Predicting Connectivity Between Main Range Forest Complex and Taman Negara

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Abstract

Taman Negara National Park represents the largest protected area gazetted for terrestrial and freshwater biodiversity in Malaysia. Main Range Forest Complex (FC), located at the west of Taman Negara National Park consist of several permanent forest reserves managed by the respective State Forestry Department. Infrastructure development, including several network of roads have resulted in the increase in forest fragmentation, including between the Main Range FC and Taman Negara, thus disrupting the movement of wildlife between them. This study aims to identify potential linkage between the Main Range FC and Taman Negara to ensure that the wildlife can continue roaming between the two habitats in Peninsular Malaysia. Occurrence data of Malayan gaur (*Bos gaurus*), Asian elephant (*Elephas maximus*), Asian tapir (*Tapirus indicus*) and Malayan tiger (*Panthera tigris*) within the study areas that were collected by the Department of Wildlife and National Parks since last 5 years were used to ascertain their distribution. These distribution data and other environmental parameters such as topography, elevation, forest types, soil types, distance from river and roads were used to delineate potential habitat (or habitat suitability) for these four wildlife species using maximum entropy (MaxEnt) modeling. The modeling produces patches of wildlife’s predicted habitat at the main range. However, different species produces different potential habitat but majority of the area consists of lowland forest. The patches were connected to the Taman Negara National Park by using corridor modeling with the main linkage at Sg. Yu. Identification of potential connectivity between fragmented forests allows effective conservation at the selected area.
Keywords: connectivity, corridor modeling, Taman Negara, wildlife

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INTRODUCTION

Over the years, conversion of forested land into agriculture, road and settlement has led to fragmentation and isolation of forested areas. As a result, movement of large ranging wildlife such as Asian elephant (*Elephas maximus*), Malayan gaur (*Bos gaurus*), Malayan tiger (*Panthera tigris*) and Asian tapir (*Tapirus indicus*) have been affected. This is a major concern to conservationists as these species are listed in IUCN Red list that needs proactive conservation efforts. The Main Range Forest Complex in Peninsular Malaysia runs longitudinal from southern Thailand to southern Peninsular Malaysia (Kawanishi et al., 2003) with a number of permanent forest reserves on either sides of the Main Range. Just east of the Main Range is Taman Negara National Park (TNNP). Being the largest Protected Area in Malaysia, it was established for the protection and preservation of the diverse fauna and flora found in Peninsular Malaysia. TNNP falls under federal and state legislation and was managed by Department of Wildlife and National Parks (Pakhriazad et al., 2009). In addition to protected areas, forest reserves also provide the needed habitats for the conservation of diverse fauna and flora of the country. However, the forest cover in Malaysia has reduced from 18.20 million hectares in 2000 to 18.06 million hectares in 2013. The area increases to 18.27 million hectares in 2014 (NRE, 2016). Therefore, the government introduced Central Forest Spine Master Plan to maintain the connectivity of fragmented forest in Peninsular Malaysia. Several ecological linkages have also been established within four forest complexes consisting of Banjaran Titiwangsa-Banjaran Bintang-Banjaran Nakawan, Taman Negara-Banjaran Timur, Pahang Tenggara, Chini, Bera Wetland, and Taman Endau Rompin-Kluang Wildlife Reserve (Jabatan Perancangan Bandar dan Desa, 2010).

The loss of forest cover is due to development of urban, roads and agriculture, such development in the past has brought about forest fragmentation leading to the disruption of free movement for wildlife. Wildlife linkage are important to
ensure continuity of a population, dispersing genetic variation, increase area and diversity of habitat, allow species to find suitable habitat and allow movement of migrating species (Horskin et al., 2006; Caro et al., 2009). Habitat suitability modelling was used to produce probability maps on occurrence of species and preferred habitat landscape’s properties (Store & Kangas, 2001). Maximum entropy modelling was commonly used for species distribution model to estimate the geological and features of interest where the distribution is defined (Phillips et al., 2004). Then, corridor modelling was executed in GIS environment with its location depends on the resistance between patches of suitable habitat.

In Peninsular Malaysia, extensive studies have been conducted on \textit{Elephas maximus}, \textit{Bos gaurus}, \textit{Panthera tigris} and \textit{Tapirus indicus}, covering various aspects such as distribution, habitat characteristics and home range (Conry, 1981; Holden et al., 2003; Sharma, 2003; Aini et al., 2015). Our objective is to identify possible linkages from the predicted suitable habitat of wildlife to other forest complexes that were fragmented by development. Therefore, main linkage from Main Range FC to the TNNP can be identified.

**METHODOLOGY**

In the study, 2 forest complexes that was a part of the Main Range forest complex which are Ulu Jelai Forest Reserve (FR) and Ulu Jelai Tambahan FR located at Kuala Lipis, Pahang were involved. Another forest complex in the study area is the western part of Taman Negara National Parks (TNNP). The data collected in the form of targeted wildlife species sighting and tracks by Department of Wildlife and National Parks (DWNP) from 2003 to 2008 were obtained and analysed. The species involves are \textit{Elephas maximus}, \textit{Bos gaurus}, \textit{Panthera tigris} and \textit{Tapirus indicus}. To predict habitat suitability, maximum entropy modelling consists of algorithm that estimate probability of distribution and produces the most uniform information in targeted area (Phillips et al., 2006). This method was executed using MaxEnt software version 3.3.3a (Computer Sciences Department, Princeton University, USA, 2004) with default setting. Auto features provide a more accurate prediction (Phillips et al., 2006). Environmental parameters used were slope, elevation, land use types, soil types, distance from river and roads as factors of habitat suitability. Land use was classified into several classes, showing forest and agriculture as major activities at the study area (Figure 1).

Habitat prediction resulted from MaxEnt would then produces patches of suitable habitat in the study area. The patches were then become fragmented due to the effect of development, mainly roads. Several factors are significant
in deciding potential linkage design including types of focal species, resistance factors, habitat patches and many more (Beier et al., 2008). Corridor modelling was performed through least-cost analysis using Corridor Designer toolbox incorporated into GIS that identify the most permeable landscape for a linkage between fragmented forests or habitat patches.

**RESULT**

**Habitat suitability**

MaxEnt model which uses presence-only data, assigns non-negative probabilities to each pixel in the study area. Habitat suitability according to respective species is shown in Figure 2, with presence of road which was considered as significant factor for forest fragmentation. The result shows that both area of Ulu Jelai FR and TNNP are suitable for all the species while Cameron Highland, Sungai Koyan
(Sg. Koyan) and Pos Lenjang shows a less coverage of suitable habitat. The model indicates that majority of potentially suitable habitats are located in forested area except in west of Ulu Jelai FR and east of TNNP. Patches of unsuitable habitat was also located at Kuala Lipis and Sg. Koyan which was mostly comprised of agricultural activities. Urban area located southwest of the study area is unsuitable for all species except for Panthera tigris. The result shows that, 81% of the area are suitable for Panthera tigris, 41% for Elephas maximus, 45% for Bos gaurus and 48% for Tapirus indicus. The movement for Panthera tigris covers a wider range regardless of the type of land cover, suggesting other environmental factors such as elevation and slope that might cause the existence of unsuitable habitat at Cameron Highlands. Compared to tiger, those factors also greatly affecting the result for elephant, gaur and tapir which reduces the size of potentially suitable habitat, limiting it at the lowland forest.

Figure 2 Habitat suitability for A (Elephas maximus), B (Bos gaurus), C (Panthera tigris) and D (Tapirus indicus) respectively.
Linkage identification

Main Range FC such as Ulu Jelai FR is separated from TNNP preventing linkage between both forest complexes. In this study, potentially suitable area was identified to serve as a linkage connecting forest fragments in the study area. Corridor modelling produces several corridor width depending on the level of resistance between the fragments. The corridor analysis, focuses on the smallest resistance corridor (0.1% width) to facilitate wildlife movement. The result for all species shows that the linkage was mainly situated on the roads (Figure 3). Elephant, gaur and tapir show linkages at the road around northern area of Pos Lenjang, Sungai Yu (Sg. Yu), Sg. Koyan and Kuala Lipis. The result for all species also shows predicted linkage at the railway due to the presence of forest on both side of the railway. Several linkages for *Elephas maximus* and *Tapirus indicus* were detected at non-road locations due to the separated patches of suitable habitat. Linkages for *Bos gaurus* was predicted only on roads and railway because it was the main factor that separated the habitat. Similarly, *Panthera tigris*’s potential linkage occurred along the roads and railway, and no linkage identified within the forest complexes. From the results, although there are linkages predicted at Kuala Lipis, but due to the higher coverage of agriculture, the location was not regarded as the main linkage towards TNNP. Since connecting Main Range FC to TNNP is significant in this study, the linkage at Sg. Yu is regarded as the main linkage for all four species.
DISCUSSION

The prediction of habitat suitability and connectivity of the four endangered species was highly affected by the continuous development in the study area. Urbanized area was not suitable for wildlife habitat in which it could cause human-wildlife conflict. Conversion of forest to agriculture will further reduce habitat size for wildlife and divides it into smaller fragments. The habitat model prediction was mainly contributed by elevation while other environmental parameters have less contribution to the species. Nevertheless, each species’ dependency differs according to its habitat characteristic. To overcome the effect of fragmentation, identification of linkage is important in providing continuous movement of wildlife within the Central Forest Spine. The result of the study suggests that most of the endangered species in Peninsular Malaysia depends on lowland forest for food, water and shelter. Thus, the prediction could be used as a basis for conservation planning in the area.
In this area, the two large forest complexes studied are Ulu Jelai FR and TNNP which was located within the Central Forest Spine. Analysis of maximum entropy modelling shows that both forest complexes are suitable for wildlife habitats. However, each species has different area of suitability with the western side of Ulu Jelai FR deemed unsuitable for all species due to elevation factor. The presence of Main Range and Cameron Highlands in that area recorded the highest elevation of 2160 m. Elephant, gaur, and tapir shows preference for lowland while tiger shows preference for both lowland and hill forests as this species is able to roam at higher altitude compared to other species (Kawanishi et al., 2003). Conversion of forested land to agriculture and urbanization plays major role on habitat loss and forest fragmentation (Magintan et al., 2012). Most of the area southwards of Ulu Jelai FR was less suitable due to the large agriculture area present mainly oil palm plantation. However, some studies recorded the presence of wildlife at agricultural area as observed at Sg. Koyan for Elephas maximus, Bos gaurus and Tapirus indicus despite the ability of forested habitat to provide food and protection for the wildlife. This condition occurred due to the abundance of saplings in agriculture area that provided food source for the wildlife (Sharma, 2003; Novarino et al., 2004; Rayan et al., 2012; Alfred et al., 2012). This suggest that the suitability of agricultural area was mainly influence by physical disturbance from human and vehicle instead (Zainal Zahari et al., 2001).

The changes of forested land largely effecting animal movement by disrupting the species traditional routes to avoid encounter with human (Noe, 2003). Development of road will divides block of forest into smaller fragments. Without consideration on wildlife linkage, construction of infrastructure such as road will create a long-term threat to wildlife (Kawanishi et al., 2010). This study shows that the potential linkage location was mainly determined by road and railway as seen at Ulu Jelai FR and TNNP. The linkage located at Sg. Yu was selected as the main linkage that connects Ulu Jelai FR blocks to the eastern forest. Other locations identified were at Jalan Ringlet - Sg. Koyan, Jalan Sg. Koyan - Berchang and Jalan Kuala Lipis (Figure 3). On the contrary, tiger has broader potential linkage covering the whole study area as it has larger suitable habitat and prefers lowland (Rayan & Linkie., 2015). Linkage selection is based on narrowest gap between forest blocks (Beier et al., 2008). Compared to other location, Sg. Yu linkage has the least resistance of wildlife crossing for all species. Area around of Kuala Lipis have more extensive road network than at Sg. Yu and Pos Lenjang causing higher resistance for linkage. Presence of roads may cause an increase of distress in movement of wildlife to other forest fragments (Clevenger et al., 2002). Therefore, the location was deemed as unsuitable linkage location for wildlife.
As recommended in National Physical Plan, connecting Main Range forest complexes to other fragmented forest is crucial in maintaining wildlife survival in Peninsular Malaysia. Habitat modelling at the study area highlighted higher potential of habitat suitability on forested area compared to other land-use. Therefore, environmental parameter such as land-use in this study needs to be updated as certain area undergoes rapid land cover change to gain better accuracy in the model. Besides habitat suitability, identification of linkage is important in conserving the biodiversity of protected area in accordance with agricultural and urban development. Kawanishi & Sunquist (2004) stated that the lack of human disturbance in TNNP maintains the diversity of wildlife in it. Thus, accentuating the significance of linkages connecting to TNNP such as in Sg. Yu.

CONCLUSION

Road expansion influence wildlife movement in which it separates forested area into smaller fragments, allowing easier access for hunting and exploitation in the forest. Linkages play important role in connecting wildlife habitat especially towards TNNP. In the study, several linkages were observed around Main Range FC such as Pos Lenjang, Sg. Yu, Sg. Koyan and Kuala Lipis. However, Sg. Yu is selected as the main linkage between Main Range FC and Taman Negara which is also an established viaduct by DWNP and Public Works Department (JKR). Smaller linkage around the TNNP needs to be further assess to verify its effectiveness as a linkage. Continuing effort from all parties should prioritize on conservation planning, mitigation and sustainable development that might occur around the linkage location. Areas surrounding the predicted linkages should be reserved as protected area. In conclusion, the most favourable wildlife habitat is a lowland forest and should be far from human disturbance.

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