

Spatial Analysis of Habitat Conservation for Hornbills: A case study of Royal Belum-Temengor forest complex in Perak State Park, Malaysia

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ABSTRACT

Habitat loss affects survival of hornbills in the wild and their dipping numbers has led Malaysia to classify them as threatened species. Thus, their habitat must be protected thorough greater conservation efforts to prevent extinction of that species. Royal Belum-Temengor forest complex in Perak State Park with a total area of 32,733.9 hectares, is one of the last remaining frontiers for the hornbills in Malaysia. This study attempts to justify a spatial site analysis of effective habitat conservation for hornbills. In addition, it aims to identify suitable habitat for hornbills using spatial characteristics. Analysis of Landsat 5TM satellite image in the study area was used to identify the most suitable habitat for the hornbills in Royal Belum–Temengor Forest Complex. The findings showed that the forest complex’s spatial characteristic is suitable with ideal characteristics for the survival of hornbills such as density of vegetation, swamp areas or water bodies, and mature size of emergent and canopy layer of trees. It is hoped this information will help conservationists and researchers to design a sound conservation and management plan to ensure long term survival of these birds.

Keywords: Dipterocarp forest, habitat conservation, hornbills, threatened species

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INTRODUCTION

Hornbills are endangered and threatened species and thus classified as protected bird species in Southeast Asia and Africa. Tropical forests are rapidly lost across Southeast Asia and this is predicted to

have severe implications for many of the region's bird species (Martin & Blackburn, 2010). One of the main habitats for hornbills in peninsular Malaysia is located at the Temengor Forest Reserve and Royal Belum State Park of Perak along the Thai-Malaysia border. However, due to logging activities at the Temengor Forest Reserve, which borders the gazetted Royal Belum Forest, this habitat has been disturbed. This means that the park must be conserved as it is rich in biodiversity, and the only place in Peninsular Malaysia where all 10 species of hornbills can be found. Currently, there are 55 hornbill species in the world, with 24 in Africa and the rest in the forests of South and Southeast Asia. Eight species of the hornbills are found in Borneo while all 10 species can be found in the Belum–Temengor forest complex, all still thriving, but some are nearly endangered (MNS PBBG, 2006).

Reputed to be rich in biodiversity, Belum-Temengor forest is one of the last remaining frontiers that supports a sizable population of hornbills. The bird's unique features are their shiny ebony black plumage, huge bill and upward-curved casqued in the shade of vibrant red, orange and yellow forms, a beautiful contrast to its surrounding (Davison, 1995). These noisy, social, omnivorous birds need large tropical forest areas with fruiting trees to forage. Moreover, giant emergent trees with nesting cavities are also important to carry on their legacy, but some species nest near the ground. The 10 species of the hornbills found at the Belum-Temengor forest are *Berenicornis comatus*, *Anorrhinus galeritus*,

Aceros corrugates, *Aceros undulates*, *Aceros subruficollis*, *Anthracoceros malayanus*, *Anthracoceros albirostris*, *Buceros rhinoceros*, *Buceros bicornis* and *Rhinoplax vigil* (MNS, 2000; Lim & Tan, 1998; Yeap, Lim & Noramly, 2005; Yeap, Sebastian, & Davison, 2007) (Table 1) (Figure 1). The species are threatened and endangered, and can be at high risk of global extinction if no long-term conservation measures are taken (Gregory, 1995; Yeap et al., 2007). The IUCN Red List of Threatened Species indicates that a taxon that has been evaluated against the Red List is close to qualifying for, or is likely to qualify for, a threatened category in the near future (IUCN, 2016). Thus, data related to the proper habitat of the hornbills for spatial site analysis are needed. Therefore, this study proposes an effective spatial habitat conservation for hornbills in Royal Belum–Temengor forest complex.

Hornbills are omnivorous, and they feed on the *Ficus carica* (Common fig), which produces “figs”, *Parkia speciosa* (bitter bean), and other wild fruits in the forest. The hornbills are a major frugivore benefitting from the fruiting trees in their surrounding (Misni, 2013). It is an important agent for natural seed dispersal in tropical forest areas, which serves to maintain forest ecosystems.

The fruit season starts in July and reaches its peak between August and September. The sources of protein for hornbills are invertebrates and small vertebrates, such as fish, snakes, rats, bats and various insects. Thus, this species also requires natural valley and dense tropical rainforest.

Hornbills Habitat and Population

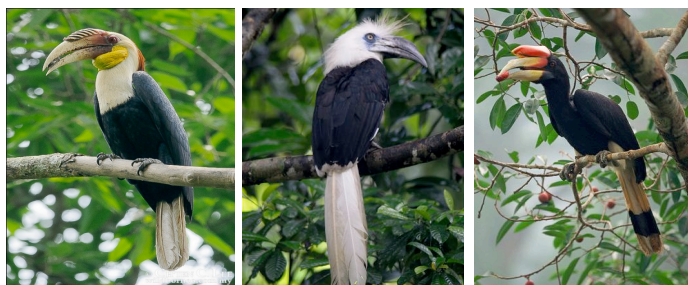
Hornbills congregate in May/June and disperse in November, moving in a north-south direction. Studies show that most hornbills in South-east Asia exploit fruit resources, which are widely dispersed in tropical rainforests (Mudappa & Raman, 2008). Thus, hornbills play a crucial ecological role in natural rainforests. A

study attempted to determine the population of hornbills and their density in order to conserve their habitat. Hala-Bala Wildlife Sanctuary and Bang Lang National Park along the Thai–Malaysia border, one of the few remaining areas of lowland forest in Thailand, has become their habitat (Gale & Thongaree, 2006).

Table 1
The 10 species of hornbills in Royal Belum–Temengor forest complex and their current conservation status (IUCN, 2016)

| No. | Scientific Name | Common Name | Local Name | Current Status |
|-----|-----------------------------------|------------------------|-----------------------------|------------------|
| 1 | <i>Berenicornis comatus</i> | White-crowned Hornbill | Eggang Jambul Putih | Near Threatened* |
| 2 | <i>Aceros corrugates</i> | Wrinkled Hornbill | Eggang Jambul Hitam | Near Threatened |
| 3 | <i>Anthracoseros malayanus</i> | Black Hornbill | Eggang Kekek | Near Threatened |
| 4 | <i>Buceros rhinoceros</i> | Rhinoceros Hornbill | Eggang Badak/ Kenyalang | Near Threatened |
| 5 | <i>Buceros bicornis</i> | Great Hornbill | Eggang Papan | Near Threatened |
| 6 | <i>Rhinoplax vigil</i> | Helmeted Hornbill | Eggang Tebang Mentua | Near Threatened |
| 7 | <i>Aceros subruficollis</i> | Plain-pouched Hornbill | Eggang Hutan | Vulnerable** |
| 8 | <i>Anorrhinus galeritus</i> | Bushy-crested Hornbill | Eggang Kawan/Buluh | Least Concerned |
| 9 | <i>Aceros undulates</i> | Wreathed Hornbill | Eggang Gunung | Least Concerned |
| 10 | <i>Antharacoseros albirostris</i> | Oriental Pied Hornbill | Eggang Kelingking/ Lilin | Least Concerned |

Note: *Any species that is likely to become an endangered species within the foreseeable future throughout all or a significant portion of its range. **Any species is likely to become endangered unless the circumstances threatening its survival and reproduction improve.



Aceros subruficollis *Berenicornis comatus* *Buceros rhinoceros*

Figure 1. Hornbill species in Tropical Africa and Asia (Ch'ien, 2016)

The population of hornbills in South East Asia is scattered in lowland areas and hill rainforests. For example, *Aceros subbrificollis* is found in southeast Myanmar, west, south-west and extreme southern Thailand, and northern Peninsular Malaysia (Klop, Curio & Lastimoza, 2000). In addition, in 1993, the population of this bird in Thailand was estimated at 1000. In Malaysia, there has been regular monitoring of these birds at Pos Chiong@Kampung Tebang in Temengor Forest Reserve, Peninsular Malaysia since 2004 and The Malaysian Nature Society has recorded the largest number of 3261 hornbills here in 2008 (MNS, 2010). The population of hornbills is estimated at between 2500 and 9999 based on records and surveys by Klop, Curio and Lastimoza (2000).

The population of hornbills fluctuates, depending on the conditions of their natural habitat. In recent times, their population has decreased rapidly because their natural habitat is threatened by illegal hunting, encroachment of forest by aboriginals for agriculture, logging of the forests in the south as well as the loss of large hollow trees, which are suitable for their nests. Protected areas and Hala Bala Wildlife Sanctuary and Bang Lang National Park and the combined area of tropical forest stretching beyond the boundaries of Thailand and Malaysia are tropical rainforests and low-lying hill dipterocarps around a height of between 130 m and 1500 m suitable as a habitat for hornbills.

Hornbills Spatial Nesting Range

Hornbills mature at the age of five and their life span is between 28 and 30 years. They breed from January to June, and nest in tall and large tree branches. Hornbills are a special type of animals, which have a natural and a renowned dedication to a monogamous partner. The female hornbills barricade themselves inside a sealed nest during nesting and brood; the nest is made of mud, faeces, and fruit peel. Female hornbills females protect their eggs from enemies such as snakes, lizards, monkeys and ferrets while the male feed the chicks and the female hornbills. The male will bring food 13 times a day to the nest and the female nest in the next three to five months until their children are independent. On average, the incubation period is about 25 days. The hornbills' nest is located in the dense natural rainforest, which is undetected by their enemy.

The most suitable habitat for hornbills is undoubtedly the primary rainforest, which has fruit trees favoured by some species and the shrubs and riverine patches favoured by others (Mudappa & Raman, 2008). Furthermore, a protected forest patch in West Malaysia, comprising 75 hectares of lowland forest and about 35 hectares of swamp forest, was reported to support only two hornbills bird species. Sometimes, those *Aceros subbrificollis* that live in an Asia, venture beyond their territories to search for fruits. Nests are aggregated within the habitat, with a mean nearest-neighbour

distance of 190 m and they are built in living as well as dead trees, at an average height of 11 m (Klop et al., 2000). Meanwhile, some nests can reach up to 22 m in height.

The big trees are favourite spots for migrating hornbills (from Thailand) that stop at the Temengor lake between September and November each year. The loss of high-canopy trees may also reduce the availability of certain types of animal prey. Species richness and population density of forest birds showed a consistent decreasing trend in the following order: primary forests > secondary forests > mixed-rural habitat > plantations; 40 year old secondary forests and the mixed-rural habitat showed high conservation potential (Sodhi et al., 2005).

METHODS

The study identified an area and boundary of the site study using remote sensing technique. Figure 2 shows the flow of satellite image processing and spatial analysis using map generated from Landsat 5 TM. It was used to generate land cover map for rainforest classification. The satellite image data (Landsat 5 TM) used in this study was downloaded from the United State Geological Survey. The map is matched and customised with characteristics of hornbills natural habitat. After the layer stacking image, the cloud checking is carried out to ensure there is free noise of the Landsat image. The image is later clipped to the boundary of the related study areas.

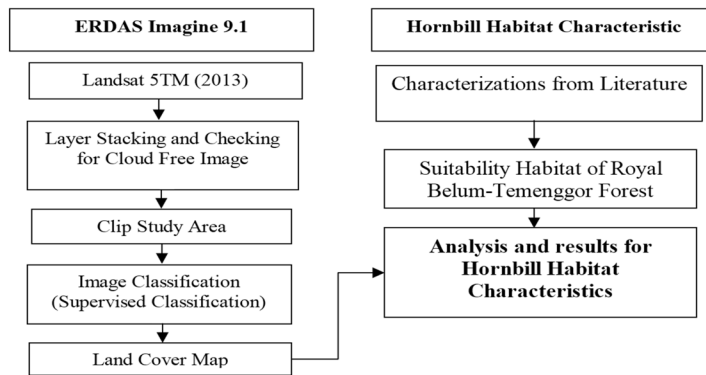


Figure 2. Flow of the satellite image processing and spatial analysis

The study area is The Royal Belum–Temengor Forest Complex. It is located in the Gerik, Perak (Hulu Perak) which is situated at elevations between 130 m and 1500 m (5°N Latitude and 101°E Longitude) (Figure 3). This 130 million-year-old reserved forest’s coverage is about 300,000 hectares and with more than 146,000

hectares of virgin forest (Davidson, 1995). The forest is divided into two sections; the upper Belum area, which stretches to the Thai-Malaysian border covering 117,500 hectares of impenetrable jungle, and the lower Belum mostly covered by Temengor Lake as shown in Figure 4. The State of Perak has decided to preserve the Belum

and Temengor forests as a permanent nature reserve. Besides that, the Belum forest has also been identified as having the potential to be an important eco-tourism destination in Malaysia (Hamzah, 2004). There are diversities in the study area with a surface elevation between 130 m and 1500 m covered with lowland and hill dipterocarp tropical forest types.

The next process is generating land use maps using the ERDAS Imagine digital image processing. Classification was performed to extract the different spectral statistical classes from the satellite images. The training fields were carried out on the Landsat satellite image. There were 21 sampling pixels to derive rainforest land cover map for the satellite image

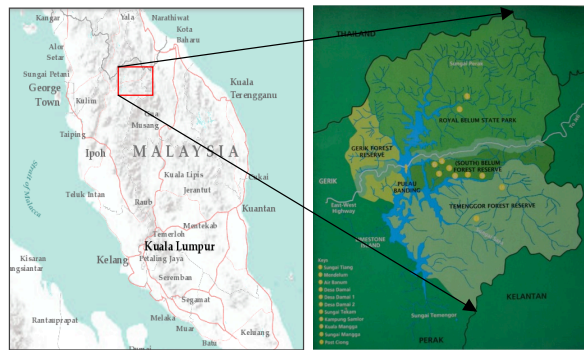


Figure 3. Location of the Royal Belum–Temengor Forest Complex (JPSM, 2016), 5°N Latitude and 101°E Longitude at elevations between 130 m and 1500 m

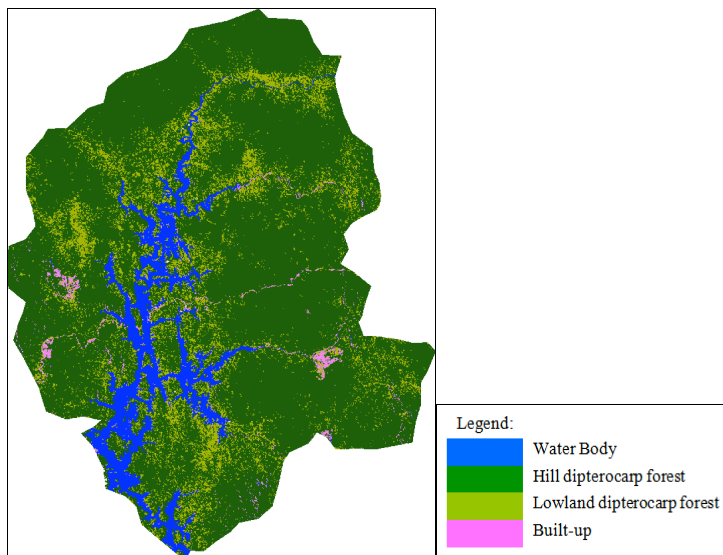


Figure 4. Land cover map for rainforest classification in Royal Belum–Temengor Forest Complex

classification through independent and supervised classification. The land cover for rainforest classification was divided into four types including; 1) water body, 2) lowland dipterocarp forest (300 m elevation), 3) hill dipterocarp forest (300–1500 m), and 4) built-up (road, aboriginal villages, and resorts). Figure 4 shows the boundary delineation of the study area. The percentage of the rainforest land cover was calculated and these values of the land cover can be used to estimate the land use/land cover types individually.

RESULTS AND DISCUSSION

The results and analysis are based on the existing rainforest and other natural earth surfaces in the site study, and the spatial analysis were associated with the significant character of habitat and population of the hornbills. The results and analysis are discussed in the following sub-sections.

Rainforest Land Cover Classification

The rainforest of Royal Belum-Temengur Forest complex is shown in Figure 3. The total acreage of the study area is 32,733.9 hectares. It is a complex terrestrial and aquatic ecosystem of dipterocarp forest (Table 2).

The four main classifications in rainforest land cover are water body, hill dipterocarp forest, lowland dipterocarp forest, and built-up area. The accuracy assessment based the supervised classification is about 91.87%. This area is covered with more than 50% of the forest area.

The hill dipterocarp forest is dominant in this forest, representing almost half of the rainforest area, 49%, followed by water body area 38%, while the low dipterocarp forest only contributes 8%, and the rest is a built-up area of 5%. The total areas of the rainforest land covering water body, hill dipterocarp forest, lowland dipterocarp forest, and built-up areas are approximately 1252.89 km², 1605.48 km², 244.10 km² and 170.88 km² respectively. The total acreage of natural rainforest area is 3273.36 km², where this area has enough coverage range area for hornbills to forage for feed, which is within 225–45 km². The Royal Belum–Temengor Forest complex is about 130 million years old (MNS, 2011), where the emergent layers of mature trees reach up to 60 m height and general canopy layers are up to 30 m width. Thus, the land covering classification of Royal Belum–Temengor Forest complex is suitable for habitat hornbills’.

Table 2
Rainforest land cover coverage

| No. | Forest Class Name | Area (hectares) | Area (Km ²) | Percentage (%) |
|-----|----------------------------|-----------------|-------------------------|----------------|
| 1 | Water body | 125,289.00 | 1252.89 | 38.29 |
| 2 | Hill dipterocarp forest | 160,548.00 | 1605.48 | 49.02 |
| 3 | Lowland dipterocarp forest | 24,410.00 | 244.10 | 7.46 |
| 4 | Built-up | 17,088.90 | 170.88 | 5.23 |
| | Total Area | 327,335.90 | 3273.36 | 100.00 |

Hornbills' Habitat Characteristics

Firstly, this spatial site analysis study will focus on the significant criteria of hornbills' habitat. The significant characteristics of hornbills habitat are referred to as the birds' shelter and nest to represent their existing and sustainable population (Table 3). The suitable tree height of the hornbills' nest is under storey and canopy layers of the rainforest, about 11–22 m, which can be protected and safe from enemies such as snakes, lizards, monkeys and ferrets from destroying and eating their eggs. This tree height coincides with this tropical rainforest characteristic, especially in the primary forest area of Royal Belum, and is suggested as highly suitable for their habitat. Those rainforest trees has large canopy sizes containing wild fruit trees favoured by this

species. Also, the maturity of the canopy and emergent layer of trees potentially can be used as nesting sites.

The result of the Royal Belum–Temengor Rainforest land uses classification show that the highest area of forest is a hill dipterocarp forest that has elevation above 300 m. The lowland dipterocarp forest and the Temenggor valley or swamp areas are also essential for hornbills to search through their territories for living animals or invertebrate and small vertebrate such as large insects, fish, snakes, and frogs as a source of protein to lay their eggs. These findings show the importance dense and larger trees at exact elevation, and mature lofty forest is suitable for nesting and must be protected from any disturbances.

Table 3
Suitability and potential of hornbill habitat

| No. | Habitat Characteristic | Suitability and potential habitat |
|-----|---|--|
| 1. | Flying range coverage is within the 225–450 km ² | The total acreage of the natural rainforest area is about 3273.36 km ² and is adequate for mass flight and find feeds. |
| 2. | Overall height range of mature trees | The forest is 130 million years old and majority heights of dense mature trees show their emergent layers are reaching up to 60 m and its canopy diameter is up to 30 m width. |
| 3. | Nests are aggregated with a nearest-neighbour distance of 190 m | The total area of Royal Belum virgin forest is 117,500 hectares, which can potentially provide more than 6000 nest sites. Shorea, a species of tree, has holes in the upper trunk, dominantly located in the emergent layer. |
| 4. | Temengor lake valley@swamp surrounded by dense dipterocarp rainforest | It is essential for hornbills to find their major type of food (wild fruits) through their territories and for searching for living animals or invertebrate and small vertebrate for sources of protein. |
| 5. | Suitable tree height of nest site | The height is about 11–22 m range in the canopy and the emergent layer of the forest for a nest site, as well as to protect from enemies and ensure the eggs are safe. |

CONCLUSION

The presence of hornbills in Royal Belum–Temengor forest complex indicates that this tropical rainforest ecosystem is healthy and thriving. However, the hornbills here are classified as threatened species. Thus, there is an urgent need to conserve and protect their habitat to avoid extinction of the species. This spatial site analysis study also showed that this forest complex's spatial characteristics such as type of forest and density of vegetation, swamp areas or water bodies, and mature size of emergent and nature tree canopies are suitable for the hornbills to thrive in The Royal Belum rainforest and its surrounding area need to be maintained and conserved naturally as a habitat for these hornbills. The Landsat 5TM satellite image is effective for continuous monitoring of their habitat. A spatial site analysis for habitat conservation is a can help the authorities and others understand why natural heritage is important for the survival of this species. This spatial site analysis also shows the most sensitive area for conservation. Findings of this study can help other researchers or the Department of Wildlife to design new conservation and restoration efforts, manage and maintain the site in the long term, and help people appreciate and learn about their natural heritage.

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