Journal of Tropical Biodiversity and Biotechnology
Volume 06, Issue 01 (2021): jtbb58612
DOI: 10.22146/jtbb.58612

Research Article

Predicting the Distribution of Sunda Pangolin (*Manis javanica* Desmarest, 1822) in Way Canguk Research Station, Bukit Barisan Selatan National Park, Lampung

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Submitted: 14 August 2020; **Accepted:** 20 March 2021; **Published online:** 14 April 2021

ABSTRACT
The distribution of a species can help guide the protection activities in their natural habitat. Conversely, the lack of information on this distribution makes the protection strategy of this species difficult. The research was conducted in Way Canguk Research Station, Bukit Barisan Selatan National Park from January until March 2018. The purposes of this research were to create a distribution prediction map of Sunda pangolin (*Manis javanica*) and estimating the environment variables that most influenced the probability of the distribution. Fourteen points of camera trap coordinates were used for presence data with nine types of environment variables such as elevation, slope, understorey, canopy cover, distance from roads, distance from rivers, distance from villages, food source, and distance from the threat. The result of maxent showed an Area Under the Curve (AUC) value of 0.909 categorized as very good. The highest probability of Sunda pangolin distributions was in the Pemerihan Resort and Way Haru Resort area, while the dominant environmental variables included the distance from the village, the canopy cover, and the distance from threat with the value 47.7; 25.85; and 15.8%, respectively. Prediction maps and environment variables can help to identify the population of Sunda pangolin in the wild and can provide input for the national parks to prioritize protection areas for Sunda pangolin from the increased poaching.

Keywords: *Manis javanica*, maxent, species distribution, Way Canguk research station

INTRODUCTION
A pangolin is a type of mammals of the Order of Pholidota having scales (Payne et al. 1985). There are four types of pangolins distributed in Asia (*Manis javanica, Manis craussicaudata, Manis pentadactyla*, and *Manis culionensis*) and four in Africa (*Manis temminckii, Manis tricuspis, Manis gigantea*, and *Manis tetradactyla*). *Manis javanica* or Sunda pangolin are distributed on the islands of Sumatra, Java, and Kalimantan (Challender 2014). Geographically, Sunda pangolins can be found at different altitudes: 10-100 masl (TEAM camera traps photo findings), 350-900 masl (Wirdateti et al. 2013), and 1170 masl (Manshur 2015).

Generally, a Sunda pangolin is a shy animal, not aggressive, and solitary, although on some occasions they found more than one individual. Sunda pangolins have an important value as a natural controller of the insect population, such as ants and termites. They can eat up to 70 thousand ants and termites per year, and they play a role in improving soil quality (Rodrigues 2011). Sunda pangolins also have high economic values, their scales are used for traditional medicine and the meat is cooked for exotic food (Sawitri & Takandjandji 2016). In Malaysia, the scales of Sunda pangolin used for asthma medication and protection from witchcraft, whereas, in Indonesia believed to protect from harmful magic (Chong 2020). Poachers used snares, traps, or dogs to catch on the Sunda pangolin (Newton et al. 2008). They are one of the protected and are included in the Appendix I Convention on International Trade in Endangered Species (CITES) due to illegal hunting since 2000 (Sawitri et al. 2012). The IUCN Red-List established Sunda pangolin as critically endangered in 2013.

One of the habitats of Sunda pangolins is Bukit Barisan Selatan National Park (BBSNP). This research is the first ecological study about Sunda pangolins in this area since 1997. Wirdateti et al. (2013) was researched the distribution and population of Sunda pangolin in Tanggamus and West Lampung, but that was not in the BBSNP area. Studies on Sunda pangolins are very rarely done in Indonesia, especially in Sumatra. So far, most of the studies on pangolins were about genetics (Nie et al. 2009; Wirdateti et al. 2013; Wirdateti & Semiadi 2017), physiology (Cahyono 2008), behavior in the captivity (Febriyanti 2016), and trades (Takandjanji & Sawitri 2016).

However, the information about the ecological nature of Sunda pangolins was found to be lacking, including the information about the distribution of Sunda pangolin in a certain region. The purposes of this research are to predict the distribution pattern of Sunda pangolins and to study the environmental variables that influenced the presence of Sunda pangolin in the BBSNP. By evaluating the distribution of Sunda pangolins, BBSNP can determine the priority areas for the protection and conservation of Sunda pangolin.

METHODS

Research location

The research was conducted at Way Canguk Research Station, Bukit Barisan Selatan National Park (BBSNP) (Figure 1) from January - March 2018. The range of altitude of this research station was 0-100 masl (Endarwin 2006).

Data collection

Presence data of Sunda pangolin (direct observation)

The presence was used for maxent analysis, and they were recorded not only by direct encounter with the species (the primary sign of existence) but also by coordinates point of presence of species from camera traps (the secondary sign of existence). Several Sunda pangolin photos were caught by camera trap installed by WCS-IP through the TEAM (Tropical Ecology Assessment and Monitoring program) from 2010-2017. Fourteen presence data of Sunda pangolin were recorded from TEAM camera trap coordinate points from 2010-2017. The camera trap installation area included three resorts: Pemerihan Resort, Way Haru Resort, and Way Nipah Resort with a total of 60. All camera trap locations were evaluated to obtain environment variables, and camera traps points were recorded using Microsoft Office Excel with three columns: species, longitude, and latitude in CSV format. Additionally, UTM (*Universal Transverse Mercator*) for a geographic coordinate system was used.

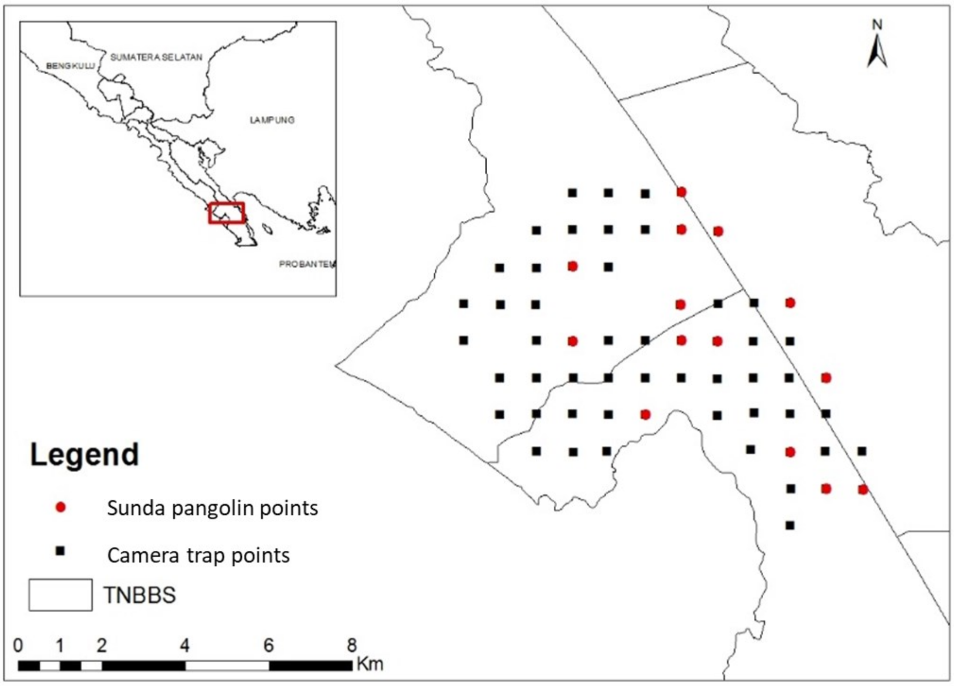

Figure 1. Research location in Bukit Barisan Selatan National Park.

Environment variables

The data of environment variables were obtained directly and indirectly. Some parameters, such as tree vegetation survey, food sources, understorey, canopy cover, and distance from threat were recorded directly. Tree vegetation survey used a 20 m x 20 m grid, and points of camera trap were used as a center point. Measurement of DBH (Diameter at the Breast Height) was carried out 1.3 m above the ground and only the trees having the DBH > 20 cm were surveyed. Food sources data were obtained from ants and termite nests in every camera trap point. Understorey data were obtained using a gridded sheet sized 1 m x 1 m which was divided into 16 squares, and camera trap points were used as the center point.

The distance from the camera trap point to obtain the data was 10 meters each in four directions following the compass direction. Canopy cover data were obtained using spherical densiometer model C in four directions based on compass direction, and camera traps points were used as the center point. Distances from threat data were obtained from traps coordinate point directly in the field and human photos of presence coordinate point at camera trap were also used.

Four data from the environment variables were recorded directly to Microsoft Office Excel with CSV format, and then ArcGIS was used for the deterministic interpolation (Arctoolbox –interpolation – IDW). The processed data were in raster format, and then they were converted into ASCII format (Arctoolbox – Conversion Tools – From Raster – Raster to ASCII). Distances from villages, road, and river data were obtained from Rupa Bumi Indonesia (RBI) map with a scale of 1:200.000 in point and line shapes. Slope and elevation data were obtained from USGS Explorer from DEM (Digital Elevation Model) 30 arc second via https://earthexplorer.usgs.gov/ website.

Data analysis

Maxent Ver. 3.4.1k at https://biodiversityinformatics.amnh.org/open_source/maxent/ (free version) was used. The maximum entropy is a species distribution model that uses two data sets: presence data and environment variables (Elith et al. 2006; Phillips et al. 2006). For presence data in this study, direct presence data and indirect presence data were used. Direct presence data was finding the species directly in the field, while the indirect presence data included camera trap coordinates, scratches, footprints, and feces data. The environment variable data used direct data or indirect data. Direct data of environment variable were obtained in the field, for example, food sources (ants and termite nest) of Sunda pangolins, and indirect data used the GIS layer of RBI maps. Direct data of the environment variables used the interpolation in the ArcGIS menu for the estimated values. Interpolation is generally divided into two, deterministic interpolation and geostatistical methods. Deterministic interpolation is a deterministic calculation that is used to measure values based on the data obtained from the field. Deterministic interpolation has various choices of menus at ArcGIS desktops such as IDW (Inverse Distance Weighting), Natural neighbour, Trend, and Splind. Geostatistical methods are based on an autocorrelated statistic model (statistical relationship based on measured points) (ArcGIS Dekstop 2020). Environment variables were obtained using the GIS layer and using Euclidean Distance. Euclidean Distance describes each cell-to-source relationship or set of sources based on straight line distance (ArcGIS Dekstop 2020).

Maxent estimates environment variables that had important roles in the prediction model, like an environment variable based on the Jackknife curve (Phillips et al. 2006). In addition, there was a response curve that had an important role in showing the presence probability of a species to the environment variables (Tarjuelo et al. 2014). The prediction was improved based on AUC (*Area Under the Curve*) value. AUC is a curve that shows the probability of a species to maps (Baldwin 2009). A prediction is acceptable if the AUC value is above 0.75. AUC values according to Baldwin (2009) can be seen in Table 1.

Table 1. Area Under the Curve (AUC) value classification.

AUC value	Model performance
0,9 – 1,0	Very good
0,8 – 0,9	Good
0,7 – 0,8	Medium
0,6 – 0,7	Not good

Presence data of the 14 coordinate points containing Sunda pangolin photos from the TEAM camera trap were saved in CSV format. The environment variable data were compiled using ASCII (asc) format with the same extent and cell size (depend on the data) in order running in maxent software. Cell size and extent are environment settings contained in tools at ArcGIS software. Cell size refers to raster size and extent refers to a range of feature data or specified raster (ArcGIS Dekstop 2020). All geographic coordinate systems used the UTM projection format. Presence data of Sunda pangolin were recorded in CSV format and environment variable in asc format. The data result was the prediction distribution of Sunda pangolins and the prediction of environment variables that most influenced the Sunda pangolins presence at the research site.

RESULTS AND DISCUSSION

Prediction distribution map of Sunda pangolin

One of the results of the maxent model was AUC values that shaped the graph, and AUC could easily compare the performance of one model with another. The black line on the AUC value was a random prediction, while the red line meant the value of training data. The AUC value of this study showed that the prediction of Sunda pangolin distribution was 0.909 (Figure 2). Based on the classification of AUC values from Araujo and Gausan (2006), the AUC value was categorized as very good.

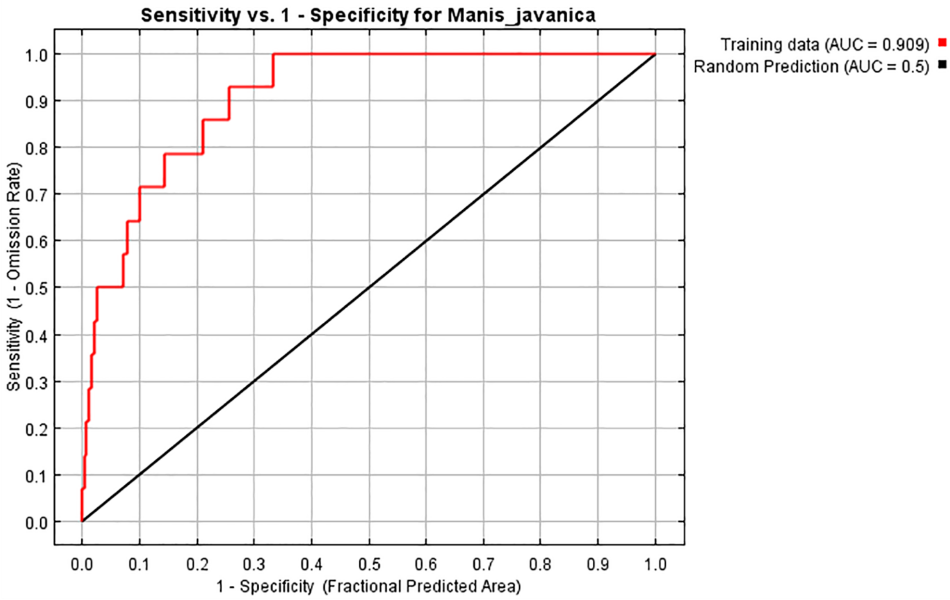

Figure 2. The sensitivity and 1-sensitivity graph of Sunda pangolin.

Figure 3 shows the prediction of the distribution of Sunda pangolin using the Maxent's analysis. The color gradations generated in the Maxent analysis provided separate information for the prediction of the presence of Sunda pangolins. The green color predicted a low distribution of Sunda pangolins presence, the orange color showed a moderate prediction

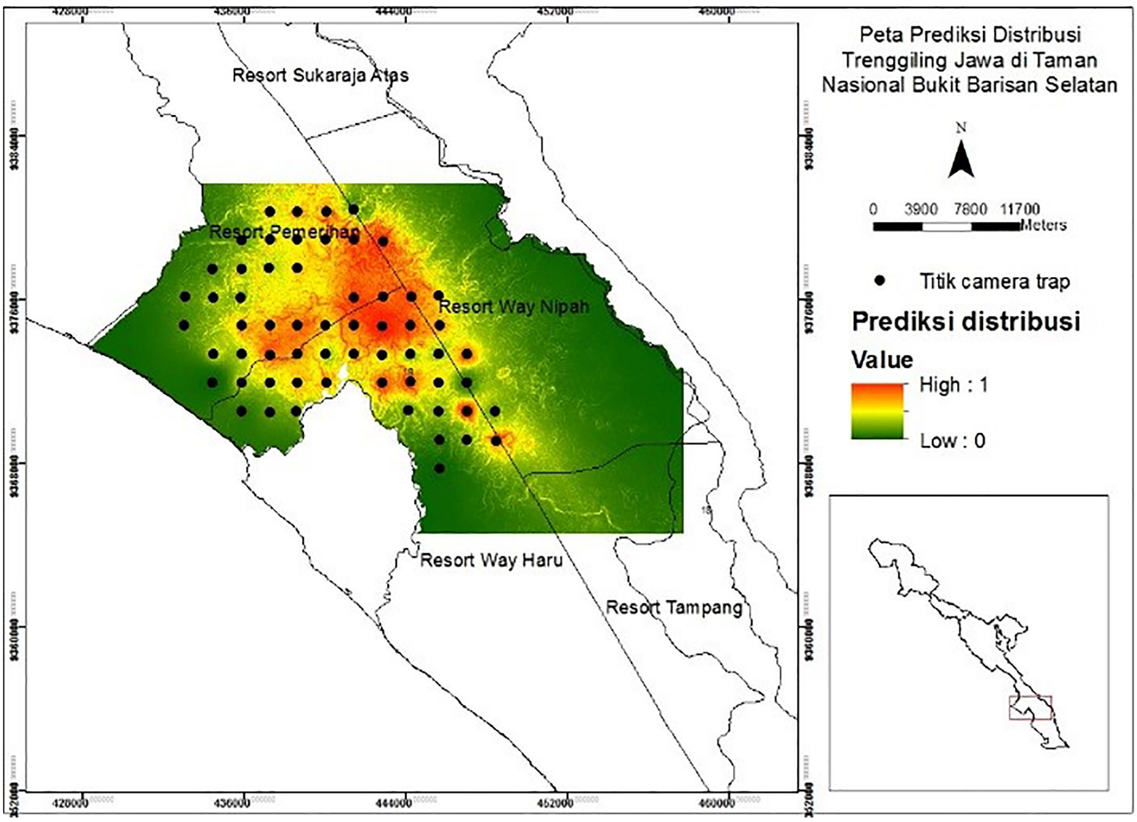

Figure 3. Prediction distribution of Sunda pangolin in BBSNP.

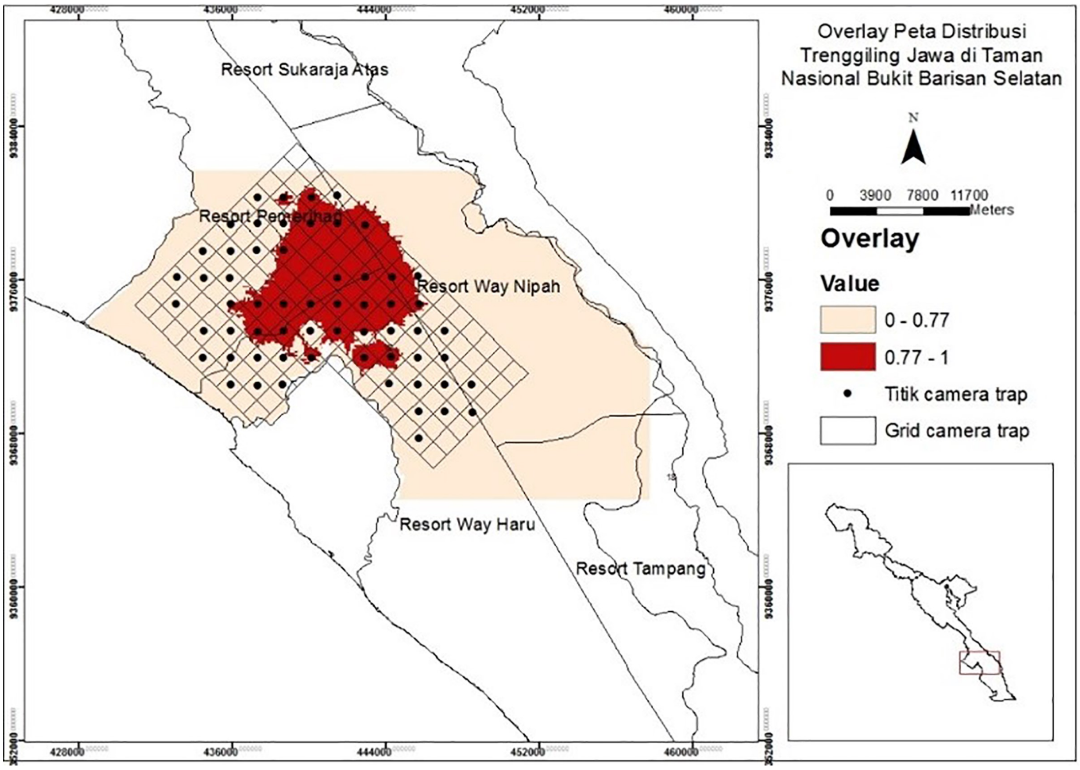

Figure 4. The overlay of distribution of Sunda pangolin in BBSNP.

distribution of Sunda pangolins, and the red color indicated as a high distribution of Sunda pangolin. The highest prediction of the Sunda pangolin was found in the Pemerihan Resort and Way Haru Resort area as indicated with the red color.

The results of the prediction distribution map, especially the line of the prediction area, were more visible using an overlay. An overlay is an overlapping thematic map process with different geographical layers to decide a spatial conclusion. The red color showed the prediction distribution area of Sunda pangolin with the probability of >0.77 (Figure 4). The highest prediction for the presence areas of Sunda pangolin was in the Pemerihan resort and Way Haru resort area. Both resorts were known to be the habitat for several endangered and protected species such as wild cats, sumatran tigers, and Sunda pangolins (Putri 2017).

Sunda pangolin tends to be found on difficult (or steep) lanes and slopes, and in this study, there were 14 points of Sunda pangolin presence found using TEAM camera traps which were located in this difficult condition. Manshur (2015) stated that slopes had an important role as an environmental variable affecting the presence of Sunda pangolin for as much as 72%. The slope was used by Sunda pangolins as an anti-predator strategy which was to roll away to protection. The slope used by Sunda pangolins ranged from 0-70 degrees (as seen from the result of the Maxent analysis), and the speed at which a Sunda pangolin roll itself could reach 15 km/ minute (Manshur 2015).

A direct encounter with Sunda pangolins did not occur in this study. However, scratches on trees and one scale of Sunda pangolin near a branching river. The scratches of Sunda pangolin that were found in the field could not use as presence data, because they were difficult to distinguish from those of the sun bear (Figure 5). The Pangolin Specialist Group (PSG) team in 2017, which conducted observations for two years in Thailand, was also still unsure whether the scratch came from Sunda pangolin. They assumed that the Sunda pangolin's scratches had 2 to 3 lines that stuck to trees or soil. Sunda pangolin scratches seen in Ragunan Zoo also had 2 to 3 lines.

Figure 5. The scratches form of Sunda pangolin in Ragunan zoo.

Contribution of the environmental variables

Maxent provides the metric to determine the importance of environment variables in contribution percentages. The results showed that the distance from the village had the highest percentage of 47.8%, followed by canopy cover and distance from the threat having a percentage of 25.8% and 15.8% respectively (Table 2).

Table 2. Contribution percentage of environment variables of Sunda pangolin.

Variable	Contribution percentage
Village	47,4
Canopy cover	25,8
Threat	15,8
River	5,9
Slope	4,3
Food source	0,7
Road	0,2
Understorey	0
Elevation	0
Total	**100%**

Maxent model estimates that environmental variables have an important role in the resulting prediction model, i.e, environmental variables based on the contribution percentages of the jackknife test results. Based on the percentage of contribution, three environmental variables were most influential in the presence of Sunda pangolins: distance from the village, canopy cover, and distance from the threat.

Based on the distance response curve from the village (Figure 6), the probability of the presence of Sunda pangolin increased the further the distance from the village was. The probability of the presence of Sunda pangolin continued to increase until the distance from the road reached 9500 m (red line). Sunda pangolins tend to avoid the center of the crowd caused by other animals and humans in order to protect themselves from predators, such as big cats (Wang 2016). Additionally, Sunda pangolins are a solitary animal which does not like to appear in groups. Sunda pangolins use the distance of village as a strategy to avoid humans (Manshur 2015).

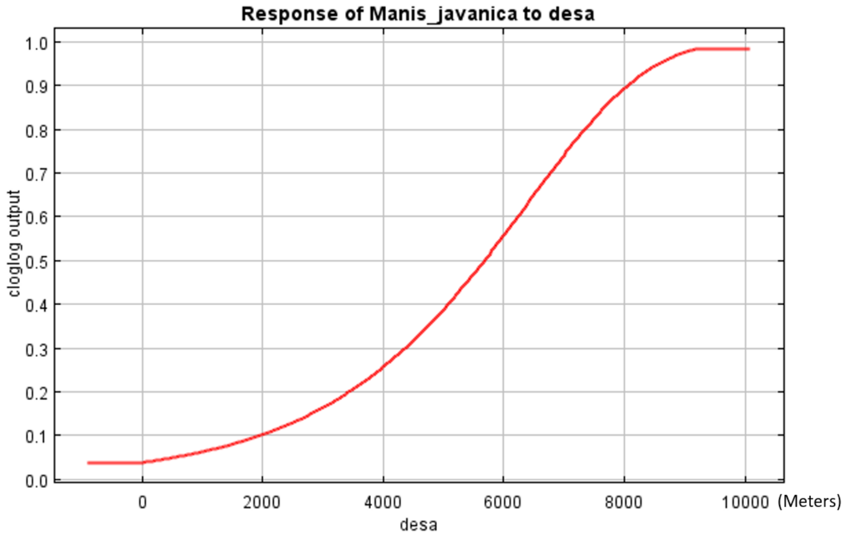

Figure 6. Environment variable response curve of the village distance of Sunda pangolin.

Besides the distance of the village, the contribution percentage of the environment variables showed that canopy cover was the second most important environment variable affecting the probability of Sunda pangolin's existence. Based on the canopy cover response curve, the probability of the presence of Sunda pangolin increased the higher the canopy cover was (Figure 7), shown by the consistent increase of the red line. The presence of Sunda pangolins increased when canopy cover values ranged from 70-90%. The high level of canopy cover density is a special habitat type used by Sunda pangolins to obtain food resources and to use as security strategies from both competitions and predators (Manshur 2015).

At the time of the study, the family of Dipterocarpaceae dominated the area where Sunda pangolins were present at the TEAM camera trap coordinates. This family grows at 0-800 masl with a wet climate and high humidity (Fajri 2008). One type of burrow made by Sunda pangolin was located under a tree trunk that had a hole near the ground. Pangolins make burrows in trees and use wood from this family because this type of wood is resistant to cold temperatures; thus, the temperature in the wood used as the burrow is still warm.

The third environment variable affecting the probability of Sunda pangolin was the distance from threats. Based on the distance from the threat response curve, the probability of the Sunda pangolin decreased the farther the distance from the threat was (Figure 8), shown by the downward red line. The Sunda pangolin is an animal that does not have many activities during the day and spends the afternoon resting and remaining silent. Sunda pangolin are difficult to find if there is no threat from natural or human predators. In addition, if the intensity of threat is too high the pangolin will go out of its burrow (based on the maxent analysis). In Indonesia, the population of Sunda pangolin in nature is still unknown. Researchers were difficult to meet Sunda pangolin, thus they used poachers to help them to research Sunda pangolin. Poachers used their steps or threats to find Sunda pangolin. The threats such as poacher using dog, traps, or used fire smoke.

Based on camera traps data, there were human illegal activities on nine camera traps coordinate.

The area of the Sunda pangolins prediction distribution map had a high level of hunting. This was evidenced by the discovery of traps made of rope, nylon straps, and iron strings. In addition, traces of poachers' tents, weapons, traps for birds, rifles or firecrackers, and animals were found. The research from Pangolin Specialist Group (PSG) team in 2017 showed that every 5 minutes, there was one pangolin take from nature. Sunda pangolin is one of the animals that most traded because it has higher economic value. Sunda pangolin tends to roll up the body when they feel threatened, and human was easy to catch. The knowing of the situation can encourage the national park and SMART patrol team to give more attention to the patrolling of the resort, thus the danger of Sunda pangolin hunting can be minimized.

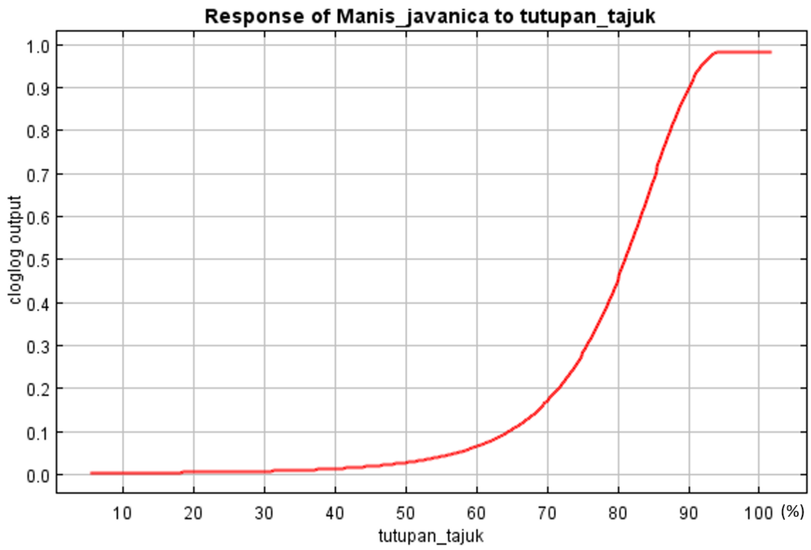

Figure 7. Environment variable response curve of canopy cover of Sunda pangolin.

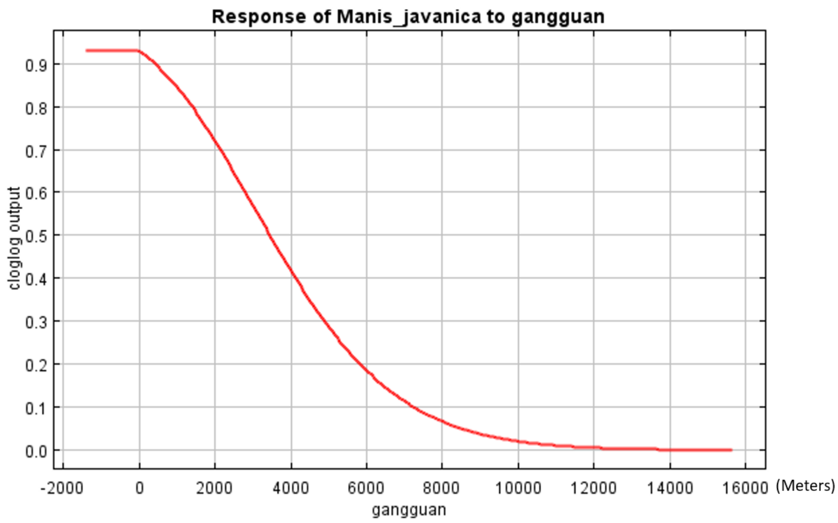

Figure 8. Environment variable response curve of the threat distance of Sunda pangolin.

CONCLUSION

Sunda pangolins tended to like with tight canopy cover of trees, found in this study. As solitary animals, Sunda pangolins tended to avoid the crowd. They would leave the burrow to look for food, and threats also made Sunda pangolins go out of their burrow and this made it was for them to be caught.

The tree environmental variables that most influence the distribution of Sunda pangolin are the distance of village (47.8%), canopy cover (25.8%), and distance from threat (15.8%). Poachers used smokes or dogs to achieve this condition. Pemerihan and Way Haru resorts were the highest prediction distribution of Sunda pangolins but they also had too much hunting and poaching. Both resorts were still the site of frequent illegal logging and trees falling naturally.

AUTHOR CONTRIBUTION

S.D.A designed the research and analyzed the data. All authors wrote the manuscript.

ACKNOWLEDGMENTS

The authors would like to thank the people that help in Way Canguk Research Station especially Mas Janji, Bray, Agung, Mas Seti, Mas Rahman, Mas Laji, and also collage friend Anggun who struggle together to collected data.

CONFLICT OF INTEREST

The authors don't have conflict of interest.

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