Extinction risk analysis of barking deer (*Muntiacus muntjac*) in Sermo Wildlife Sanctuary

Relissiana, H Marhaento*, Subeno
1 Forest Resources Conservation Department, Faculty of Forestry, Gadjah Mada University, Yogyakarta 55281, Indonesia

Corresponding: marhaento@ugm.ac.id

Abstract. Sermo Wildlife Sanctuary (SWS) is a habitat of barking barking deer (*Muntiacus muntjac*) that is included as one of the protected species according to Ministerial Decree of Forestry and Environment No. 92/2018. The latest report from the authority, the Yogyakarta Natural Resources Conservation Agency (BKSDA Yogyakarta), stated that in 2017, it was estimated that there are only six individual barking deer inside the SWS. Their existence is threatened due to several activities such as tourism and agriculture practices. It should be noted that SWS was formerly a production forest so that local communities have been used to involve in forest management. Apparently, after the forest status has been changed into a protected area, the activities inside the forest are still remaining and thus potentially result in disturbing the barking barking deer habitat. This study aims to assess the extinction risk of the barking deeper inside the SWS. This study used the Spatial Multicriteria Analysis (SMCA) through Geographical Information Systems (GIS) technique to assess the extinction risk of barking deer in SWS. The results show that 137.21 hectares or 73.77% of the total area of SWS is an area that is prone to barking deer habitat. Therefore, it is necessary to take conservation measures and increase supervision so that habitat threats can be minimized.

Keywords: extinction risk, barking deer, protected area, GIS

1. Introduction

According to Indonesia Law No.5 of 1990, Wildlife Sanctuary, or in Bahasa Indonesia known as Suaka Margasatwa (SM), can be described as a nature reserve area that is characterized by diversity and uniqueness of animal species, which a habitat improvement can be done to preserve their existence. Sermo Wildlife Sanctuary (SWS) is one of the wildlife sanctuaries located in Yogyakarta special province, which was established through the Decree of the Minister of Forestry Number SK. 3112/MENHUT-VII/KUH/2014. Different from other wildlife sanctuaries whose land cover is mainly covered by natural forest, the SWS area was a production forest managed by KPH Yogyakarta, so that is dominantly covered by a single species (i.e., monoculture). However, although it was developed as a production forest, it was managed with intercropping systems involving local communities to plant crops in between the main tree commodity\(^1\). Since it was initially formed as a production forest, the diversity of food supply for animals in SWS is relatively limited. The reduction of vertical stratification and horizontal heterogeneity of forests may cause a decrease in the quality of habitat for wildlife\(^9\).

Barking deer (*Muntiacus muntjac*) is one of the priorities animals to be preserved in SWS. The barking deer has a conservation status “Least Concern” according to the International Union for Conservation of Nature (IUCN) as Least Concern, and “Protected” according to the Minister of Environment and Forestry Regulation No. 92 of 2018. From the latest survey results in SWS, the number of barking deer inside SWS is about six individuals\(^1\). This is a relatively small number of barking deer population in SWS, and thus expected to experience the threat of population decline in the future.
It should be noted that the main threat of declining barking deer population is mainly due to the decreasing of the wildlife habitat. Anthropogenic pressures from an increase in human activities such as road construction and settlement development inside the forest area are the main cause of the damage of wildlife habitat. A large number of publications have shown that road construction has caused a forest fragmentation that gives the distance between habitat patches causing isolation between habitat areas. As a result, this forest fragmentation will disrupt and reduce the diversity and population number of species inside the forest, including barking deer\(^2\). In addition, Sermo is part of the Menoreh hills and geologically formed by a denudational area, in which the soil is relatively easy to be eroded\(^8\). This condition makes Sermo potentially prone to landslides which can damage the forest and will affect the availability of food, shelter, and microclimate for animals.

Since there are many factors that threaten the barking deer, serious attention is needed to preserve the existence of barking deer in SWS. This study aims to assess the risk of barking deer extinction in the SWS through the application of Geographical Information Systems (GIS). The results of our study can be used as a basis for mitigation strategies to avoid the declining barking deer population.

2. Methodology

2.1. Study area

This research was conducted in Sermo Wildlife Sanctuary, Kulon Progo Regency, Yogyakarta Special Region. SWS is geographically located between 7\(^\circ\)47'00" to 7\(^\circ\)50'00" South Latitude (LS) and 110\(^\circ\)00'00" to 110\(^\circ\)09'30" East Longitude (BT). SWS is located between two villages, namely Hargowilis Village in Kokap District and Karangsari Village in Pengasih District.

2.2. Methods

2.2.1. data collection.

Data collection was carried out directly in the field to create a threat map of barking deer habitat in SWS. The first step of data collection is a literature study to determine the criteria and sub-criteria on the barking deer habitat suitability map and the barking deer vulnerability map. Secondly, we used the presence of barking deer caught by camera traps to assess the habitat suitability map. Thirdly, the habitat vulnerability was determined based on the encroachment points, that were obtained through Forum Group Discussion (FGD) with the SWS manager and the local communities (i.e., MMP).

2.2.2. Data analysis.

The Spatial Multicriteria Analysis (SMCA) was used to analyse habitat suitability and vulnerability maps. We chose this method since it can be used for complex decision-making and provides an alternative for selecting spatial locations\(^6\). In the analysis, scores and weights are given to each criterion and sub-criteria. The scores and weights for the habitat suitability were determined based on the number of barking deer encountered by the camera trap in each criterion. We used six criteria for habitat suitability such as slope, altitude, canopy closure, ground cover closure, distance from roads, and distance from rivers. While the scores and weights for the habitat vulnerability were determined based on the number of points of encroachments in each criterion. We used six criteria for habitat vulnerability such as slope, altitude, distance from roads, distance from rivers, distance from settlements, and distance from tourist sites. The largest scores and weights were given to the criterion that has the highest influence. Furthermore, we multiplied the scores and the weights of each criterion and then classified them into three classes, namely low, medium, and high classes\(^5\).

The results of habitat suitability and vulnerability maps then were spatially combined to produce the extinction risk of barking deer in SWS. We used a key of determination as shown in Table 1 to obtain three levels of risks namely low risk, medium risk, and high risk. We noted that all the spatial analysis conducted in this research was executed using ArcGis v.10.6.
3. Results and discussion

3.1. Spatial distribution of barking deer’s habitat risk

Table 2 shows the scores and weights for each criterion for habitat suitability and vulnerability of the barking deer in SWS. For the habitat suitability, we found that among the six criterion altitude has the largest weight with a value of 0.29, while ground cover closure has the smallest weight with a value of 0.05. While for the habitat vulnerability, distance from tourist area has the largest weight, while altitude has the smallest weight with a value of 0.05.

Table 2. Scores and weights of criteria and sub-criteria for barking deer habitat suitability and vulnerability based on the SMCA method

| Criteria                  | Weight | sub-criteria | Score | Weight | sub-criteria | Score |
|---------------------------|--------|--------------|-------|--------|--------------|-------|
| Slope (%)                 | 0.24   | <15%         | 10    | <25%   | 30           |
|                           |        | 15-40%       | 20    | 25-40% | 20           |
|                           |        | >40%         | 30    | >40%   | 10           |
| Altitude (msl)            | 0.29   | <150         | 10    | <150   | 30           |
|                           |        | 150-250      | 30    | 150-250| 20           |
|                           |        | >250         | 20    | >250   | 10           |
| Canopy closure (%)        | 0.14   | <40%         | 10    | -      | -            |
|                           |        | 40-60%       | 20    | -      | -            |
|                           |        | >60%         | 30    | -      | -            |
| Ground cover closure (%)  | 0.05   | <40%         | 10    | -      | -            |
|                           |        | 40-60%       | 20    | -      | -            |
|                           |        | >60%         | 30    | -      | -            |
| Distance from road (meters) | 0.19 | <100         | 30    | <200   | 30           |
|                           |        | 100-200      | 20    | 200-400| 20           |
|                           |        | >200         | 10    | >400   | 10           |
| Distance from the river (meters) | 0.10 | <150         | 20    | <100   | 10           |
|                           |        | 150-300      | 30    | 100-200| 30           |
|                           |        | >300         | 10    | >200   | 20           |
| Distance from settlement (meters) | 0.10 | <200         | 20    | -      | -            |
|                           |        | 200-400      | 30    | -      | -            |
|                           |        | 400-600      | 25    | -      | -            |
|                           |        | 600-800      | 15    | -      | -            |
|                           |        | >800         | 10    | -      | -            |
Figure 1 shows the results of the barking deer's habitat suitability map, habitat vulnerability map, and habitat risk map. For the habitat suitability, it was observed that the SWS is a good habitat for barking deer with 131.58 hectares (70.75%) of the total area are highly suitable. However, at the same time, the habitat vulnerability of the barking deer is classified as moderately to highly vulnerable, with a value of 77.81 hectares (41.84%) and 89.91 hectares (48.35%), respectively. Combining that two information, we were able to obtain the extinction risk level of barking deer in the SWS such as 137.21 hectares (73.77%) of the total area is high risk, 42.58 hectares (22.9%) is moderate risk, and 5.97 hectares (3.21%) is low risk. Table 3 shows the distribution of low, medium, and high levels of habitat suitability, susceptibility to encroachment, and habitat risk in SWS.

Table 3. The distribution of low, medium, and high levels of habitat suitability, susceptibility to encroachment, and habitat risk in Sermo Wildlife Sanctuary.

| Level | Habitat Suitability | Habitat vulnerability | Habitat Threat |
|-------|---------------------|-----------------------|----------------|
| Low   | 4.20                | 18.26                 | 5.97           |
| Medium| 50.20               | 77.81                 | 42.58          |
| High  | 131.58              | 89.91                 | 137.21         |
3.2. Discussion

We found that there were six barking deers caught by camera traps. From our analysis, the area of SWS is most suitable as a habitat for barking deer. It was observed that barking deer in SWS seems to choose locations that are close to the road, even though barking deer are animals that are quite sensitive to the presence of humans. The difference in barking deer behaviour was probably forced by the changes in the SWS habitat, where forest fragmentation due to road construction across SWS area so that has limited the movement of barking deer. Thus, they adapt to the new environment, although actually barking deer requires quite a large area to meet their daily needs including food, protection, and breeding.

The habitat vulnerability in SWS is quite high in particular due to tourism in the SWS area. There are 13 tourism potential sites where 10 sites are located outside the utilization block, which later require a good tourism management practice in order to avoid habitat damage. In addition, the land-based activities carried out by the community around SWS includes the extraction of firewood, grazing, and planting herbs has increased the habitat vulnerability. Some locals are still carrying out land-based activities inside the SWS in particular due to long-time culture since the area is still formed as a production forest. In addition, road development has increased access to the forest.

With a condition of high habitat suitability but at the same time highly habitat vulnerability, the risk of barking deer extinction in SWS is high. Therefore, the authorities must take action to mitigate the risk. To date, several efforts have been carried out by the SWS manager to increase the public participation in the conservation activities, for example by forming groups of Masyarakat Mitra Polhut (MMP) and Masyarakat Peduli Api (MPA). However, during our field surveys, we found that many local communities still do not understand that SWS is mainly dedicated to habitat improvement thus quite limited to human activities. Based on the results we obtained, the authorities can formulate certain actions to reduce the threat to barking deer such as increasing the wildlife monitoring mainly in the suitable area and involving more local communities in the forest conservation activities. We believe that with good cooperation between managers and the local community, the extinction risk of barking deer habitat in SWS can be minimized so that barking deer populations can increase.

4. Conclusion

Based on the results of the Spatial Multi Criteria Analysis, we found that most of the SWS areas have a high level of habitat suitability with an area of 131.58 hectares or 70.75% of the total area, which elevation, slope, and distance to the road are detected as the most influential criterion. In terms of habitat vulnerability, we found that most of the areas have a high level of habitat vulnerability with an area of 89.91 hectares or 48.35% of the total area, which distance from tourism sites and distance to the road are the most influential criterion. These conditions resulted in a high risk of barking deer with an area of 137.21 hectares or 73.77% of the total area. Our results show that there is a serious threat to barking deer existence in SWS, so that conservation measures are urgently needed to conserve the barking deer habitat.

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