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Habitat occupancy patterns and activity rate of native mammals in tropical fragmented peat swamp reserves in Peninsular Malaysia

Selvadurai Sasidhran [a], Nurfatin Adila [a], Mohd Saifulnizam Hamdan [a], Liza D. Samantha [a], Najjib Aziz [b], Norizah Kamarudin [a], Chong Leong Puan [a,c], Edgar Turner [d], Badrul Azhar [a,c,*]

[a] Department of Forest Management, Faculty of Forestry, Universiti Putra Malaysia, UPM Serdang, 43400 Selangor, Malaysia
[b] School of Land and Food, University of Tasmania, Tasmania 7001, Australia
[c] Biodiversity Unit, Institute of Bioscience, Universiti Putra Malaysia, UPM Serdang, 43400 Selangor, Malaysia
[d] Department of Zoology, University of Cambridge, Downing Street, Cambridge CB2 3EJ, UK

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ABSTRACT

Intensive land use plays a major role in tropical peat swamp deforestation in Southeast Asia. In Peninsular Malaysia, the North Selangor Peat Swamp Forest (NSPSF) is the second largest remaining peatland ecosystem. Although the NSPSF is recognized as a biodiversity hotspot area in the region, this peat swamp forest is rapidly shrinking because of the expansion of commercial oil palm agriculture. More than 87% of the NSPSF has been designated as reserves, but in reality, this is not comparable to protected area status. The NSPSF is under constant threats from forest conversions, forest fires, and road constructions. Faunal biodiversity loss is likely to occur in the NSPSF unless immediate action is taken by stakeholders. To determine the habitat occupancy and activity rate of native mammals, we conducted camera-trap survey at 45 sites located within the NSPSF. From a total survey effort of 2565 trap nights in an area of 778 km^2, 16 mammal species were recorded. Our data provide vital information on the occupancy of high conservation value species in the NSPSF. However, we did not record Sumatran rhinoceros (*Dicerorhinus sumatrensis*) and Malayan tiger (*Panthera tigris*), nor did we find any indirect evidence such as footprints, indicating that these species are extirpated from this region. We found that mammal activity rate responded differently to *in situ* habitat quality and landscape factors according to feeding guild. Government stakeholders should focus on prohibiting further forest conversion and prioritize the upgrading NSPSF's conservation status from reserve to protected area.

1. Introduction

The expansion of agriculture around the world has caused significant controversy and debate over the past 30 years (Yaffee, 1994; Angelstam, 1996; Lindenmayer and Franklin, 2003; Rudel et al., 2009). Rapid agricultural expansion has replaced forest and poses a serious threat to many natural ecosystems in the next 50 years (Tilman et al., 2001). Land modification by humans, including habitat conversion and fragmentation is currently the biggest threat to biodiversity worldwide (Primack, 2001; Kerr and Deguise, 2004). The tropical rainforests of Southeast Asia are disappearing at an alarming rate, partly as a result of forest conversion to oil palm plantations (Linkie et al., 2003; Fitzherbert et al., 2008; Danielsen et al., 2009). The oil palm industry with fiber plantations and logging concessions are often highlighted as the major drivers of deforestation and biodiversity loss in Southeast Asia (Clements et al., 2010; Linkie and Ridout, 2011; Abood et al., 2014). Despite being considered by environmental NGOs as a serious threat to forest biodiversity, oil palm cultivation continues to expand (Rudel et al., 2009; Sodhi et al., 2004; Sodhi and Brook, 2006) and it has become a key driver of tropical peat swamp forest clearance (Carlson et al., 2012).

Between 1990 and 2005, oil palm plantations in Malaysia have expanded by a total of 1.87 million ha (MPOB, 2007) and, as of 2013, a total area of 5.22 million ha of the country has been planted with oil palm (MPOB, 2013). As a result, the impacts of industrial oil palm expansion on tropical forests and biodiversity in the region are a major conservation concern (Koh and Wilcove, 2007; Scharlemann and Laurance, 2008). To date, little research has focused on the actual impacts of oil palm expansion on forest biodiversity, although it is clear from existing studies that oil palm plantations support a significantly lower biodiversity

* Corresponding author at: Department of Forest Management, Faculty of Forestry, Universiti Putra Malaysia, UPM Serdang, 43400 Selangor, Malaysia.
E-mail address: b_azhar@upm.edu.my (B. Azhar).

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across a range of taxonomic groups, compared to forest habitats and most other commercial crops (Fitzherbert et al., 2008; Foster et al., 2011). In a meta-analysis, Danielsen et al. (2009) recorded a 62% drop in vertebrate species richness and an 11% drop in invertebrate species richness between forest and oil palm plantations. This loss of species is likely the result of reduced structural complexity in oil palm plantations and more extreme microclimatic conditions (Luskin and Potts, 2011; Hardwick et al., 2015), as well as an increased density of roads, which can lead to access for illegal hunting and killing of wildlife by vehicles (Azhar et al., 2013a; Luskin et al., 2014).

The protection and restoration of peat swamp forests are conservation priorities that require urgent action, because peat swamp forests are more vulnerable to human disturbances than other forest ecosystems (Posa et al., 2011). Peat swamp forests are critical for biodiversity conservation and support many specialized species and unique ecosystem types. In addition, they can provide a refuge for species that are extirpated from non-peat swamp areas, affected by degradation and climate change (Parish et al., 2008). Peat swamp forests are also important for the large volumes of carbon they store and disturbance of these areas can result in large releases of carbon dioxide, contributing to global green-house gas effects. Indeed a recent study indicated that Peninsular Malaysia, Sumatra and Borneo may have net annual carbon emissions of 230–310 Mt CO_{2e-}, as a result of the conversion of 20% of their total peatland areas to oil palm (Miettinen et al., 2012).

In Malaysia, out of 336 mammal species recorded, a total of 71 species are threatened (IUCN, 2014; Vié et al., 2009). Deforestation and fragmentation can affect large-bodied mammals more than other species, because of their large home-range requirements (Kinnaird et al., 2003). Extinction risk may be determined by human population density, because human exploitations such as direct persecution, destruction of habitats and reduction in prey numbers are the main causes of population decline (Cardillo et al., 2004). Large mammals, especially carnivores, face the highest extinction risks, because they are more vulnerable to human activities, such as habitat destruction and fragmentation (Forero-Medina et al., 2009). Retaining forest fragments is therefore important, both because of the habitat it contains and because it can act as a corridor between contiguous areas of forest (Laurance et al., 2008; Lees and Peres, 2009).

Mammals have been a focus of conservation for a long time and continue to serve as the traditional focus of government spending on wildlife conservation (Ceballos et al., 2005; Schipper et al., 2008; Redford et al., 2011). However, crucial monitoring work is often overlooked, resulting in the under-recording of species in different areas. For example, the most significant species recorded at the North Selangor Peat Swamp Forest (NSPSF) is the Sumatran Rhinoceros (Prentice and Aikanathan, 1989), but this has not been captured or sighted since 1994 (Tan, 2003). Camera traps represent an extremely useful tool for wildlife research into secretive and cryptic mammal species (Rowcliffe and Carbone, 2008; Matsubayashi et al., 2011; Bernard et al., 2012). Camera trapping can be used to obtain biological data on mammal species, such as diversity, relative abundances, activity patterns and presence or absence (Kawanishi et al., 1999; Srbek-Araujo and Chiarello, 2005; De Luca and Rovero, 2006; Grassman et al., 2006; Linkie et al., 2007; Rovero et al., 2013a). Camera traps are also rapidly becoming one of the most important tools in conservation, especially in occupancy estimation studies (Linkie et al., 2007). Indirectly, photographs of mammal species can also be used to provide other important information such as the relationship between predators and prey (Kawanishi and Sunquist, 2003; Azlan and Davison, 2006).

Our goal was to determine the diversity of native mammals in the NSPSF. As well as estimating the habitat occupancy for the different mammal species, we also investigated the role of *in situ* habitat quality (i.e. vegetation structure) and landscape attributes in determining animal activity. Such work in the NSPSF is particularly timely, owing to the range of threats this area currently faces. Besides plantation expansion, increased cattle grazing and new road construction, such as the recent Ijok-Teluk Intan highway, may also threaten mammal diversity, as it has in other parts of the world (Bissonette, 2002; Laurance et al., 2008). Since 2002, 592 ha of the area has been lost to fire (Parish et al., 2014), which is also likely to impact species in the area. Such a range of different land-uses and increasing pressures on remaining forest habitats may also exacerbate human-wildlife conflict and extinction of wide-ranging carnivores in large protected areas (Woodroffe and Ginsberg, 1998).

2. Methodology

2.1. Study area

The North Selangor Peat Swamp Forest (NSPSF; 3′40′26.56″N, 101′4′29.52″E and 3′32′4.40″N, 101′27′33.36″E) is one of the largest remaining extensive patches of peat swamp forest found on the western coast of Peninsular Malaysia. It includes of the Sungai Karang Forest Reserve (50,106 ha), the Sungai Dusun Wildlife Reserve (4330 ha) and the Raja Musa Forest Reserve (23,486 ha) (Parish et al., 2014). The NSPSF covers approximately 779 km^2 and was actively logged for 30 years before being designated as a forest reserve in 1990 (Kumari, 1996). The forest reserves have different levels of forest degradation and the edges of the forests are generally heavily disturbed (e.g. cattle farming and oil palm farming) (see Fig. 1).

The original pristine forest has been entirely logged over and it is unlikely that any old growth forest remains (Prentice and Aikanathan, 1989; Chan, 1989). Intensive logging ceased 25–30 years ago, before which commercial timber were extracted throughout the reserves. At present, although being designated a forest reserve, some parts of the forest are still being converted to oil palm, with more than 1000 ha within the NSPSF being recently cleared for new plantations. More than 60% of the NSPSF's perimeter is surrounded by oil palm plantations or small holdings (Azhar et al., 2011). Only the Sungai Dusun Wildlife Reserve is officially classified as a protected area (Abdul, 1996), and therefore is expected to remain intact forest for conservation into the future.

The forest is a secondary mixed swamp forest with trees such as: *Macaranga pruinosa*, *Campnosperma coriaceum*, *Shorea platycarpa*, *Parartocarpus venenosus*, *Ixora grandiflora*, *Pternandra galeata*; ferns such as: *Stenochlaena palustris*, *Asplenium longissimum*, *Nephrolepsis biserrata*; palms such as: *Crytostachys* sp.; sedges such as: *Cyperus rotundus* and abundant stands of *Pandanus atrocarpus* (Yule and Gomez, 2008). Thirty-five fish species (Beamish et al., 2003), 173 bird species, four primate species and 16 mammal species (Prentice and Aikanathan, 1989) have been recorded in the NSPSF.

2.2. Sampling design

We established 45 sampling sites randomly across the NSPSF (Fig. 2), at which all measurements were made. Each point of camera-trap deployment was chosen on the basis of the presence of visible animal trails, footprints, scats and tree marks by wildlife. Accessibility to the points from the highway was also an important factor to choose camera-trap points. The furthest distance between sites was 40 km and the closest was 500 m. The Universal Transverse Mercator coordinates of the sample sites were determined using a handheld Global Positioning System (GPS) receiver (Garmin 72H).