Jurnal Manajemen Hutan Tropika, *29*(2), 119–126, August 2023
EISSN: 2089-2063
DOI: 10.7226/jtfm.29.2.119

Scientific Article
ISSN: 2087-0469

Habitat Suitability Modeling of Javan Slow Loris (*Nycticebus javanicus*) in the Forest Cluster of Gunung Halimun Salak

Misbah Satria Giri[1*], Ahmad Munawir[1], Atih Sundawiati[1], Mochamad Erlan Sodahlan[1], Yogi Prasetyo[1], Hermita Widi Nugrahareni[1], Henri Kurniawan[2], Albert Joni Rinekso[2], Dede Aulia Rahman[3*]

[1]Gunung Halimun Salak National Park, Ministry of Environment and Forestry, Jl. Raya Cipanas, Kabandungan, Sukabumi, Indonesia 43368
[2]Star Energy Geothermal Salak, Jl. Jayanegara, Kabandungan, Sukabumi, Indonesia 43368
[3]Department of Forest Resources Conservation and Ecotourism, Faculty of Forestry and Environment, IPB University, Academic Ring Road Campus IPB Dramaga, Bogor, Indonesia 16680

Received January 26, 2023/Accepted July 25, 2023

Abstract

Javan slow loris (Nycticebus javanicus) is one of the endemic wildlife on Java Island. This species owns particular characteristics, including arboreal, solitary, and nocturnal natures. The species is threatened due to habitat loss and illegal trafficking. Nevertheless, their current geographic distribution remains unclear and environmental factors impact on these species is mostly unknown. This study aims to predict the habitat suitability of javan slow loris in the Conservation Management Forest Unit area of Mount Halimun Salak Forest Group. The study employs a species distribution modeling approach using Maximum Entropy. The presence data of javan slow loris was collected from the radio-telemetry devices used in post-release monitoring. The modeling utilizes elevations, distance from the settlements, slopes, and land covered as its environment variables. The result shows that 52% of the study areas, or 54,669 ha are suitable as the habitat of N. javanicus. Since as the largest protected area on Java Island, Gunung Halimun Salak National Park is one of the natural habitats that are pivotal for this species. This study provides essential documentation for developing management strategies within protected areas. Hence, the result of the study could serve as one of the factors in the determination of animal release location in the future.

Keywords: *conservation, Nycticebu javanicus, Mount Halimun Salak, presence-only model*

**Correspondence author*: *satriagr1@gmail.com*; *dedeaulia@apps.ipb.ac.id*

Introduction

On the 25th of September 2015, the General Assembly of the United Nations officially rectified the agenda for sustainable development goals as a global development agreement. One of the agendas is to put an end to the hunting and trading of protected floras and faunas, as well as to resolve both supply and demand of illegal animal products (UN General Assembly, 2015). This is appropriate to the occurrence of the illegal trading of wildlife that is still happening in Indonesia, where it is relatively effortless to find wildlife for sale in the market. This wildlife is not living only as pets or die as decorations but is also traded as consumer goods and medicines (Rajagukguk, 2014; Rahayu, 2015).

Mangunjaya et al. (2017) state that hunting and trafficking are considered the greatest threat to the continuation of wildlife. The high economic value of these animals, both the whole of the body and the part of the body, encourages illegal trading. Nowadays, illegal trafficking is spreading and even makes use of social media and networking (Nekaris, 2014). Javan slow loris (*Nycticebus javanicus*) is one of the wildlife that is commonly found at the black market (Shepherd et al., 2005; Nijman et al., 2017), including in the South-East Asia (Moore et al., 2015; Romdhoni et al., 2018).

Based on the assessment, the IUCN designated the population status of the *N. javanicus* as a critically endangered species (Nekaris et al., 2020). The javan slow loris is one of the most threatened species in the genus of *Nycticebus*. It is endemic to the Indonesian island of Java (Lehtinen, 2013), which contains 141 million people and has one of the world's highest human population densities, greatly restricting the javan slow loris's island-wide distribution (Nekaris et al., 2020). Asides from hunting and illegal trading, wildlife in Java, including the javan slow loris, has encountered the loss of its natural habitat over the recent decades and poses a threat to its population (Voskamp et al., 2014; Sodik et al., 2019; Sodik et al., 2020; Sari et al., 2020). The habitat loss of wildlife is a major threat to their survival. The development of forest resources through the expansion of smallholder farmland, large-scale monoculture plantations and infrastructure, which has helped Indonesia to achieve economic growth, has resulted in forest loss and decline over the last 25 years (Rahman et al., 2022b). Based on the deforestation rate published by the Forestry Department for the 2003–2006 period, the rate in the island was 2,500 ha year^{-1} or 0.2% of the total deforestation in Indonesia. The forest area on the island of Java is currently only around 24% of the area of the island of Java, which is 128,297 km^2.

Jurnal Manajemen Hutan Tropika, *29*(2), 119–126, August 2023
EISSN: 2089-2063
DOI: 10.7226/jtfm.29.2.119
Scientific Article
ISSN: 2087-0469

In general, *N. javanicus* inhabits the primary and secondary forests (Sodik et al., 2019; Nekaris et al., 2020), but it could also reside in the area of mixed vegetation (Nekaris et al., 2017), where food is available (Matondang et al., 2018), as well as trees for sleeping activity (Wirdateti et al., 2010). Furthermore, it could also inhabit the plantation area (Romdhoni et al., 2018; Sodik et al., 2020), such as coffee plantations (Sari et al., 2020), which are areas dominated by humans.

With a total area of 87,699 ha, Gunung Halimun Salak National Park (GHSNP) is the largest terrestrial protected habitat for wildlife in the island of Java. The area has become the predominant habitat for various key species, such as *Panthera pardus melas* (Wibisono et al., 2018) and *Hylobates moloch* (Supriatna, 2006). Furthermore, it is recorded that at least five species of primates in this area (Giri et al., 2019), including *N. javanicus* (Arismayanti et al., 2018). Since, as the largest protected area in Javan Island, GHSNP is one of natural habitats that is pivotal for the conservation of *N. javanicus* (Thorn et al., 2019).

N. javanicus is nocturnal, cryptic, tend to live in solitary, and most of its life is carried out in the trees or arboreal (Nekaris et al., 2007; Nekaris et al, 2014; Sinaga & Masyud 2017; Thorn et al., 2019; Hendrian et al., 2020). These characteristics serve as the reasons why it is difficult to find or observe this species in the nature (Wiens & Zitzmann, 2003). Consequently, there is only limited information regarding its behavior and ecology (Nekaris et al., 2014), as well as its estimation of abundance in the nature (Pliosungnoen et al., 2010), including in the GHSNP area.

To date, the information regarding potential habitat of *N. javanicus* is sparse in GHSNP area (Voskamp et al., 2014). Research on *N. javanicus* in GHSNP is generally conducted on rehabilitated *N. javanicus* that was released into the GHSNP area (Arismayanti et al., 2018) and within the scope of its behavior and the population status in a small sampling site. Nevertheless, the study holds an important role in the effort to rescue the population of *N. javanicus*.

Razgour et al. (2016) and Li et al. (2020) argue that spatial modeling could be used as one of the approaches to predict the distribution and habitat of *N. javanicus*. In its development, this method is widely recognized as the species distribution model/SDM (Rahman et al., 2022a). Furthermore, it is contended that the modeling approach of species distribution is applicable to analyze the species with barely information regarding its population distribution, as well as the species with low home range analyzing (Tsoar & Kadmon 2007; Qiao et al., 2018; Thorn et al., 2019).

Until today, there is no data available yet concerning the prediction of population distribution and habitat of *N. javanicus* in the GHSNP area. Maximum Entropy (MaxEnt) has been used on limited data characteristics (Wisz et al., 2008), where only present data is available (Philips et al., 2006; Philips & Dudik, 2008; Franklin, 2010; Rahman et al., 2019), as is commonly found in biodiversity data collection in protected areas. This study uses the presence-only model MaxEnt to obtain information regarding the suitability of the *N. javanicus* habitat in the GHSNP area and its surroundings. Due to its critically endangered area and high level of hunting and illegal trading, the species' release is important, so habitat suitability modeling is important to determine areas of possible release, especially in GHSNP. At last, we used the modeled distributions to support conservation issues of *N. Javanicus*, especially assessing habitat suitability for current and future release locations for this species.

Methods

The Halimun Salak Conservation Management Forest Unit (CMFU), with a total area of 105,072 ha, serves as the location for the study on the habitat suitability of *N. javanicus* (KLHK, 2017). The area lies in three administrative areas, including Bogor and Sukabumi Districts in West Java Province, as well as in Lebak District in Banten Province.

The study employed MaxEnt 3.4.1. to predict the habitat locations that are suitable as habitats for *N. javanicus* (McCarthy et al., 2014; Rahman, 2020; Rahman et al., 2020). In the process, MaxEnt is modeling the similarity between the characteristics of the data and the determined environment variables (*covariate*) (Phillips et al., 2006; Phillips & Dudik 2008). The modeling of habitat suitability for release activity involves two (2) information, which is 1) the occurrence of the animal, and 2) environment variables that affect the distribution of *N. javanicus* (Rahman et al., 2019; Zegarra et al., 2020; Rahman et al., 2022a).

During the period of 2014 to 2015, YIARI (the Foundation of IAR Indonesia) has monitored and collected 9,274 points of the occurrence of the released *N. javanicus*. The researchers conducted a rarefying occurrence of *N. javanicus* to evade spatial autocorrelation. The autocorrelation from the points of occurrence would inflict bias in the development of the model (Rahman et al., 2022a;b). As many as 264 points of the animal's appearance were analyzed. Since the distribution of the points tends to group, hence a process of bias grid was conducted to minimize the bias of the modeling result (Phillips et al., 2009; Wibisono et al., 2018, Rahman et al., 2020). Furthermore, the data of the presence was processed using Ms. Excel and then converted into *comma-separated value* (.csv) format.

It is argued that the environment variables are selected by the consideration of living patterns (Fransson, 2018), ecology (Zegarra et al., 2020), and the characteristics of the habitat (Franklin, 2010) of *N. javanicus*. The study assembled eight (8) environment variables consisting of slopes (Franklin, 2010; Sodik et al., 2019), elevations, distance from the rivers, as well as the settlements, land cover (McCarthy et al., 2014; Voskamp et al., 2014; Sodik et al., 2020), rainfall (Hijmans et al., 2005; Austin, 2007), and NDVI (Jiang et al., 2006). Each environment variable is independent, thus it does not have a strong correlation. The utilization of variables that are correlated strongly would result overestimated parameters. Consequently, would diminish the ability to predict the locations (Morueta-Holme et al., 2010; Dormann et al., 2013), which could stimulate overfitting of the modeling result.

To evade this predicament, a multicollinearity test is applied (Rahman et al., 2022a) to the utilized environment variables in the procedure. There was an action of minimizing a variable that possesses a strong correlation value. It is recorded that several studies are using 0.5 for the correlation value or $R^2 \geq 0.5$ in the positive or negative correlation (McCarthy et al., 2014), however, this study is

Jurnal Manajemen Hutan Tropika, *29*(2), 119–126, August 2023
EISSN: 2089-2063
DOI: 10.7226/jtfm.29.2.119
Scientific Article
ISSN: 2087-0469

utilizing 0.7 for the correlation value or $R^2 \geq 0.7$ (Dormann et al., 2013). Moreover, the entire environment variables have already been converted into the .asc format (Phillips et al., 2006; Phillips & Dudik, 2008; Young et al., 2011).

The study carried out the processing and the selection of the variables frequently to achieve the best model, as well as the finest description that befits the field condition (Giri & Munawir, 2021). In consequence, the process is utilizing the environment variables that include elevations, slopes, distance from the settlements, and land cover. Furthermore, there were several adjustments that comprise 1) performing a measurement of jackknife level; 2) changing the output format into logistic and output type into .asc; 3) utilizing the random test percentage = 25%; 4) replicating as many 10 times; 5) utilizing subsample as type of replication; and 6) maximum number of iteration is 5.000 times (Voskamp et al., 2014; Rahman et al., 2017; Wibisono et al., 2018; Rahman et al., 2022).

Furthermore, the receiver operating characteristic (ROC) is derived from the omission analysis. The area underneath the ROC curve or area under the curve (AUC) shows the modeling performance resulting from the MaxEnt process (Phillips et al., 2006; Phillips & Dudik, 2008). AUC value equal to 0.5 depicts that the modeling performance is not superior to random. When the value is close to 1.0, the modeling performance is better (Young et al., 2011; Li et al., 2020). Swets (1988) divides five classifications based on the AUC value, which are 0.5–0.6 (fail); 0.6–0.7 (poor); 0.7–0.8 (adequate); 0.8–0.9 (superior); and 0.9–1 (excellent).

To see the magnitude of environmental variables' role in the ongoing modeling results, we use the percent contribution (PC) value (Phillips et al., 2006). The higher the PC value, the more significant the contribution of this variable to the habitat suitability of the modeled species. Meanwhile, we use the permutation important (PI) value to describe environmental variables' level of importance in the ongoing modeling results (Phillips et al., 2006; Muttaqin et al., 2019).

Results and Discussion

The number of occurrence data used in the analysis after removing the spatial autocorrelation was 59 points. In addition, based on the multicollinearity test on environmental variables, the covariates that are retained in the model are four variables, which are: height, distance from settlements, slope, ground cover. With the AUC value equal to 0.764 with standard deviation value 0.045 ($SD < 0.05$), it is concluded that the modeling result of *N. javanicus* is fall into the adequate category (Figure 1).

The variable of elevation has the highest PI value which is 56.1%. This means that if the variable is removed, then it would decrease the AUC value by 56.7%. While, the variable of land cover has the lowest PI value. On contrary, this low PI value depicts that if we withdrew the variable of land cover, then the decline of the AUC value would not be significant by only 0.5% as it can be seen in Table 1.

As it is shown in Table 1, the environment variables that contribute in influencing the modeling result of MaxEnt (> 10%) sequentially are the distribution of elevation (56.7%), distance from the settlement (25.5%), and slope (10.8%). However, this table does not indicate the animal's inclination towards environment variables. It tends to show the variable effect in modeling the similarity of the environmental characteristics.

Based on several previous analysis, MaxEnt spatial modeling predicts the location of the habitat sutability and the distribution of *N. javanicus*. Onojeghuo et al. (2015) argue that the species distribution is the principal factor in the wildlife conservation and management. Furthermore, the said spatial modeling result is classified into three categories (Jenks, 1967; Li et al., 2020) consisting of 1) unsuitable; 2) suitable; 3) highly suitable.

Based on the analysis of *N. javanicus*' habitat suitability in CFMU Halimun Salak and its surrounding, 93,533.7 ha of the area is unsuitable; 47,551.1 ha of the area is suitable; and 37,999.4 ha is highly suitable. However, when it is overlaid

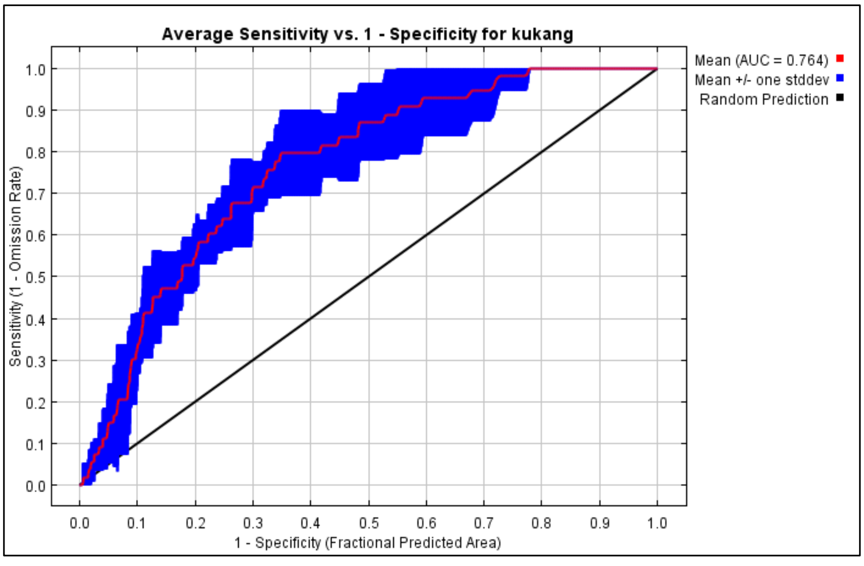

Figure 1 The AUC graph of spatial modeling result of *Nycticebus javanicus*' habitat suitability.

Jurnal Manajemen Hutan Tropika, *29*(2), 119−126, August 2023
EISSN: 2089-2063
DOI: 10.7226/jtfm.29.2.119

Scientific Article
ISSN: 2087-0469

against the CFMU total area only, 49,679.9 ha are unsuitable; 30,529.8 ha are suitable, and 24,169.6 ha are highly suitable for the habitat of *N. javanicus*. It shows that more than 50% or precisely 52% (54,669.4 ha) of CFMU Halimun Salak area is suitable for the habitat of *N. javanicus*. The distribution of *N. javanicus*' habitat suitability map based on the modeling is depicted in Figure 2.

The elevation has become the most contributed variable to the modeling result. Following the behavior of *N. javanicus*, altitude is becoming the factor of limitation in its movement. Based on the overlay result against *digital elevation model* (DEM) map, the suitable habitat for *N. javanicus'* in Gunung Salak landscape is in the altitude range of 530–1,900 masl. While in the Halimun landscape, the habitat distribution of *N. javanicus* is in the altitude range of 500–1,650 masl.

Arismayanti et al. (2018) concluded that the home range of *N. javanicus* in GHSNP area is in the altitude range 941–1,361 masl. Moreover, in Gunung Gede Pangrango National Park, *N. javanicus* was found in the altitude range of 600–1,600 masl, and even in some areas, it can be found at the altitude of 2,300 masl (Thorn et al., 2009; Nekaris et al., 2014; Nekaris et al., 2020). The information indicates the relevance of the result of spatial modeling to previous similar studies.

Table 1 The contribution analysis of the environment variables

Variables	PC (%)	PI (%)
Elevation	56.7	56.1
Distance from the settlement	25.5	31.8
Slope	11.6	11.6
Land cover	6.2	0.5

Javan slow loris often was actively found in agricultural areas e.g., coffee and rubber plantations (Cabana et al., 2017; Sari et al., 2020), bamboo forests (Voskamp et al., 2014; Nekaris et al., 2017), and settlements (Nekaris et al., 2017; Sodik et al., 2020). The wide niche of *N. javanicus* is due to the abundance of food available in forests to agricultural areas (Pliosungnoen, 2010). Insects, calliandra, resin, and nectar are types of food that the Javan slow loris consume (Cabana et al., 2017; Sinaga & Masyud, 2017; Romdhoni et al., 2018; Fransson, 2018). Moreover, the behavior that consists of nocturnal, arboreal, solitary, and slow movement (Wiens & Zitzmann, 2003) is its strategy to evade the attention of its prey and other intrusions, including the human (Basalamah et al., 2010). It makes *N. javanicus* possible to conduct activities around the settlements since it possesses different active times to humans (nocturnal in contrast to diurnal).

Based on *N. javanicus*' habitat suitability map depicted in Figure 2, the distribution of *N. javanicus* is located in the outskirt of Gunung Halimun Salak National Park area. The secondary forest and agricultural areas dominate this particular area. Parallel to the modeling result, the land cover does not hold an impact on the distribution of *N. javanicus*. Furthermore, it contributes the lowest to the model, which is 6.2%. On the contrary, aside from the field and the river (Fransson, 2018), the elevation highly impacts the distribution of *N. javanicus* (Nekaris et al., 2020).

The middle area of GHSNP is a primary forest, where its mountainous topography is not suitable for the habitat of *N. javanicus*. Big and tall trees dominate this area, while shrubs are rarely found. Shrubs are often discovered in secondary forest. The connectivity between the branches and the twigs is high in the area with this type of characteristic, but with low availability of food richness. Thus, it encourages *N. javanicus*

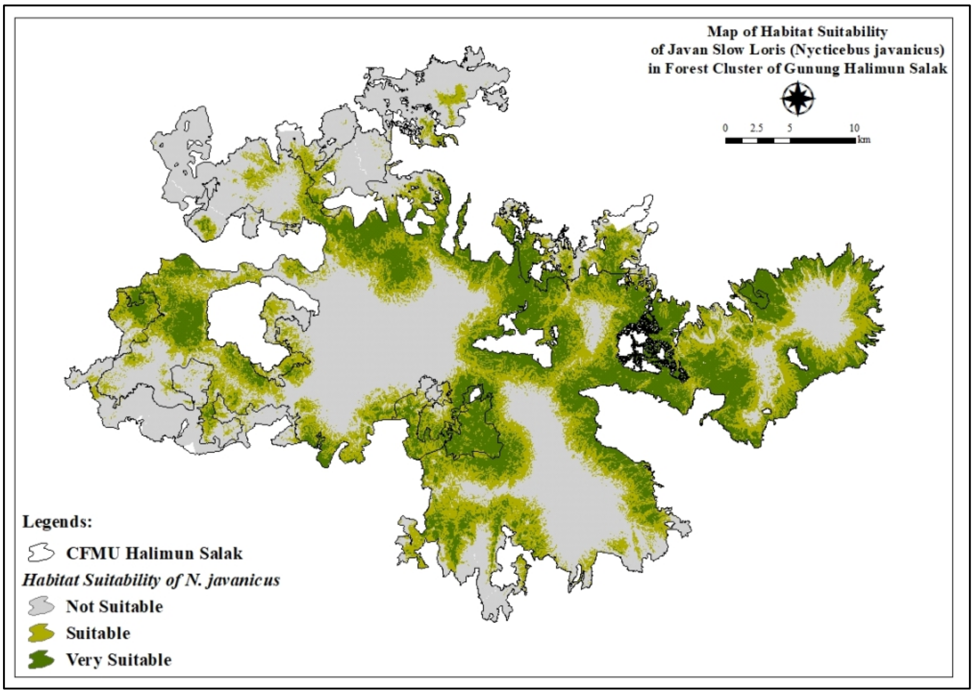

Figure 2 The map of *Nycticebus javanicus*' habitat suitability in CFMU Halimun Salak area.

to move places (Nekaris et al., 2014, Nekaris et al., 2020).

N. javanicus utilizes most of its time moving around and consuming food (Arismayanti et al., 2018). In line with the notion, topography and slope do pose as the factor of limitation for *N. javanicus* (Sodik et al., 2019; Sari et al., 2020). *N. javanicus* is using its hand to move and can adapt to extreme topography (Nekaris, 2014). Fransson (2018) stated that canopy is the prominent habitat factor in the survival of *N. javanicus*. Sodik et al. (2019) added that this species can keep moving as long as the canopies are available.

Various studies show that Javan slow loris is often discovered outside the natural forests and conservation areas (Nekaris et al., 2017; Matondang et al., 2018; Sari et al., 2020). However, the notion could be due to a lack of conducted habitat studies within the national park areas. Nevertheless, the information on the distribution of species is essential to implementing conservation initiatives for the species and is crucial for effectively managing protected or non-protected areas that are part of essential ecosystem areas that are interconnected. To successfully and efficiently protect javan slow loris within fast-changing habitats, collaboration and analysis of current data throughout their ranges are crucial. Furthermore, recognizing areas where the presence of the javan slow loris is most likely to occur gives stakeholders an essential tool for conservation, such as deciding which areas are suitable for release locations.

Conclusion

With the total area of 105,072 ha, Halimun Salak CMFU is the largest tropical rainforest remains in Javan Island. This study provides the answer that in recent years, Gunung Halimun Salak Forest CMFU areas are sufficient habitat for *N. javanicus*. The number of the total area that is suitable habitat for *N. javanicus* serves as evidence that this area is indeed a suitable habitat for these animals. The area has become the appointed location for the release of javan slow loris, particularly the one that originated from the animal rescue and rehabilitation center. This study provides essential documentation for developing management strategies within protected areas for *N. javanicus* population. Hence, the result of the study could serve as one of the factors in the determination of animal release location in the future.

Acknowledgment

We would like to say thank you very much to the Head of Halimun Salak National Park Office, YIARI, Indonesian Sintas Foundation, and to all of the supported parties in this study that we could not mention.

References

Arismayanti, A., Perwitasari, R. D., & Winarti, I. (2018). The home range and space utilization of javan slow loris (*Nycticebus javanicus*) in Gunung Halimun Salak National Park. *Jurnal Sumberdaya Hayati*, *4*(2), 28–41. https://doi.org/10.29244/jsdh.4.2.28-41

Austin, M. (2007). Species distribution models and ecological theory: A critical assessment and some possible new approaches. *Ecological Modelling*, *200*(12), 1–19. https://doi.org/10.1016/j.ecolmodel. 2006.07.005

Basalamah, F., Zulfa, A., Suprobowati, D., Asriana, D., Susilowati, Anggraeni, A., & Nurul, R. (2010). Status populasi primata di Taman Nasional Gunung Gede Pangrango dan Taman Nasional Gunung Halimun Salak, Jawa Barat. *Jurnal Primatologi Indonesia*, *7*(2), 55–59.

Cabana, F., Dierenfeld, E., Wirdateti, W., Donati, G., & Nekaris, K. A. I. (2017). The seasonal feeding ecology of the javan slow loris (*Nycticebus javanicus*). *American Journal of Physical Anthropology*, *162*(4), 768–781. https://doi.org/10.1002/ajpa.23168

Dormann, C. F., Elith, J., Bacher, S., Buchmann, C., Carl, G., Carré, G., …, & Leitão, P. J. (2013). Collinearity: A review of methods to deal with it and a simulation study evaluating their performance. *Ecography*, *36*(1), 27–46. https://doi.org/10.1111/j.16000587.2012.07348.x

Franklin, J. (2010). *Mapping species distributions: Spatial inference and prediction (Ecology, biodiversity and conservation)*. Cambridge: Cambridge University Press. https://doi.org/10.1017/CBO9780511810602

Fransson, L. (2018). *Fine scale habitat and movement patterns of javan slow loris (Nycticebus javanicus) in Cipaganti, West Java, Indonesia*. Sweden: Committee of Tropical Ecology, Uppsala University.

Giri, M. M. S., & Munawir, A. (2021). *The habitat suitability analysis and the determination of locations for released wildlife in Gunung Halimun Salak National Park for the duration of 2021–2025*. Jakarta: Direktorat Jenderal Konservasi Sumber Daya Hutan dan Ekosistem. Kementerian Lingkungan Hidup dan Kehutanan.

Giri, M. M. S., Pairah, Sodahlan E., Sahid, A., Ekariono, W., Ambarita, E., & Sutisna, C. (2019). Keanekaragaman primata di areal operasi panas bumi, Taman Nasional Gunung Halimun Salak. *Jurnal Primatologi Indonesia*, *16*(1), 3–9.

Hendrian, A., Hendrayana, Y., & Supartono, T. (2020). Aktivitas harian kukang jawa (*Nycticebus javanicus*) pasca habituasi di Suaka Margasatwa Gunung Sawal Ciamis. *Prosiding Seminar Nasional Konservasi untuk Kesejahteraan Masyarakat I*, *1*(1), 37–44.

Hijmans, R. J., Cameron, S. E., Parra, J. L., Jones, P. G., & Jarvis, A. (2005). Very high-resolution interpolated climate surfaces for global land areas. *International Journal of Climatology*, *25*(15), 1965–1978. https://doi.org/10.1002/joc.1276

Jenks, G. F. (1967). The data model concept in statistical mapping. *International Yearbook of Cartography*, *7*, 186–190.

Jiang, Z., Huete, A. R., Chen, J., Chen, Y., Li, J., Yan, G., & Zhang, X. (2006). Analysis of NDVI and scaled different vegetation index retrievals of vegetation fraction.

Remote Sensing of Environment, *101*(3), 366–378. https:doi/org/10.1016/j.rse.2006.01.003

[KLHK] Kementerian Lingkungan Hidup dan Kehutanan. (2017). Keputusan Menteri Lingkungan Hidup dan Kehutanan Nomor SK.628/MENLHK/SETJEN/PLA.2/11/2017 tanggal 10 November 2017 tentang Penetapan Wilayah Kesatuan Pengelolaan Hutan Konservasi Kelompok Hutan Gunung Halimun Salak terletak di Kabupaten Bogor dan Kabupaten Sukabumi, Provinsi Jawa Barat dan di Kabupaten Lebak, Provinsi Banten seluas 105.072 Hektar Jakarta: Kementerian Lingkungan Hidup dan Kehutanan.

Lehtinen, J. (2013). Distribution of the javan slow loris (*Nycticebus javanicus*): Assesing the presence in East Java, Indonesia [thesis]. Oxford: Oxford Brookes Unversity.

Li, Y., Li, M., Li, C., & Liu, Z. (2020). Optimized maxent model predictions of climate change impacts on the suitable distribution of *Cunninghamia lanceolata* in China. *Forests*, *11*(3), 302. https://doi.org/10.3390/f11030302

Mangunjaya, F. M., Prabowo, H. S., Tobing, I. S. L., Abbas, A. S., Saleh, C., Sunarto, ..., & Mulyana, T. M. (2017). *Pelestarian satwa langka untuk keseimbangan ekosistem: Penuntun sosialisasi fatwa MUI No. 4, 2014 tentang fatwa pelestarian satwa langka untuk menjaga keseimbangan eksosistem*. Jakarta: Lembaga Pemuliaan Lingkungan Hidup dan Sumber Daya Alam, Majelis Ulama Indonesia (MUI) Pusat.

Matondang, N. F., Dewi, B. S., & Winarti, I. (2018). Penggunaan ruang kukang sumatera (*Nycticebus coucang*) pelepasliaran International Animal Rescue Indonesia (IARI) di Hutan Lindung KPHL Batutegi Blok Kalijernih Tanggamus Lampung. *Jurnal Sylva Lestari*, *6*(1), 39–49. https://doi.org/10.23960/jsl1640-50

McCarthy, J., Wibisono, H., McCarthy, K., Fuller, T., & Andayani, N. (2014). Assessing the distribution and habitat use of four felid species in Bukit Barisan Selatan National Park, Sumatra, Indonesia. *Global Ecology and Conservation*, *3*, 210–221. https://doi.org/10.1016/j.gecco.2014.11.009

Moore, R. S., Cabana, F., & Nekaris, K. A. I. (2015). Factors influencing stereotypic behaviours rescued of animals from Asian animal markets: A slow loris case study. *Applied Animal Behaviour Science*, *166*, 131–136. https://doi.org/10.1016/j.applanim.2015.02.014

Morueta-Holme, N., Fløjgaard, C., & Svenning, J. C. (2010). Climate change risks and conservation implications for a threatened small-range mammal species. *PLoS ONE*, *5*(4), e10360. https://doi.org/10.1371/journal.pone.0010360

Muttaqin, L. A., Murti, S. H., & Susilo, B. (2019). MaxEnt (Maximum entropy) model for predicting prehistoric cave sites in Karst area of Gunung Sewu, Gunung Kidul, Yogyakarta. *Proceedings SPIE Volume 11311, Sixth Geoinformation Science Symposium, 113110B*. https://doi..org/10.1117/12.2543522

Nekaris, K. A. I., Blackham, G. V., & Nijman, V. (2007). Conservation implications of low encounter rates of five nocturnal primate species (*Nycticebus* spp.) in Asia. *Biodiversity and Conservation*, *17*, 733–747. https://doi.org/10.1007/s10531-007-9308-x

Nekaris, K. A. I., Pambudi, J. A. A., Susanto, D., Ahmad, R. D., & Nijman, V. (2014). Densities, distribution and detectability of a small nocturnal primate (javan slow loris *Nycticebus javanicus*) in a montane rainforest. *Endangered Species Research*, *24*(2), 95–103. https://doi.org/10.3354/esr00585

Nekaris, K. A. I., Poindexter, S., Reinhardt, K. D., Sigaud, M., Cabana, F., Wirdateti, W., & Nijman, V. (2017). Coexistence between javan slow lorises (*Nycticebus javanicus*) and humans in a dynamic agroforestry landscape in West Java, Indonesia. *International Journal of Primatology*, *38*, 303–320. https://doi.org/10.1007/s10764-017-9960-2

Nekaris, K. A. I. (2014). Extreme primates: Ecology and evolution of asian lorises. *Evolutionary Anthropology: Issues, News, and Reviews*, *23*(5), 177–187. https://doi.org/10.1002/evan.21425

Nekaris, K. A. I., Shekelle, M., Wirdateti, Rode-Margono, E. J., & Nijman, V. (2020). *Nycticebus javanicus* (errata version published in 2021). The moore red list of threatened species 2020: e.T39761A205911512. https://doi.org/10.2305/IUCN.UK.2020-2.RLTS.T39761A205911512.en

Nijman, V., Spaan, D., Rode-Margono, E. J., & Nekaris, K. A. I. (2017). Changes in the primate trade in Indonesian wildlife markets over a 25-year period: Fewer apes and langurs, more macaques and slow lorises. *American Journal of Primatology*, *79*(1), e22517. https://doi.org/10.1002/ajp.22517

Onojeghuo, A. O., Blackburn, A. G., Okeke, F., & Onojeghuo, A. R. (2015). Habitat suitability modeling of endangered primates in Nigeria: Integrating satellite remote sensing and spatial modeling techniques. *Journal of Geoscience and Environment Protection*, *3*(8), 23–38. https://doi.org/10.4236/gep.2015.38003

Phillips, S. J. & Dudik, M. (2008). Modeling of species distributions with Maxent: New extensions and a comprehensive evaluation. *Ecography*, *31*, 161–175.

Phillips, S. J., Anderson, R. P., & Schapire, R. E. (2006). Maximum entropy modeling of species geographic distributions. *Ecological Modelling*, *190*(34), 231–259.

Phillips, S. J., Dudík, M., & Elith, J. (2009). Sample selection bias and presence-only distribution models: Implications for background and pseudo-absence data. *Ecological Applications*. *19*(1), 181–197. https://doi.org/10.1890/07-2153.1

Pliosungnoen, M., Gale, G., & Savini, T. (2010). Density and microhabitat use of bengal slow loris in primary forest and non-native plantation forest. *American Journal of Primatology*, *72*, 1108–1117. https://doi.org/10.1002/ajp.20875

Qiao, H., Feng, X., Escobar, L. E., Peterson, A., Soberón, J., Zhu, G., & Papes, M. (2018). An evaluation of transferability of ecological niche models. *Ecography*, *42*, 521–534. https://doi.org/10.1111/ecog.03986

Rahayu, T. (2015). Perlindungan hukum terhadap satwa dari perdagangan liar (Studi pada Wildlife Rescue Center, Pengasih Kulon Progo Yogyakarta) [undergraduate thesis]. Yogyakarta: Universitas Islam Negeri Sunan Kalijaga.

Rahman, D. A., Gonzalez, G., Haryono, M., Muhtarom, A., Firdaus, A.Y., Aulagnier, S. (2017). Factors affecting seasonal habitat use and predicted range of two tropical deer in Indonesian rainforest. *Acta Oecologica*, *82*, 41–51. https://doi.org/10.1016/j.actao.2017.05.008

Rahman, D. A., Rinaldi, D., Kuswanda, W., Siregar, R., Noorchasanatun, F., Hakim, F., ..., & Putro, H. R. (2019). Determining the landscape priority and their threats for the critically endangered *Pongo tapanuliensis* population in Indonesia. *Biodiversitas*, *20*, 3584–3592. https://doi.org/10.1305/biodiv/d201217

Rahman, D.A. (2020). Ecological niche and potential distribution of the endangered *Bos javanicus* in south-western Java, Indonesia. *THERYA*, *11*, 57–68. https://doi.org/10.12933/therya-20-840

Rahman, D. A., Condro, A. A., Rianti, P., Masy'ud, B., Aulagnier, S., & Semiadi, G. (2020). Geographical analysis of the Javan deer distribution in Indonesia and priorities for landscape conservation. *Journal for Nature Conservation*, *54*, 125795. https://doi.org/10.1016/j.jnc.2020.125795

Rahman D. A, Condro A. A, Giri M. S. (2022a). *Model distribusi spesies: Maximum entropy*. Bogor: IPB Press.

Rahman, D. A., Santosa, Y., Purnamasari, I., Condro, A.A. (2022b). Drivers of three most charismatic mammalian species distribution across a multiple-use tropical forest landscape of Sumatra, Indonesia. *Animals*, *12*(19), 2722. https://doi.org/10.3390/ani12192722

Rajagukguk, E. V. (2014). Efektivitas peraturan perdagangan satwa liar di Indonesia. *Jurnal Wawasan Hukum*, *31*(2), 216–228.

Razgour, O., Rebelo, H., Di Febbraro, M., & Russo, D. (2016). Painting maps with bats: Species distribution modelling in bat research and conservation. *Hystrix*, *27*(1), 11753. https://doi.org/10.4404/hystrix-27.1-11753

Romdhoni, H., Komala, R., Sigaud, M., Nekaris, K. A. I., & Sedayu, A. (2018). Studi pakan kukang jawa (*Nycticebus javanicus* Goeffroy, 1812) di Talun Desa Cipaganti, Garut, Jawa Barat. *AL-KAUNIYAH*: *Journal of Biology*, *11*(1), 9–15. https://doi.org/10.15408/kauniyah.v11i1.4914

Sari, D. F., Budiadi, & Imron, M. A. (2020). The utilization of trees by endangered primate species javan slow loris (*Nycticebus javanicus*) in shade-grown coffee agroforestry of Central Java. *IOP Conference Series: Earth and Environmental Science*, *449*, 012044. https://doi.org/10.1088/1755-1315/449/1/012044

Shepherd, C. R., Sukumaran, J., & Wich, S. A. (2005). *Open season: An analysis of the pet trade in Medan, North Sumatra, 1997–2001*. Kuala Lumpur: TRAFFIC Southeast Asia.

Sinaga, M. W. A. & Masyud B. (2017). Pemanfaatan ruang dan perilaku harian kukang sumatera (*Nycticebus coucang* Boddaert, 1785) di Taman Hewan Pematang Siantar (THPS) Sumatera Utara. *Media Konservasi*, *22*(3), 304–311.

Sodik, M., Pudyatmoko, S., Semedi, P., & Imron, M. (2019). Resource selection by javan slow loris *Nycticebus javanicus* E. Geoffroy, 1812 (Mammalia: Primates: Lorisidae) in a lowland fragmented forest in Central Java, Indonesia. *Journal of Threatened Taxa*, *11*(6), 13667–13679. https://doi.org/10.11609/jott.4781.11.6.13667-13679

Sodik, M., Pudyatmoko, S., Semedi, P., Tafrichan, M., & Imron, M. (2020). Better providers of habitat for javan slow loris (*Nycticebus javanicus* E. Geoffroy 1812): A species distribution modeling approach in Central Java, Indonesia. *Biodiversitas*, *21*(5), 1890–1900. https://doi.org/10.13057/biodiv/d210515

Supriatna, J. (2006). *Conservation programs for the endangered javan gibbon* (*Hylobates moloch*). Jakarta: Conservation International Indonesia and Department of Biology, University of Indonesia..

Swets, J. (1988). Measuring the accuracy of diagnostic systems. *Science*, *240*, 1285–1293.

Thorn, J. S., Nijman, V., Smith, D., & Nekaris, K. A. I. (2019). Ecological niche modelling as a technique for assessing threats and setting conservation priorities for asian slow lorises (Primates: *Nycticebus*). *Diversity and Distributions*, *15*, 289–298. https://doi.org/10.1111/j.1472-4642.2008.00535.x

Tsoar, A., & Kadmon, R. (2007). A comparative evaluation of presence only methods for modelling species distribution. *Diversity and Distributions*, *13*, 397–405. https://doi.org/10.1111/j.1472-4642.2007.00346.x

UN General Assembly. (2015, October 21). Transforming our world: The 2030 agenda for sustainable development, A/RES/70/1. https://www.refworld.org/docid/57b6e3e44.html.

Voskamp, A., Rode-Margono, J., Coudrat, C., Wirdateti, Abinawanto, A., Wilson, R., & Nekaris, K. A. I. (2014). Modelling the habitat use and distribution of the threatened javan slow loris *Nycticebus Javanicus*. *Endangered Species Research*, *23*, 277–286. https://doi.org/10.3354/esr00574

Wibisono, H. T., Wahyudi, H. A., Wilianto, E., Pinondang, I. M. R., Primajati, M., Liswanto, D., & Linke, M. (2018). Identifying priority conservation landscapes and actions for the critically endangered javan leopard in Indonesia: Conserving the last large carnivore in Java Island. *PloS ONE*, *13*(6), e0198369. https://doi.org/10.1371/journal.pone.0198369

Wiens, F. & Zitzmann, A. (2003). Social structure of the solitary slow loris *Nycticebus coucang* (Lorisidae). *Journal of Zoology*, *261*, 35–46. https://doi.org/10.1017/S0952836903003947

Wirdateti, Dahrudin, H., & Sumadijaya, A. (2010). Sebaran dan habitat kukang jawa (*Nycticebus javanicus*) di lahan pertanian (hutan rakyat) wilayah Kabupaten Lebak (Banten) dan Gunung Salak (Jawa Barat). *Zoo Indonesia*, *20*(1), 17–25.

Wisz, M. S., Hijmans, R. J., Li, J., Peterson, A. T., Graham, C. H., & Guisan, A. (2008). Effects of sample size on the performance of species distribution models. *Diversity and Distribution*, *14*, 763–773.

Young, N., Carter, L., & Evangelista, P. (2011). *A maxent model v3.3.3e tutorial* (*ArcGIS v10*). Colorado: Colorado State University.

Zegarra, O., Pacheco, J., & Pacheco, V. (2020). Distributional patterns of the brazilian free-tailed bat *Tadarida brasiliensis* in the Peruvian Territory. *THERYA*, *11*(3), 495–507. https://doi.org/10.12933/therya-20-995