population is located in the secondary swamp forest, shrub swamp and swamp forest which are not forested again, hence creating a little intersection with ponds and settlements. However, since we did not use the mining feature (often intersect with the habitat of *N. larvatus*), we did not have the exact measurement of how vast the intersecting area between the mining area and the *N. larvatus* habitat. Nevertheless, from these data, we still can see that around 28% of them could be located beyond the concessions and protected areas. Wildlife ecotourism development approach can be taken as an alternative solution for the areas located outside the concessions, protected and agricultural areas (Maccoll and Tribe 2017). Nature-based ecotourism is currently high in demand in Indonesia. The demand comes from both local and foreign tourists. This ecotourism approach serves as not only a way to converse wildlife and its habitat, but as well as economical booster factor to the surrounding community. To support the achievement of those impacts, the role of local government in seeing the whole big picture of this opportunity is very important. The local government is expected to be able to socialize the awareness of the importance of conserving *N. larvatus* species to the locals. By this approach, it is expected that the habitat destruction due to land conversion, illegal logging and hunting can be then prevented.

Table 4. *N. larvatus* potential distribution area in protected areas and concessions. Percentage (%) represents the percentage of the protected areas, concessions area, and land cover intersect with suitability habitat of *Nasalis larvatus*

Province State	Total suitable area	In Protected Area	In Concession Areas (km²)				Total in Concession areas	Outside concessions	
			Logging concessions	ERCs	ITP	IOPP		Plantations and Agriculture	Others
West Kalimantan	**8974**	908	221	150	1765	3517	**5652**	1287	1126
Central Kalimantan	**7181**	1114	0	1293	29	378	**1700**	1366	3001
South Kalimantan	**6129**	207	8	0	372	65	**446**	4096	1381
East Kalimantan	**3521**	90	604	1	335	638	**1579**	394	1458
Nort Kalimantan	**857**	0	120	4	75	214	**413**	15	429
Total	**26661**	**2318** **9%**	**953** **4%**	**1449** **5%**	**2576** **10%**	**4813** **18%**	**9790** **37%**	**7158** **27%**	**7395** **28%**
Low Risk	617	-	57	0	212	143	412	61	560
High Risk	3572	-	167	65	625	579	1435	584	1552

Note: Other: Potential distribution of *N. larvatus* outside protected areas, concession areas, plantation, and agriculture



A B

Figure 3. Distribution of *N. larvatus* in Kalimantan. A. Distribution map of *Nasalis. larvatus* habitat combining with occurrence data. B. Distribution map of *N. larvatus* overlap with protected areas, concessions area, and land cover type

Anthropogenic risk and implications for the conservations of *Nasalis larvatus*

The Indonesian government is committed to doing the conservation of *N. larvatus*. One of the planned strategies is to manage the population in the fragmented priority areas which have the size ≤10 km². To that end, we provide locations with high-risk level; therefore, the field surveys on the sites that have a large number of threats can be carried out (Table 5). Our results show that the locations with high-risk levels intersect with the industrial oil palm plantation concessions, industrial tree plantation concessions, plantations areas, agriculture areas and spread evenly across the five provinces. This indicates that the land clearing patterns in palm oil concession areas, plantations, and agricultural area have caused many fragmented habitats and high habitat pressures. In fact, the habitat of *N. larvatus* outside the concession area and protected areas are not safe, as evidenced by the high risk (1,552 km ²) of the location. Particular attention paid to these locations is crucial, considering the continued decreasing number of *N. larvatus* population, its increasingly restricted habitat and its sensitive behavior towards human activities.

In addition, we also provide locations with low-risk value. These locations have low habitat threat values. Our results show that sites with low-risk scores are lower in number when compared to the total habitat of *N. larvatus* with high-risk values. Furthermore, these low-risk areas sprawl only in West Kalimantan and slightly in Central and North Kalimantan. This indicates that almost all of *N. larvatus* habitats have high levels of habitat threat, while areas with low habitat threats are very small in number.

We created two scenarios which we expect could be the solution. The first scenario has the assumptions of (i) industrial tree palm plantation concessions (10% of current *N. larvatus* distribution), (ii) industrial oil palm plantation concessions (18% of current distribution), (iii) plantations and agriculture (27% of current distribution), (iv) habitats of *N. larvatus* outside concession areas, protected areas, agriculture and plantations (28% of current distribution) will be deforested. Under this scenario, probably there will be only at most 18% of habitats remained or in other words, 82% of the habitats will be gone. This scenario shows how high the habitat threats to populations of the proboscis. We assume that there are no changes in land cover in the protected areas, logging concessions, and ecosystem restoration concessions. Therefore, the habitat can still be maintained, although, in reality, those three things are unlikely to occur. We also did not include the hunting and mining concession factors as the major threats to our assumptions.

The second scenario is the conservative one, where we assume that protected areas, logging concessions, ecosystem restoration concessions, and *N. larvatus* distribution outside concession areas, agriculture and plantations area (Table 4), is about 46% of the current distribution. However, this scenario may be less realistic given the high rate of human growth requiring settlements and the high economic value of wetlands making them vulnerable to human uses such as conversion to ponds, farmland, and plantations. Thus, the Indonesian government must show their seriousness in giving their commitments. Some changes in land use patterns need to be taken, especially in West Kalimantan, where permits for the establishment of oil palm plantations and other plantations can be found all over the province. By limiting the granting of such permits, the remaining distribution of *N. larvatus* is expected to be at least maintained.

Table 5. Table of recommendations for priority survey areas with high risk (fragmented habitat) and low risk (for protected areas extensions), based on the distribution of *N. larvatus* and result of the risk assessments

Province	Low Risk (District and sub-district)	Recommendation for priority survey to potential habitat with high risk (District and sub-district)
West Kalimantan	Ketapang District: Simpang Hulu Kubu Raya District: Batu Ampar (in concession area), Kubu, Terentang	Kapuas Hulu District: Badau, Batang Lupar, Bunut Hilir, Embaloh Hilir, Embau, Empanang, Hulu Gurung, Manday, Putussibau, Seberuang, Selimbau, Semitau, Silat Hulu Ketapang District: Kendawangan, Manis Mata, Marau, Matan Hilir Selatan, Matan Hilir Utara, Pulau Maya/Karimata, Simpang Hilir, Simpang Hulu, Sukadana Kubu Raya District: Batu Ampar, Kubu, Mempawah hilir, Mempawah Hulu, Senga Temila, Sungai Ambawang, Sungai Kakap, Sungai Raya, Telok Pakedai, Terentang Sambas District: Jawai, Ledo, Paloh, Pemangkat, Sambas, Sanggau Ledo, Sei Raya, Sejakung, Selakau, Seluas, Tebas, Teluk Keramat Sanggau District: Belitang Hilir, Belitang Hulu, Toba Sintang District: Belimbing, Kayan Hilir, Nanga Pinoh, Sepauk, Sintang, Tempunak
Central Kalimantan	East Kotawaringin District: Ketapang Mentaya Baru, Mentayan Hilir Utara	Barito Selatan District: Awang, Benua Lima, Dusun Hilir, Dusun Selatan, Dusun Tengah, Dusun Timur, Jenamas, Patangkep Tutui, Pematang Karau Barito Utara District: Lahei Kapuas District: Kahayan Hilir, Kahayan Kuala, Kahayan Ttengah, Kapuas Barat, Kapuas Kuala, Kapuas Murung, Kapuas Timur, Mantangai, Pandih Batu, Pulau Petak, Selat, Timpah Kota Waringin Barat District: Arus Selatan, Balai Riam, Bulik, Kota Waringin Lama, Kumai, Sukamara Kota Waringin Timur District: Baamang, Campaga, Danau Sembuluh, Hanau, Kamipang, Kantingan Kuala, Ketapang/Mentaya Baru, Kota Besi, Mentaya Hilir Selatan, Mentaya Hilir Utara, Mentaya Hulu, Parenggean, Pulau Hanaut, Pulau Malan, Seruyan Hilir, Seruyan Tengah, Tasik Payawan, Tewang Senggalang Garin Pangka Raya District: Bukit Batu, Pahandut
South Kalimantan	-	Banjar District: Aluh-aluh, Aranio, Asrtambul, Banjar Baru, Cempaka, Gambut, Karang Intan, Kertak Hanyar, Llandasan Ulin, Pengaron, Sungai Pinang, Sungai Tabuk Barito Kuala District: Alalak, Anjir Muara, Bakumpai, Barambai, Belawang, Kuripan, Mekar Sari, Tabukan, Tabunganen, Tamban Hulu Sungai Selatan District: Angkinang, Daha Selatan, Kandangan, Padang Batung, Telaga Langsat Hulu Sungai Tengah District: Batang Alai Selatan, Batang Alai Utara, Haruyan, Labuhan Amas Selatan, Labuhan Amas Utara, Pandawan Hulu Sungai Utara District: Awayan, Batu Mandi, Danau Panggang, Halong, Juai, Paringin Banjarmasin City: Banjar Barat, Banjar Selatan, Banjar Timur, Banjar Utara Kota Baru District: Batu Licin, Hampang, Kelumpang Hulu, Kelumpang Selatan, Kusan Hilir, Kusan Hulu, Pamuka Selatan, Pamuka Utara, Sampanahan, Satui, Sungai Durian. Tabalong District: Banua Lawas, Haruai, Kelua, Murung Pudak, Upau Tanah Laut District: Bati-bati, jorong, Kintap, Kurau, Panyipatan, Pelaihari, Takisung Tapin District: Candi Laras Selatan, Candi Laras Utara, Tapin Selatan, Tapin Tengah, Tapin Utara
East Kalimantan	-	Kdy. Balikpapan District: Balikpapan Barat, Balikpapan Timur, Balikpapan Utara Kutai District: Anggana, Bongan, Jempang, Kembang Janggut, Kenohan, Kotabangun, Loa Janan, Loa Kulu, Muara Ancalong, Muara Badak, Muara Bengkal, Muara Jawa, Muara Kaman, Muara Pahu, Muara Wahau, Penyinggahan, Sanga-Ssanga, Sangkulirang, Semboja, Tabang, Tenggarong Pasir District: Batu Sopang, Kuaro, Long Ikis, Long Kali, Muara Koman, pasir Balengkong, Penajam, Tanjung Aru, Waru Berau District: Gunung Tabur, Kelay, Sembaliung, Talisayan
North Kalimantan	Nunukan District: Lumbis, Sembakung	Bulongan District: Kayan Hilir, Long Peso, Lumbis, Malinau, Nunukan, Sembakung, Sesayap, Tanjung Palas Berau District: Segah

The map of the *N. larvatus* distribution (Fig. 3) shows that the current distribution probability overlaps with concession areas, plantation land, or agricultural areas. To that end, we advise that an appropriate safeguarding habitat of *N. larvatus* in those areas should be carried out. Safeguarding areas along the river that are known as habitats for proboscis are essential to exist in order to ensure their resources and resting sites. The widening of riparian areas is also another solution given that *N. larvatus* is highly dependent on the habitat on the riverside. This addition can be based on the home range of the proboscis so that an extra 500 meters in the riparian area will be crucial to the survival of its habitat. Although this increase in width may be detrimental to the entrepreneurs, the preservation of the riverside area has high ecological benefits.

Therefore, making essential ecosystem areas a master plan at the landscape level that considers all remaining population of *N. larvatus*, as well as all different land use patterns that include the monkey's habitat to ensure its population survival is urgently needed. The development should be planned and carried out in the manner and spirit of maintaining the habitat of *N. larvatus* outside the conservation area. Essential ecosystem areas are situated outside the conservation areas which are ecologically important for biodiversity purpose that includes the balance existence of both natural and artificial ecosystems outside the forest area. With this scheme, the habitat management of the *N. larvatus* will fully cover both plantation and community agricultural areas.

In conclusion, our results show that about 91% of the *N. larvatus* distribution take place outside the conservation area, of which about 37% is in concession areas, 27% in plantations and agricultural areas, and the remainder is vulnerable to land changes such as mining, ponds, and settlements because they have a high-risk value. From these findings, we can conclude that the extent of conservation areas in Kalimantan is not sufficient to save the remaining population of *N. larvatus* due to a large number of threats that can be found outside the conservation area.

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