BIODIVERSITAS
Volume 22, Number 1, January 2021
Pages: 272-277

ISSN: 1412-033X
E-ISSN: 2085-4722
DOI: 10.13057/biodiv/d220133

Conservation status of large mammals in protected and logged forests of the greater Taman Negara Landscape, Peninsular Malaysia

GOPALASAMY REUBEN CLEMENTS[1,2,3,♥], SUSANA ROSTRO-GARCÍA[3,4], JAN F. KAMLER[3,4], SONG HORNG LIANG[5], ABDUL KADIR BIN ABU HASHIM[6]

[1]Department of Biological Sciences and Jeffrey Sachs Center on Sustainable Development, Sunway University, Malaysia.
Jl. Universiti, Bandar Sunway, 47500 Petaling Jaya, Selangor, Malaysia, ♥email: reubenc@sunway.edu.my.org
[2]Rimba, Kuala Lumpur, Malaysia. Jl. Ampang, Bukit Nanas 50450, Kuala Lumpur, Malaysia
[3]Panthera, 8 West 40th St., 18th Floor, New York, NY 10018, USA
[4]Wildlife Conservation Research Unit, The Recanati-Kaplan Centre, Department of Zoology, University of Oxford. Abingdon, United Kingdom
[5]Pertubuhan Pelindung Alam Malaysia. Jl. Casa Green, 43200 Cheras, Selangor, Malaysia
[6]Department of Wildlife and National Parks (DWNP) Peninsular Malaysia. Jl. Cheras Km. 10, 56100 Kuala Lumpur, Malaysia

Manuscript received: 6 September 2020. Revision accepted: 23 December 2020.

Abstract. *Clements GR, Rostro-García S, Kamler JF, Liang SH, Hashim AKBA. 2021. Conservation status of large mammals in protected and logged forests of the greater Taman Negara Landscape, Peninsular Malaysia. Biodiversitas 22: 272-277.* Peninsular Malaysia contains a large community of IUCN Threatened mammal species, although recent records in some protected areas is unknown. The greater Taman Negara Landscape is one of the national priority areas for tiger conservation, but the recent occurrence of large mammals in the landscape has not been sufficiently updated. Here, we conducted systematic camera-trap surveys in protected and logged forests of the Taman Negara Landscape: Merapoh in Taman Negara National Park (TNM), and the Dungun Timber Complex (DTC), respectively. We found that the diversity of large mammals in TNM appeared to be the same between 2000 and 2016. The detection frequencies (DF) of several Threatened species, such as Malayan tiger (*Panthera tigris jacksoni*), dhole (*Cuon alpinus*), and Malayan pangolin (*Manis javanica*), were similar between surveys, suggesting the relative abundance of these species likely remained stable during the past 16 years. However, the DF of Asian elephant (*Elephas maximus*) and Malayan tapir (*Tapirus indicus*) were lower compared to 2000. In DTC, overall mammalian diversity was relatively lower than in TNM, primarily due to the non-detection of two large ungulates: gaur (*Bos gaurus*) and sambar (*Rusa unicolor*). Nevertheless, we recorded several other Threatened species of mammals, suggesting there is potential for this forest reserve to preserve some of Peninsular Malaysia's most Threatened mammal species. Our results suggest that the Taman Negara Landscape is still an important global site for the conservation of several Threatened species, and we recommend an increase in wildlife law enforcement efforts to ensure the survival of its large and diverse mammalian community.

Keywords: Biodiversity, carnivores, large mammals, Malaysia, Taman Negara National Park

INTRODUCTION

Large mammals have experienced steep declines throughout Southeast Asia, and many are now listed as Threatened species by the IUCN. Large apex carnivores, in particular, have exhibited massive range contractions in Southeast Asia, including tiger (*Panthera tigris;* Lynam and Nowell 2011; Kawanishi 2015), leopard (*P. pardus*; Rostro-García et al. 2019), and dhole (*Cuon alpinus*; Kamler et al. 2015). The primary reasons for the declines include poaching for the illegal wildlife trade, habitat loss, and prey declines (Kamler et al. 2015; Kawanishi 2015; Rostro-García et al. 2018). Similarly, large ungulates also have experienced density declines and large range contractions in Southeast Asia, such as gaur (*Bos gaurus*; Duckworth et al. 2016), and sambar (*Rusa unicolor*; Timmins et al. 2015), mainly due to poaching and habitat loss.

Peninsular Malaysia harbors several highly threatened mammal species, including the Critically Endangered Malayan tiger (*P. tigris jacksoni*), Critically Endangered Indochinese leopard (*P. pardus delacouri*), Endangered dhole, Endangered Asian elephant (*Elephas maximus*), Endangered Malayan tapir (*Tapirus indicus*), and the Critically Endangered Malayan pangolin (*Manis javanica*). Other Mammalian species listed as Vulnerable within Peninsular Malaysia include the mainland clouded leopard (*Neofelis nebulosa*), sun bear (*Ursus malayanus*), binturong (*Arctictis binturong*), southern pig-tailed macaque (*Macaca nemestrina*), Sumatran serow (*Capricornis sumatraensis*), gaur, and sambar. Clearly, Peninsular Malaysia contains a large community of Threatened species with vastly different body sizes and ecological needs. Large protected areas containing diverse habitats likely offer the best hope for conserving such a wide variety of Threatened species in Peninsular Malaysia.

Taman Negara National Park (4,343 km^2, hereafter Taman Negara), established in 1938-39, is Peninsular Malaysia's largest protected area, and one of the largest protected areas in Southeast Asia. The biodiversity of Taman Negara is high; camera-trap surveys in three different grids in 2000 recorded >30 mammal species >1 kg (Kawanishi and Sunquist 2004). That survey confirmed that Taman Negara, at that time, contained all the mammal

species that historically would have occurred there, including the Sumatran rhinoceros (*Dicerorhinus sumatrensis*; Kawanishi and Sunquist 2004). Although the Sumatran rhinoceros is now probably extinct in Taman Negara and other areas of Peninsular Malaysia (Havmøller et al. 2016), the current occurrence of other Threatened mammals in Taman Negara is unknown.

Logging and deforestation have negative consequences for mammalian biodiversity, especially when degraded forests are converted to plantations (Edwards et al. 2010; Wilcove et al. 2013). However, selective logging in concessions not converted to plantations can retain much of their value for biodiversity (Berry et al. 2010; Woodcock et al. 2011). To improve the conservation potential of logging concessions, some have adjusted their management practices to become eco-friendly. For example, the Dungun Timber Complex (DTC; 1,067 km^2), adjacent to the eastern border of Taman Negara, follows the tenets of sustainable forest management and has been compliant with the Forest Stewardship Council's certification standards since 2008. However, it is not known if DTC, which has never been systematically camera-trapped before, currently contains a similar diversity of species as Taman Negara.

In 2016, we systematically camera trapped in the western part of Taman Negara, near the Merapoh outpost (TNM). By comparing our results to those obtained in the 2000 survey (Kawanishi and Sunquist 2004), we could assess if TNM has conserved the diverse community of Threatened mammalian species during the past 16 years. We also systematically camera trapped within DTC, and compared the mammalian biodiversity to that in TNM.

MATERIALS AND METHODS

Study area

This study was conducted in the greater Taman Negara Landscape (i.e., Taman Negara National Park and surrounding reserve forests), located in north-central Peninsular Malaysia. Specifically, surveys were conducted in two study areas within the landscape: 1) TNM, located in the western part of Taman Negara in Pahang state near the Merapoh outpost, and 2) DTC, located in Terengganu state, adjacent to the eastern border of Taman Negara National Park (Figure 1).

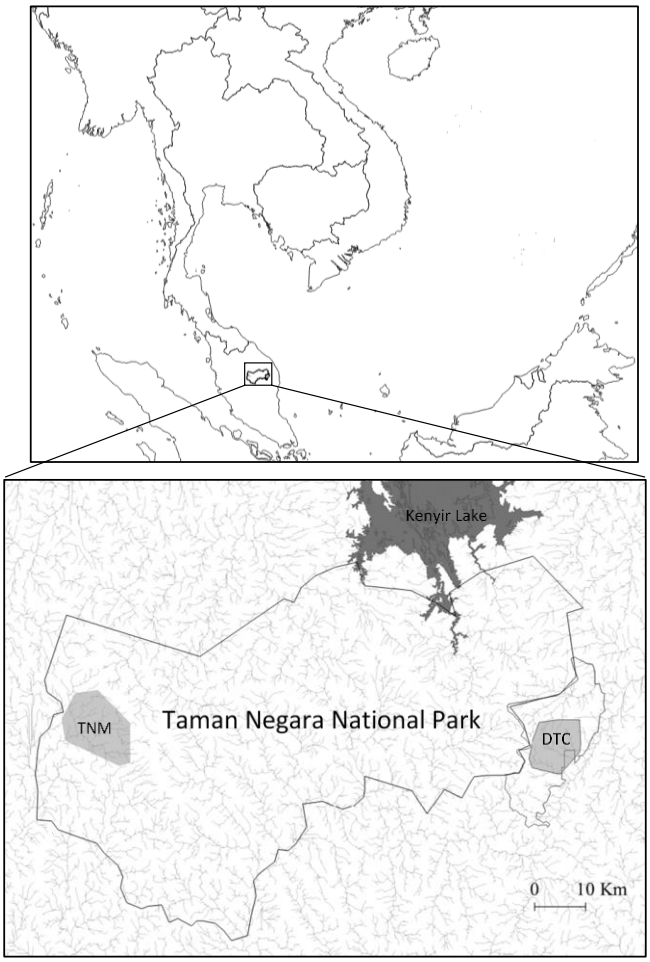

Figure 1. Location of the two study sites where we conducted camera-trap surveys in 2016: Merapoh within Taman Negara National Park (TNM; 4º41'35.0"N, 102º02'10.4"E), and Dungun Timber Complex (DTC; 4º36'36.9"N, 102º56'48.1"E), Peninsular Malaysia. Waterbodies throughout the greater Taman Negara Landscape are shown

Data collection

In TNM, we deployed paired camera traps (Panthera, V6IR) at 47 stations, encompassing an area of about 140 km^2, for 3 months from June to September 2016. In DTC, we deployed 60 camera traps (Reconyx HC500) at 30 stations, encompassing an area of about 90 km^2, for 3 months from August to November 2016. With the exception of one station in Merapoh, all stations comprised of 2 camera traps set on opposite sides of the path. We placed a 2x2 km cell grid over each study area, and aimed to place one station within each cell, so stations were spaced on average about 2 km apart. On both sites, we placed stations along animal trails, ridgelines, and old logging roads. Cameras were attached to trees approximately 45 cm above the ground and 2-5 m from the middle of the path.

Data analysis

Based on the photographs obtained, we calculated the detection frequencies (DF) for all mammal species >1 kg. Although there is a high diversity of small mammal species on the study sites, several of which were recorded during the surveys, we considered mammals only >1 kg because we used a moderate sensitivity setting and cameras were placed 45 cm above the ground, thus many small mammals likely were not photographed due to their size and height. We defined the DF as the number of notionally independent photographs of each species divided by total camera trap days per 100 trap days (O'Brien et al. 2003). We considered independent events as photographs of the same species taken >30 minutes apart at the same station (O'Brien et al. 2003). To compare our results to the survey in 2000, we calculated DF from that survey based on the number of photographs shown for the Merapoh camera-trap grid in Table 8 of Kawanishi and Sunquist (2004). When calculating the DF from Kawanishi and Sunquist (2004), we used the total number of camera-trap days for their Merapoh grid (n = 4,336) and assumed the photographs in Table 8 corresponded to independent events (>30 minutes apart).

The camera-trap study in 2000 by Kawanishi and Sunquist (2004) had the same number of camera stations (n = 47) as our survey, but their stations were about 4 km apart, so they covered a slightly larger area (200 km^2; Kawanishi and Sunquist 2004). Nevertheless, the camera-trap grids overlapped almost completely, therefore the habitat characteristics were the same between studies. Additionally, the survey in 2000 was carried out over every month of the year (Kawanishi and Sunquist 2004), although the total number of camera trap days was similar to our study.

RESULTS AND DISCUSSION

Based on data from 4,054 camera-trap days, we photographed 31 mammal species that were >1 kg in TNM, in addition to recording the sign of otter (*Lutra* spp.) along streams, for a total of 32 recorded species (Table 1). The previous survey conducted in 2000 in TNM photographed 27 mammal species >1 kg, in addition to observing or seeing the sign of 3 additional species, for a total of 30 recorded species (Table 1). The only two mammal species that we photographed in TNM, that were not recorded in the 2000 survey, were the masked palm civet (*Paguma lavarta*) and banded linsang (*Prionodon linsang*; Table 1). However, Kawanishi and Sunquist (2004) photographed these two species in a concurrent camera-trap grid in another part of Taman Negara, suggesting these two species also likely occurred in TNM in 2000. Therefore, overall mammalian species composition in TNM appeared to be the same between 2000 and 2016.

The DF of Malayan tiger and dhole was similar between 2000 and 2016, however, the DF of Indochinese leopard was lower in 2016 compared to 2000 (Table 1). All small felids and other small carnivores were captured more often in 2016 compared to 2000, except for the Malay civet (*Viverra tangalunga*; Table 1). Large ungulates, such as gaur, sambar, and Sumatran serow, had DF that was similar between 2000 and 2016, whereas all smaller ungulates had higher DF in 2016 compared to 2000. Sun bear, primates, and porcupines all had higher DF in 2016 compared to 2000. Interestingly, Asian elephant and Malayan tapir had much lower DF in 2016 compared to 2000, whereas the Malayan pangolin had slightly lower DF in 2016. However, the comparisons of DF between studies should be viewed with caution because differences in DF cannot be unambiguously attributed to actual differences in abundance, but may have arisen from differences in detection caused, for example, by the use of different camera-trap models, camera set-up techniques, or selection criteria of station locations.

Nonetheless, the maintenance of mammalian biodiversity levels in TNM, including several Endangered and Critically Endangered species, is significant for Malaysia and the region. The unprecedented levels of deforestation and biodiversity loss in Southeast Asia are some of the highest in the world (Duckworth et al. 2012; Clements et al. 2014; Heino et al. 2015; Hughes 2017). The ability of protected areas in Southeast Asia to conserve the biodiversity when facing such threats is questionable. Other assessments of biodiversity after 10 or more years within protected areas in Southeast Asia are rare, and have previously occurred only in eastern Cambodia and Northern Laos. In eastern Cambodia, camera-trap surveys from 2009 to present showed dramatic declines in apex carnivores, including the extirpation of tiger and near extirpation of leopard and dhole, from one of the country's largest protected areas (Rostro-García et al. 2018; unpublished data, WildCRU, WWF Cambodia, and Panthera). In northern Laos, camera-trap surveys from 2003 to 2017 in the country's largest national park documented the extinction of tiger and leopard (Rasphone et al. 2019). To our knowledge, Taman Negara is the only park in Southeast Asia where camera-trapping surveys conducted more than 10 years apart have confirmed that biodiversity has been maintained. Consequently, Taman Negara plays a major role as a regional hotspot, with the potential to become a crucial stronghold for Southeast

Asia's most Threatened mammal species, including Malayan tiger, Indochinese leopard, dhole, Asian elephant, Malayan tapir, and Malayan pangolin. However, it is imperative that law enforcement activities increase in Taman Negara to better protect this important biodiversity site from the illegal activities that are increasing in the region, primarily poaching for the illegal wildlife trade and deforestation.

Based on 2,375 camera-trap days, we photographed 29 mammal species that were >1 kg in DTC. Because of a lack of previous surveys before the logging began in DTC, the original biodiversity of this site is not known. However, given that it borders Taman Negara, we assume that the original biodiversity of DTC would have been the same as that found in Taman Negara. There were four mammal species that we not detected in DTC but that were photographed in TNM: sambar, gaur, large Indian civet (*Viverra zibetha*), and long-tailed macaque (*Macaca fascicularis*; Table 1). The latter two species likely were rare in TNM, based on the extremely low DF at that site (Table 1). Consequently, absence of photographs of these two species in DTC might have been due to the smaller area surveyed and lower number of trap nights, which presumably could result in failure to detect a few of the rarest species, especially those with small body sizes and home ranges. However, the lack of photographs of sambar and gaur in DTC suggests that these two species might have been absent from the site, given that these species are more easily photographed due to their large body sizes and larger home ranges. The only species photographed in DTC that were not recorded in TNM was the crab-eating mongoose (*Herpestes urva*). The absence of photographs of crab-eating mongoose in TNM could be due to a failure to detect this species given its small body size and presumably home range. Overall, biodiversity of mammal species >1 kg appeared to be similar between TNM and DTC in 2016, with the exception of the apparent absence of sambar and gaur from DTC. We are unsure why sambar and gaur were apparently absent from DTC, but it might have been because of differences in habitat types between sites, or higher levels of human activities, including logging and possibly poaching, in DTC compared to TNM.

The DF of Malayan tiger, Indochinese leopard and dhole were lower in DTC compared to TNM, with leopard showing the largest difference. These differences could be due to the smaller area surveyed and lower number of trap nights, which presumably could result in smaller DF of the apex carnivores, characterized by having large home ranges. Alternatively, the differences could reflect a lower abundance of apex carnivores in DTC compared to TNM. In contrast, the DF of medium-sized felids, including clouded leopard and Asian golden cat, were higher in DTC compared to TNM. In fact, the felid with the largest DF in DTC was the clouded leopard, which possibly was due to mesopredator release as a result of the lower abundance of apex carnivores (Ritchie and Johnson 2009), although it also could have been due to differences in habitat and prey between sites. Although the DF of smaller carnivores in DTC were variable, overall they were somewhat similar to TNM (Table 1), except for leopard cat (*Prionailurus bengalensis*), which had a lower DF in DTC compared to TNM. The DF of smaller ungulates, such as red muntjac (*Muntiacus muntjac*) and Eurasian wild pig (*Sus scrofa*), were slightly lower for DTC compared to TNM. However, the overall DF of these ungulates were relatively high in DTC, suggesting that large carnivores likely had sufficient prey in DTC, despite the non-detection of sambar and gaur. Regarding other small potential prey, the DF of mouse deer (*Tragulus* spp.) and Malayan porcupine (*Hystrix brachyuran*) were considerably lower in DTC compared to TNM. Although the DF of Malayan tapir and Malayan pangolin were similar between sites, the DF of Asian elephant was extremely low in DTC, as only one photograph was obtained. However, because the effects of diverse confounding factors (e.g., movement patterns, camera-trap set up) cannot be disentangled from the effects of abundance, these results should be considered with caution. Nonetheless, both surveys were run simultaneously for most of the period, therefore seasonal effects on the species should not have affected our results. Overall, our results suggest that DTC has the potential to preserve some of Peninsular Malaysia's most Threatened mammal species, and appropriate management practices at this site could hopefully ensure the conservation of these species in the future.

In summary, our study showed that TNM has maintained the diversity of mammal species >1 kg during the past 16 years. Our study also showed that the eco-certified logging concession DTC has the potential to preserve some of Peninsular Malaysia's most Threatened mammal species, however, the low DF of Asian elephant, and the non-detection of sambar and gaur, are causes for concern. Overall, our findings suggest that the Taman Negara Landscape is an important global site for the conservation of several Threatened species. Because poaching of large felids and other species might be increasing in Malaysia (Rayan and Linkie 2015; Belecky and Gray 2020), we recommend an increase in conservation efforts to maintain the forested area within Taman Negara Landscape, as well as an increase in law enforcement efforts to ensure the survival of its large and diverse community of species. We also recommend the establishment of long-term camera-trap surveys in the Taman Negara Landscape and other protected areas in Malaysia to monitor the changes in biodiversity and relative abundance of species over time.

Table 1. The detection frequencies (DF; number of independent photographs divided by total camera traps days multiplied by 100) of mammals >1 kg recorded in camera-trap surveys conducted in 2016 near Merapoh in Taman Negara National Park (TNM) and in the Dungun Timber Complex (DTC). The DF of mammals recorded in TNM in 2000 (calculated from Kawanishi and Sunquist 2004) were included for comparison purposes

Species – IUCN classification[a]	TNM 2016	TNM 2000	DTC 2016
Canidae			
Dhole (*Cuon alpinus*) - EN	0.17	0.14	0.13
Felidae			
Malayan tiger (*Panthera tigris jacksoni*) - CR	0.42	0.51	0.34
Indochinese leopard (*Panthera pardus delacouri*) - CR	1.58	2.61	0.42
Clouded leopard (*Neofelis nebulosa*) - VU	0.42	0.12	1.68
Asian golden cat (*Catopuma temminckii*) - NT	0.57	0.48	1.01
Marbled cat (*Pardofelis marmorata*) - NT	0.89	0.02	1.39
Leopard cat (*Prionailurus bengalensis*) - LC	2.98	1.36	1.01
Ursidae			
Sun bear (*Ursus malayanus*) - VU	4.42	2.21	4.97
Mustelidae			
Yellow-throated marten (*Martes flavigula*) - LC	2.24	0.12	1.22
Malayan weasel (*Mustela nudipes*) - LC	0.07	---[b]	0.04
Otter spp. (*Lutra* spp.)	---[b]	---[b]	0.04
Herpestidae			
Crab-eating mongoose (*Herpestes urva*) - LC	---	---	0.29
Viverridae			
Malay civet (*Viverra tangalunga*) - LC	0.81	1.41	0.25
Large Indian civet (*Viverra zibetha*) - LC	0.02	0.05	---
Masked palm civet (*Paguma larvata*) - LC	0.22	---[c]	0.59
Common palm civet (*Paradoxurus hermaphroditus*) - LC	0.17	0.02	0.29
Banded civet (*Hemigalus derbyanus*) - NT	0.27	0.02	0.76
Binturong (*Arctictis binturong*) - VU	0.15	0.02	0.17
Prionodontidae			
Banded linsang (*Prionodon linsang*) - LC	0.20	---[c]	1.73
Suidae			
Eurasian wild pig (*Sus scrofa*) - LC	8.78	3.04	6.32
Cervidae			
Sambar (*Rusa unicolor*) - VU	0.44	0.46	---
Red muntjac (*Muntiacus muntjac*) - LC	7.15	3.18	5.47
Mouse deer (*Tragulus* spp.) - LC	6.02	0.65	1.73
Bovidae			
Gaur (*Bos gaurus*) - VU	0.07	0.12	---
Sumatran serow (*Capricornis sumatraensis*) - VU	0.10	0.02	0.04
Elephantidae			
Asian elephant (*Elephas maximus*) - EN	1.46	3.85	0.04
Tapiridae			
Malayan tapir (*Tapirus indicus*) - EN	2.57	7.31	2.40
Cercopithecidae			
Southern pig-tailed macaque (*Macaca nemestrina*) - VU	1.21	0.25	0.38
Long-tailed macaque (*Macaca fascicularis*) - LC	0.02	0.02	---
White-thighed surili (*Presbytis siamensis*) - NT	0.44	---[b, d]	0.08
Hystricidae			
Malayan porcupine (*Hystrix brachyuran*) - LC	4.34	1.29	0.59
Asiatic brush-tailed porcupine (*Atherurus macrourus*) - LC	0.44	0.14	4.29
Manidae			
Malayan pangolin (*Manis javanica*) - CR	0.02	0.07	0.08

Note: [a] CR = Critically Endangered, EN = Endangered, VU = Vulnerable, NT = Near Threatened, LC = Least Concern. [b] Presence within the camera-trap grid during the survey was confirmed by a sighting, vocalization, or sign. [c] Presence was not confirmed within the camera-trap grid, but it was confirmed by photographs within another grid inside Taman Negara National Park during the survey (Kawanishi and Sunquist 2004). [d] Referred to as banded langur (*Presbytis femoralis*) by Kawanishi and Sunquist (2004).

ACKNOWLEDGEMENTS

We thank the Malaysian government for permits to conduct the surveys, particularly the Department of

Wildlife and Parks (DWNP), Mohd Taufik bin Abdul Rahman (director of Protected Area division), Mohd Zakimi bin Mat Yunus (head of Taman Negara-Merapoh) and other DWNP staff at the Merapoh outpost. We also thank Haji Wan from DTC for allowing us to conduct the survey in the forest concession, and DTC staff for providing logistical support. We thank Tey Kiat Loong, Liang Neo Song Wee, and many indigenous field assistants who helped with the fieldwork. We also thank A. Rasphone (Wildlife Conservation Society, Lao PDR) and R. Crouthers (WWF Cambodia) for reviewing the paper and providing helpful comments. The operational costs of the surveys were provided by Panthera.

REFERENCES

Belecky M, Grey TNE. 2020. Silence of the snares: Southeast Asia's snaring crises. WWF International, Gland, Switzerland.

Berry NJ, Phillips OL, Lewis SL, Hill JK, Edwards DP, Tatatao NB, Ahmad N, Magintan D, Khen CV, Maryati M, Ong RC, Hamer HC. 2010. The high value of logged tropical forests: lessons from northern Borneo. Biodivers Conserv 19: 985-997.

Clements GR, Lynam AJ, Gaveau D, Yap WL, Lhota S, Goosem M, Laurance S, Laurance WF. 2014. Where and how are roads endangering mammals in Southeast Asia's forests? PLoS ONE 9: e115376. DOI: 10.1371/journal.pone.0115376.

Duckworth JW, Batters G, Belant JL, Bennett EL, Brunner J, Burton J, Wirth R. 2012. Why South-East Asia should be the world's priority for averting imminent species extinctions, and a call to tackle this urgent issue. Sapiens 5: 77-95.

Duckworth JW, Sankar K, Williams AC, Samba Kumar N, Timmins RJ. 2016. *Bos gaurus*. The IUCN Red List of Threatened Species 2016: e.T2891A46363646. www.iucnredlist.org

Edwards DP, Hodgson JA, Hamer KC, Mitchell SL, Ahmad AH, Cornell SJ, Wilcove DS. 2010. Wildlife-friendly oil palm plantations fail to protect biodiversity effectively. Conserv Lett 3: 236-242.

Havmøller RS, Payne J, Ramono W, Ellis S, Yoganand K, Long B, Dinerstein E, Williams C, Putra RH, Gawi J, Talukdar BK, Burgess N. 2016. Will current conservation responses save the critically endangered Sumatran rhinoceros *Dicerorhinus sumatrensis*? Oryx 50: 355-359.

Heino M, Kummu M, Makkonen M, Mulligan M, Verburg PH, Jalava M, Rasanen TA. 2015. Forest loss in protected areas and intact forest landscapes: A global analysis. PLoS ONE 10: e0138918. DOI: 10.1371/journal.pone.0138918.

Hughes AC. 2017. Understanding the drivers of Southeast Asian biodiversity loss. Ecosphere 8: e01624. DOI: 10.1002/ecs2.1624

Kamler J F, Songsasen N, Jenks K, Srivathsa A, Li S, Kunkel K. 2015. *Cuon alpinus*. The IUCN Red List of Threatened Species 2015: e.T5953A72477893. www.iucnredlist.org

Kawanishi K, Sunquist ME. 2004. Conservation status of tigers in a primary forest of Peninsular Malaysia. Biol Conserv 120: 329-344.

Kawanishi K. 2015. *Panthera tigris* ssp. *jacksoni*. The IUCN Red List of Threatened Species 2015: e.T136893A50665029. www.iucnredlist.org

Lynam AJ, Nowell K. 2011. *Panthera tigris* spp. *corbetti*. The IUCN Red List of Threatened Species 2011: e.T136853A4346984. www.iucnredlist.org

O'Brien TG, Kinnaird MF, Wibisono HT. 2003. Crouching tigers, hidden prey: Sumatran tiger and prey populations in a tropical forest landscape. Anim Conserv 6: 131-139.

Rasphone A, Kéry M, Kamler JF, Macdonald DW. 2019. Documenting the demise of tiger and leopard, and the status of other carnivores and prey, in Lao PDR's most prized protected area: Nam Et-Phou Louey. Glob Ecol Conserv 20: e00766. DOI: 10.1016/j.gecco.2019.e00766

Rayan DM, Linkie M. 2015. Conserving tigers in Malaysia: A science driven approach for eliciting conservation policy change. Biol Conserv 184: 18-26.

Ritchie EG, Johnson CN. 2009. Predator interactions, mesopredator release and biodiversity conservation. Ecol Lett 12: 982-998.

Rostro-García S, Kamler JF, Clements GR, Lynam AJ, Naing H. 2019. *Panthera pardus* spp. *delacouri*. The IUCN Red List of Threatened Species 2019: e.T124159083A124159128. www.iucnredlist.org

Rostro-García S, Kamler JF, Crouthers R, Sopheak K, Prum S, In V, Pin C, Caragiulo A, Macdonald DW. 2018. An adaptable but threatened big cat: density, diet and prey selection of the Indochinese Leopard (*Panthera pardus delacouri*) in eastern Cambodia. R Soc Open Sci 5: 171187.

Timmins R, Kawanishi K, Giman B, Lynam A, Chan B, Steinmetz R, Sagar Baral H, Samba Kumar N. 2015. *Rusa unicolor*. The IUCN Red List of Threatened Species 2015: e.T4179085628124. www.iucnredlist.org

Wilcove DS, Giam X, Edwards DP, Fisher B, Koh LP. 2013. Navjot's nightmare revisited: Logging, agriculture, and biodiversity in Southeast Asia. Trends Ecol Evol 28: 531-540.

Woodcock P, Edwards DP, Fayle TM, Newton RJ, Khen CV, Bottrell SH, Hamer KC. 2011. The conservation value of South East Asia's highly degraded forests: evidence from leaf-litter ants. Philos T R Soc B 366: 3256-3264.