

## Predicted distribution of the flat-headed cat *Prionailurus planiceps* (Mammalia: Carnivora: Felidae) on Borneo

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Wilting et al. (2016: Table 2) list all co-authors' affiliations.

**Abstract.** The flat-headed cat *Prionailurus planiceps* is classified as one of the most threatened cat species in the world. Its range is restricted to southern Thailand, peninsular Malaysia and the two largest Sunda Islands, Borneo and Sumatra. Its association with wetlands and lowland areas puts great pressure on this species, because these habitats are most threatened by degradation and agricultural conversions. Borneo has been identified as the stronghold for flat-headed cat. Of 140 flat-headed cat occurrence records for Borneo, 50 (Balanced Model) or 76 (Spatial Filtering Model) were used to estimate potential habitat suitability. Although we predicted suitable habitat for the flat-headed cat scattered across the lowlands of Borneo, some large lowland areas are predicted to be unsuitable, a likely consequence of forest conversion to oil palm plantations. Of particular predicted importance are forests in Brunei Darussalam, the Sabangau National Park and surrounding forest complex in Central Kalimantan and forests in North Kalimantan, as well as the central forest block in Sabah. The main threat to the flat-headed cat is on-going transformation of forested areas to monoculture plantations, as the species appears unable to use these human-dominated habitats. Of particular importance for long-term survival of flat-headed cat is conservation of land near rivers and peat swamp forests.

**Key words.** Borneo Carnivore Symposium, Brunei, conservation priorities, habitat suitability index, Indonesia, Malaysia, species distribution modelling, survey gaps

**Abstrak (Bahasa Indonesia).** Kucing Tandang *Prionailurus planiceps* diklasifikasikan sebagai salah satu jenis kucing liar yang paling terancam di dunia. Daerah sebarannya terbatas di Thailand Selatan, Semenanjung Malaysia dan dua Kepulauan Sunda terbesar, Borneo dan Sumatera. Asosiasi jenis ini adalah lahan basah dan dataran rendah, yaitu kawasan yang mendapatkan tekanan yang sangat tinggi saat ini oleh degradasi dan konversi menjadi lahan pertanian, sehingga tekanan terhadap Kucing Tandang juga sangat tinggi. Borneo telah diidentifikasi sebagai benteng terbaik untuk Kucing Tandang. Kami mengumpulkan 140 catatan kehadiran Kucing Tandang di Borneo, dimana 50 (Model Penyeimbang) atau 76 (Model Spasial Tersaring) digunakan untuk mengestimasi habitat yang sesuai. Walaupun prediksi habitat yang sesuai tersebar di dataran rendah Borneo, tetapi hasil penelitian kami juga menyatakan sebagian besar kawasan dataran rendah tidak sesuai untuk habitat, yang merupakan konsekuensi dari konversi hutan menjadi perkebunan sawit. Prediksi kawasan penting adalah kawasan hutan di Brunei Darussalam, Taman Nasional Sebangau dan sekitar kawasan hutan di Kalimantan Tengah, kawasan hutan di Kalimantan Utara, juga kawasan hutan di Sabah. Ancaman utama jenis Kucing Tandang adalah konversi kawasan hutan menjadi kawasan tanaman monokultur sehingga jenis ini tidak dapat hidup di kawasan yang didominasi oleh aktivitas manusia. Suatu yang paling penting bagi kelestarian jenis Kucing Tandang ini adalah mempertahankan kawasan sempadan sungai dan kawasan hutan rawa gambut.

**Abstrak (Bahasa Malaysia).** Kucing Hutan *Prionailurus planiceps* dianggap sebagai salah satu spesies kucing yang paling terancam di dunia. Taburan spesies ini terhad di selatan Thailand, Semenanjung Malaysia dan di dua kepulauan Sunda yang terbesar iaitu Borneo dan Sumatera. Perkaitannya dengan tanah basah dan kawasan tanah rendah memberikan tekanan yang tinggi kepada spesies ini kerana habitat ini sangat terancam dengan kemusnahan dan aktiviti penukaran tanah kepada akuakultur. Borneo telah dikenal pasti sebagai kawasan utama untuk Kucing Hutan. Kami mengumpul sejumlah 140 rekod Kucing Hutan di Borneo. Daripada jumlah itu, 50 rekod (Model Seimbang) atau 78 rekod (Model yang ditapis secara spasial) telah digunakan untuk meramal kesesuaian habitat yang berpotensi bagi spesies ini. Walaupun kami meramalkan habitat yang sesuai untuk Kucing Hutan adalah bertaburan di seluruh kawasan tanah rendah Borneo, keputusan yang kami perolehi turut mencadangkan bahawa sesetengah kawasan tanah rendah yang luas adalah tidak sesuai bagi Kucing Hutan. Ini kemungkinan disebabkan kawasan tersebut telah dijadikan ladang kelapa sawit. Antara kawasan penting yang diramal untuk spesies ini adalah hutan di Brunei Darussalam, Taman Negara Sabangau dan kompleks hutan di Kalimantan Tengah, hutan di bahagian utara Kalimantan Timur serta kompleks hutan di bahagian tengah Sabah. Ancaman utama bagi Kucing Hutan adalah penukaran kawasan hutan kepada ladang monokultur yang masih lagi berlaku pada ketika ini. Ini kerana spesies ini dilihat tidak mampu untuk mengguna kawasan yang telah didominasi oleh manusia. Antara langkah penting untuk kelangsungan hidup jangka panjang Kucing Hutan adalah pemuliharaan kawasan hutan yang berhampiran dengan sungai dan hutan paya gambut.

## INTRODUCTION

The flat-headed cat *Prionailurus planiceps* (Vigors & Horsfield), is one of the smallest – weighing as little as 1.5–2 kg (Muul & Lim, 1970) – and most threatened cat species in the world (Wilting et al., 2015). Very little is known about the ecology of this species. Morphological adaptations, such as webbed feet, and information from the few available records suggest that the flat-headed cat (Fig. 1) is closely associated with freshwater and lowland habitats (Wilting et al., 2010). Gumal et al. (2010) documented that flat-headed cats are excellent swimmers. Captive feeding trials suggested a dietary preference for fish (Traeholt & Idris, 2011) and also Banks (1931) reported that they feed mostly on fish and some fruits (Banks, 1931). Although further dietary research under natural conditions is needed, these findings indicate that flat-headed cat feeds on fish and other prey (e.g., crabs and frogs) associated with water sources. Records obtained in this study indicate that flat-headed cat is largely nocturnal, although Traeholt & Idris (2011) suggested crepuscular–diurnal activity, as does a recent daytime video footage from Krau Wildlife Reserve (C. Traeholt pers. comm.). Nothing is known about its home-range sizes and population densities.

The flat-headed cat is one of the few monotypic cat species, but no in-depth phylogenetic analysis has been conducted. In 2008, its status on The IUCN Red List of Threatened Species was elevated from Vulnerable to Endangered, reflecting increased extinction risk (Wilting et al., 2015). In 2010, the distribution of flat-headed cat was assessed using species distribution modelling techniques (Wilting et al., 2010). These authors demonstrated that over 50% of historical habitat (i.e., that before large-scale human landscape transformation started in the second half of the 20th century) has been converted to land-cover types believed to be unsuitable for flat-headed cats (e.g., croplands, plantations). Only 10–20% of apparently suitable land-cover in the estimated geographic range of this species is fully legally protected, based on IUCN criteria. Remaining habitats are highly fragmented with few large forest patches (over 1000 km<sup>2</sup>) remaining. Most of the remaining and apparently suitable habitat for this species is on Borneo and 11 key localities for the conservation of the flat-headed cat have been proposed (Wilting et al., 2010). Compiling the Borneo Carnivore Database revealed more occurrence records of flat-headed cat, allowing the earlier predictions for Borneo to be refined with a more comprehensive dataset and a more robust modelling approach (by accounting for the sampling bias or differences in search effort, respectively).

In Malaysian Borneo (states of Sabah and Sarawak) and in Indonesia, the flat-headed cat is fully protected under the



Fig. 1. Flat-headed cat *Prionailurus planiceps* camera-trapped in Tangkulap Forest Reserve, Sabah, Malaysian Borneo on 18 March 2009. Credit: Mohamed & Wilting/IZW, SFD, SWD.

Sabah Wildlife Conservation Enactment (1997), the Sarawak Wild Life Protection Ordinance (1998) and the Appendix of The Government of Republic of Indonesia Regulation No. 7 (1999), respectively. In Brunei Darussalam the flat-headed cat is currently not formally protected. All three countries are parties to the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) and the flat-headed cat is listed on CITES Appendix II. Thus, trade of flat-headed cat is theoretically controlled. Currently, there is no evidence that flat-headed cat is traded on international black markets (Chris R. Shepherd pers. comm.), but there are records of incidental captures of flat-headed cat in traps (Gumal et al., 2010).

## RESULTS AND DISCUSSION

**Species occurrence records.** Of 140 records collected, 35 were excluded from modelling because their spatial precision was too low (over 5 km; Categories 4 and 5), whereas 51 records had high precision (within 2 km, Category 1) and were collected between 2001 and 2011 (Table 1). Most records were collected from Sabah, because of the greater sampling effort in this state, but also from Brunei Darussalam, Sarawak (particularly northern areas closer to the coast) and various parts of Kalimantan (Fig. 2). Because of sampling bias, only 50 (Balanced Model =  $M_1$ ) or 76 (Spatial Filtering Model =  $M_2$ ) records were used for modelling (see Kramer-Schadt et al., 2016).

**Habitat associations.** In contrast to many other small carnivore species, the 12 respondents of the questionnaire were highly consistent in their assessment of suitable land-cover for the flat-headed cat (Table 2). All respondents agreed that important habitats for the flat-headed cat include lowland forests (below 500 m), swamp forests and mangroves, and they ranked upland forests (500–1000 m) as marginally suitable (possibly suitable as corridors); by contrast montane forests, forest mosaics (both lowland and highland), and plantations and croplands were considered unsuitable for flat-headed cat (Table 2). These scores suggest that the flat-headed cat might be one of the most habitat-restricted carnivore species of Borneo, although more intensive surveys from ‘low-ranked habitats’ are greatly needed to evaluate this scoring.

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Table 1. Summary of occurrence records for flat-headed cat *Prionailurus planiceps* on Borneo.

Spatial Precision	Total No. of Records	No. of Records in M <sub>1</sub>	No. of Records in M <sub>2</sub>	No. of Recent Records 2001–2011
Category 1 below 500 m	53	13	33	51
Category 2 500 m – 2 km	13	11	13	6
Category 3 2–5 km	39	26	30	6
Category 4 above 5 km	17	-	-	2
Category 5 (no coordinates*)	18	-	-	1
<b>Total</b>	<b>140</b>	<b>50</b>	<b>76</b>	<b>66</b>

M<sub>1</sub> = Balanced Model; M<sub>2</sub> = Spatial Filtering Model (2 km); \*only coarse location description was available.

Table 2. Land-cover reclassification for flat-headed cat *Prionailurus planiceps* based on a questionnaire completed by 12 respondents working on carnivores on Borneo.

Land-cover Class	Mean of Reclassification	Range of Reclassifications
Lowland forest	3.42	3–4
Upland forest	1.88	1–2
Lower montane forest	0.88	0–1
Upper montane forest	0.00	0–0
Forest mosaics/lowland forest	0.65	*
Forest mosaics/upland forest	0.48	#
Swamp forest	3.89	3–4
Mangrove	3.67	3–4
Old plantations	0.13	0–1
Young plantations and crops	0.00	0–0
Burnt forest area	0.00	0–0
Mixed crops	0.00	0–0
Bare area	0.00	0–0
Water and fishponds	0.20	0–2
Water	0.00	0–0

\*/#Calculated based on the mean of the reclassification of old plantation and \*lowland forest or #upland forest, respectively.

Habitat suitability rank ranges from 0 (unsuitable) to 4 (most suitable); further detail, and on land-cover classes, in Kramer-Schadt et al. (2016).

**Habitat suitability index (HSI) model.** The habitat assessments had a strong effect on the predicted habitat suitability model (see Kramer-Schadt et al., 2016) for flat-headed cats throughout Borneo, with all predicted core habitats occurring in extreme lowland areas. However, because large tracts of lowlands have been converted to plantations (mainly of oil palm; see Gaveau et al., 2014), it is apparent that these areas were also excluded from predicted suitable habitats (e.g. large areas in eastern Sabah; Fig. 3). As with Wilting et al. (2010), this updated predicted habitat suitability map suggests that large parts of flat-headed cat suitable habitat lies outside larger national parks, especially outside those along the central ‘Heart of Borneo’ centred on the Sarawak–Kalimantan border. Although these forests are less disturbed by human activities (Gaveau et al., 2014),

they are dominated by upland and montane forests that have limited suitability for this species.

The mapped predictions of the habitat suitability index model in Fig. 3 need to be interpreted with caution (see Kramer-Schadt et al. 2016 for more details). Of note, some areas, particularly in South and West Kalimantan had little information, mainly because of the lower survey efforts in these areas. Although search-effort bias has been minimised during the modelling, these areas might still be underrepresented in the distribution map especially if they are climatically distinct from the rest of Borneo. This is particularly likely for South Kalimantan which has a more pronounced dry season (see Kramer-Schadt et al., 2016: Fig. 3A). Thus, unless there are records sufficiently spatially



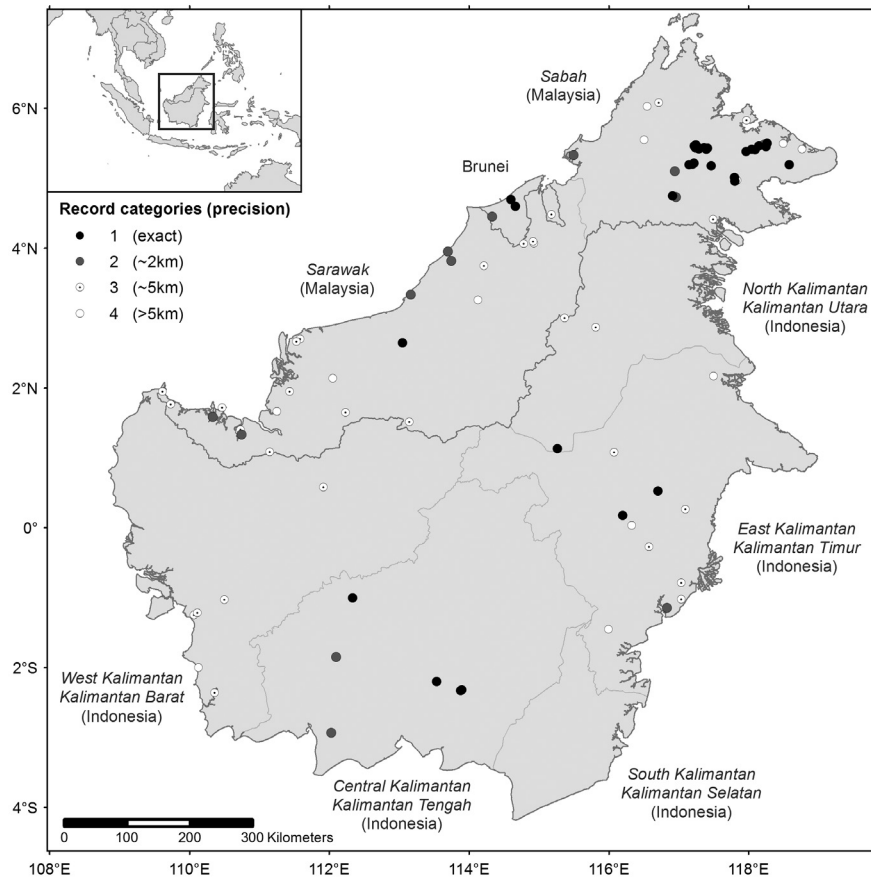


Fig. 2. Location of flat-headed cat *Prionailurus planiceps* occurrence records in Borneo, showing categories of spatial precision as well as country and state boundaries.

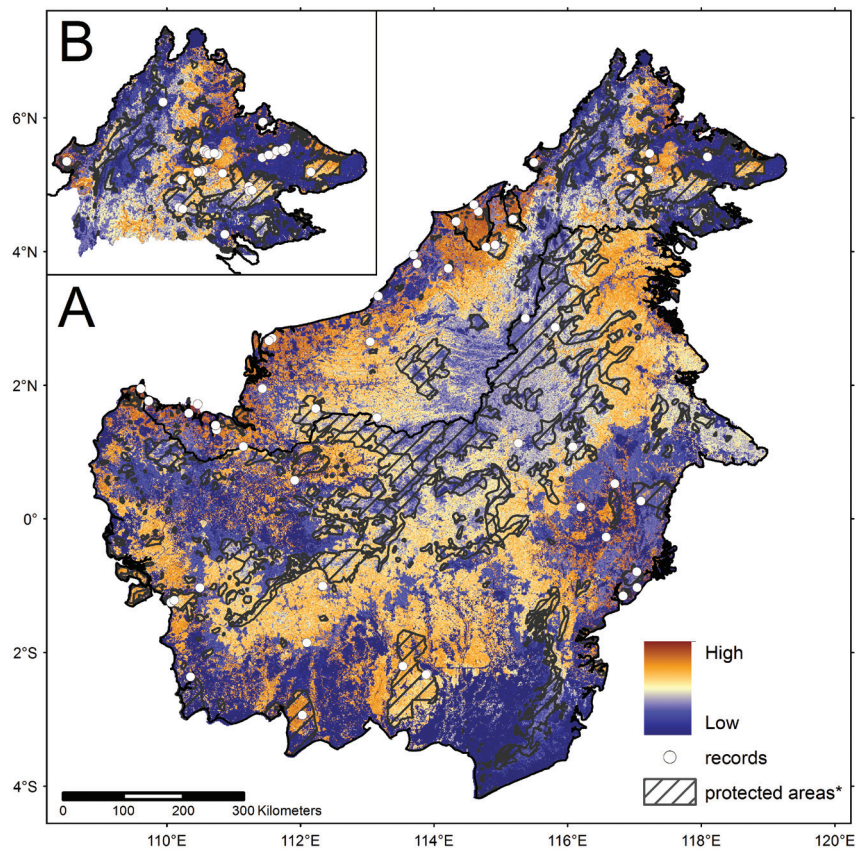


Fig. 3. Predicted Habitat Suitability Index (HSI) model for flat-headed cat *Prionailurus planiceps* including location records used in models. A, Balanced Model for the island of Borneo; B, Spatial Filtering Model for Sabah, Malaysia. Sources for protected area information: see Kramer-Schadt et al. (2016).

precise to have been used in the model, the prediction cannot accurately reflect the potential for occurrence in that region. In general, further surveys are needed to verify if the lower predictions are because of the minimal survey efforts or reflect a genuine lower suitability of these areas for the species, perhaps because of different climatic conditions or because large areas have been transformed to unsuitable land-cover (see Kramer-Schadt et al., 2016: Fig. 3B). Based on the current predicted distribution, the following important localities and conservation actions are suggested (see Fig. 3).

**Brunei Darussalam.** A large portion of Brunei Darussalam remains covered by lowland forests (Gaveau et al., 2014) and thus it is not surprising that Brunei is a key predicted location for the occurrence of the flat-headed cat. In particular, the Belait district and the eastern Temburong District were predicted to be highly suitable.

**Sarawak, Malaysia.** Within Sarawak, potential flat-headed cat habitat is highly fragmented and a key conservation priority is to enhance linkages between protected areas and forest fragments. Potential habitat areas for the flat-headed cat in Sarawak are Maludam National Park and Samunsam Wildlife Sanctuary (see also Wilting et al., 2010), areas in and around Loagan Bunut and Gunung Mulu National Parks, and other lowland forests in north-eastern Sarawak near the Brunei Darussalam border. In 2011, a flat-headed cat was captured in a coastal fishing village just 27 km from Kuching (Tisen & Mohd-Azlan, 2013). Health screening revealed that the cat was positive for feline panleukopenia (FPV) and despite treatment, the cat died in captivity (Tisen & Mohd-Azlan, 2013).

**Sabah, Malaysia.** Eastern Sabah was presumably a stronghold for flat-headed cat in historical times (Wilting et al., 2010). Large scale forest conversion has, however, resulted in a high degree of fragmentation within these lowlands (e.g., McMorro & Talip, 2001). Nevertheless, key localities remain forested, including the Tabin Wildlife Reserve and the neighbouring Lower Kinabatangan – Segama Wetlands. These wetlands have recently been designated as Sabah's first Ramsar site (Ramsar Convention CoP 10: 2008), a promising step for their long-term conservation and for ensuring the linkage between Tabin Wildlife Reserve and the Lower Kinabatangan Wildlife Sanctuary, both key flat-headed cat sites (Hearn et al., 2010; Wilting et al., 2010). The second major forest complex for the flat-headed cat in Sabah is the Deramakot – Ulu Segama – Malua forest complex north and south of the upper Sungai [=River] Kinabatangan. Several recent camera-trapping studies in these areas photographed flat-headed cat (Mohamed et al., 2009; Ross et al., 2010; Samejima et al., 2012).

**North Kalimantan and East Kalimantan, Indonesia.** North Kalimantan has particular potential to be important for flat-headed cat. Especially, the north-eastern lowland forests in the Sebuku–Sembakung region are predicted to contain suitable flat-headed cat habitat. However, large parts of this area are currently neither protected nor managed but instead face strong pressure for local economic

development. Oil palm plantations are expected to expand rapidly. Conservation actions such as the protection of forests or sustainable, certified large-scale forest management using low-impact logging techniques have the potential to contribute substantially to the conservation of flat-headed cat, as well as other threatened wildlife species, in this complex. In the southern part of East Kalimantan, wetlands in and around Teluk Adang and Teluk Apar Nature Reserves are also predicted to contain suitable habitat for the flat-headed cat, but these are increasingly fragmented by expansion of shrimp farms and the road network.

**South Kalimantan, Indonesia.** The modelling generally classified South Kalimantan as unsuitable habitat. As stated above, one reason could be that South Kalimantan has greater seasonal climate variation than most other parts of Borneo (see Kramer-Schadt et al., 2016) so flat-headed cat, with its strong association with water resources, might be sensitive to the harsher dry season (Wilting et al., 2010). In addition, the larger forest blocks in South Kalimantan are in the Meratus mountains, a rugged mountainous area, presumably not flat-headed cat habitat. The few lowland and wetland areas in South Kalimantan along the Barito and in the coastal lowlands have largely been converted and thus are unlikely to contain suitable habitat for the flat-headed cat. However, survey efforts in South Kalimantan have been so low that it is also possible that this area was not predicted to contain suitable habitat only because of this search-effort bias (see above).

**Central Kalimantan, Indonesia.** The 5600 km<sup>2</sup> Sabangau National Park and forest complex in Central Kalimantan is very likely to be one of the most important sites for the flat-headed cat, with recent camera-trapping recording this species several times (Cheyne et al., 2009). Adjacent to this protected area are forests (e.g., Mungku Baru and Bawan Forest) also predicted to contain suitable habitat for flat-headed cat, but these forests are currently not listed as protected according to the IUCN criteria (Mungku Baru is a community forest and Bawan has no protection status). Tanjung Puting National Park is also predicted to contain suitable flat-headed cat habitat, but it is isolated from other potential flat-headed cat habitat.

**West Kalimantan, Indonesia.** Compared with other parts of Borneo, West Kalimantan is largely unstudied and records of flat-headed cat are rare. Further studies are needed to evaluate if the generally lower prediction of suitable habitat results from a lack of records by lower search effort, or if some other habitat or climate characteristics resulted in the lower suitability prediction (see above). Despite generally lower habitat suitability, two areas previously identified by Wilting et al. (2010) appear suitable for flat-headed cat. The first is the large Upper Kapuas Peat Swamp Forest including the Danau Sentarum National Park, where the species was reportedly observed and recorded in interviews in the mid 1990s (Jeanes & Meijaard, 2000). The second predicted region is the coastal area in Gunung Palung National Park and areas south (Sungai Putri forest block) as well as north (on and north of Pulau Maya) of the national park.

## RESEARCH PRIORITIES

An understanding of most flat-headed cat ecological parameters is lacking. Most information was derived from the few direct sightings, camera-trap pictures or live-trapped and captive individuals. This uncertainty results in higher uncertainties in the predictive distribution maps, because the habitat suitability assessments exert a large influence on these maps (Kramer-Schadt et al., 2016). Thus, there is great need for in-depth ecological studies, particularly emphasising fine-scale habitat use and response to anthropogenic disturbances. For example, a radio-telemetry study could provide valuable information on the association of flat-headed cat with freshwater sources. Diet analyses using common techniques would presumably be challenging, given difficulties in finding flat-headed cat faeces. Stable isotope analyses of hair samples from museum specimens (e.g., Ben-David & Flaherty, 2012) might help overcome these difficulties and provide further insights in the feeding ecology and habitat associations of flat-headed cat.

## GENERAL CONSERVATION PRIORITIES AND POTENTIAL STARTING POINTS

Recent records from the fragmented Kinabatangan Wildlife Sanctuary in Sabah are a promising sign that the flat-headed cat can survive in fragmented landscapes, provided forest persists along the main rivers and their tributaries. Thus, an important conservation action for the Endangered flat-headed cat should be the conservation and restoration of riverine forests. Given the extensive networks of rivers in the lowlands of Borneo, these restored habitats would be likely also to function as corridors for flat-headed cats between already protected or sustainably managed areas. There is great potential for a joint conservation initiative with the palm oil industry: through the Roundtable for Sustainable Palm Oil (RSPO), more private stakeholders have recently demonstrated responsibility for sustainable and environmentally friendly development. In addition to the benefits for highly threatened swamp forest specialists such as flat-headed cat, otter civet *Cynogale bennettii* Gray, and hairy-nosed otter *Lutra sumatrana* (Gray), such buffers would also provide benefits for local communities by reducing land erosion and flooding and improving quality of drinking water (Wells et al., 2013). Sustainable management according to the RSPO guidelines would further reduce pollution of freshwater systems. Pollution, along with habitat loss, is plausibly one of the major threats for wetland species in Borneo. Although a large proportion of Borneo's lowland forests and wetlands are already converted to plantations, this potential collaboration provides a promising starting point for successful long-term conservation of the flat-headed cat.

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