

Predicted distribution of the bay cat *Catopuma badia* (Mammalia: Carnivora: Felidae) on Borneo

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

Abstract. The bay cat *Catopuma badia* is a small cat endemic to the tropical forests of Borneo. One of only seven cats to be listed as Endangered by The IUCN Red List of Threatened Species, the bay cat is seldom seen, rarely photographed and is widely held to be one of the least known of the world's wild cats. Consequently its distribution is known only poorly, hindering efforts for its conservation. Here we use MaxEnt niche distribution modelling to make predictions regarding its current distribution on Borneo. We collected a total of 71 occurrence records for the bay cat, stemming from all Bornean regions apart from Brunei and South Kalimantan, of which 40 were used in our modelling. Our habitat suitability modelling predicts that an extensive, contiguous area of interior Borneo, much of it hill forest, but also containing lowland and submontane forest, is suitable for the bay cat, supporting an earlier hypothesis that this cat is widespread across the island. Extreme lowlands, supporting mangrove and swamp forest habitats, were typically predicted as low suitability, as were the considerable areas of Borneo now converted to oil palm plantations. Based on the current predicted distribution we provide a list of priority areas for the conservation of the bay cat across Borneo.

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

Abstrak (Bahasa Indonesia). Kucing Merah *Catopuma badia* adalah jenis kucing liar endemik di hutan tropis Borneo. Merupakan salah satu jenis kucing liar dari tujuh jenis yang terdaftar sebagai jenis kucing liar yang terancam punah pada Daftar Jenis Terancam Punah IUCN. Jenis ini jarang terlihat, jarang tertangkap kamera dan secara luas diketahui merupakan salah satu jenis yang paling jarang ditemukan di dunia. Oleh karena itu jenis ini sebarannya tidak diketahui, sehingga menghambat upaya konservasinya. Dalam tulisan ini kami menggunakan pemodelan sebaran niche MaxEnt untuk memprediksi sebaran Kucing Merah di Borneo. Secara keseluruhan kami mengumpulkan 71 catatan kehadiran Kucing Merah yang berasal dari seluruh wilayah Borneo, dari Brunei hingga Kalimantan Selatan, 40 catatan di antaranya kami gunakan untuk pemodelan. Dari prediksi pemodelan kesesuaian habitat diketahui bahwa daerah yang luas di pedalaman Borneo yang sebagian besarnya berupa kawasan hutan dataran tinggi (hutan perbukitan) yang juga terdapat hutan dataran rendah dan hutan sub dataran tinggi adalah kawasan yang diprediksi paling sesuai untuk Kucing Merah. Hal ini sesuai dengan hipotesa awal yang menyatakan bahwa jenis ini tersebar luas di keseluruhan Pulau Borneo. Daerah dataran rendah yang terdepan seperti hutan mangrove dan hutan rawa diprediksi rendah kesesuaian habitatnya, demikian pula dengan beberapa daerah di Kalimantan yang telah dikonversi menjadi perkebunan Kelapa Sawit. Berdasarkan prediksi sebaran yang diperoleh, kami menyusun daftar wilayah prioritas untuk konservasi Kucing Merah di Borneo.

Abstrak (Bahasa Malaysia). Kucing Merah Borneo, *Catopuma badia*, adalah spesis kucing liar yang endemik di hutan tropika Borneo. Kucing ini merupakan satu-satunya daripada tujuh spesis kucing, yang disenarai sebagai Terancam di dalam Senarai Merah Spesis Terancam IUCN. Spesis ini jarang dilihat mahupun ditangkap-gambar dan ia dipercayai merupakan spesis kucing liar yang paling kurang diketahui di dunia. Sehubungan itu, taburan kucing ini tidak banyak diketahui dan keadaan ini menyukarkan usaha-usaha pemuliharaan dilaksanakan. Dalam kajian ini kami menggunakan pendekatan pemodelan MaxEnt ceruk untuk membuat ramalan tentang taburan semasa Kucing Merah di Borneo. Kami mengumpul sejumlah 71 rekod spesis kucing ini yang diperolehi dari semua bahagian Borneo kecuali Brunei dan Kalimantan Selatan. Daripada jumlah rekod ini, sebanyak 40 rekod telah digunakan dalam pemodelan kami. Keputusan pemodelan kesesuaian habitat kami meramalkan bahawa sebahagian besar kawasan pedalaman Borneo, terutama sekali di kawasan hutan bukit iaitu termasuk juga kawasan hutan tanah rendah dan submontan, adalah sesuai dihuni oleh Kucing Merah. Keputusan ini menyokong hipotesis awal mengenai taburan kucing ini yang meluas di keseluruhan pulau Borneo. Walau bagaimanapun, kawasan tanah yang sangat rendah seperti di habitat hutan bakau dan hutan paya, diramal mempunyai kesesuaian yang rendah. Begitu juga kawasan ladang kelapa sawit yang meliputi sebahagian besar pulau Borneo diramal mempunyai kesesuaian yang rendah. Berdasarkan kepada ramalan taburan semasa yang kami perolehi, kami menyenaraikan kawasan keutamaan bagi pemuliharaan spesis Kucing Merah ini di Borneo.

INTRODUCTION

The bay cat *Catopuma badia* (Gray), endemic to Borneo, is one of only seven wild cats currently listed as Endangered by The IUCN Red List of Threatened Species (Hearn et al., 2008). Despite its threatened status there remains a paucity of information regarding even its basic ecology and distribution (Sunquist & Sunquist, 2002), upon which effective conservation strategies rely. In the mid-nineties Sunquist et al. (1994: 67) stated that “the bay cat...is one of the world’s least known felids”. Twenty-one years later this remains true. There are only 12 museum specimens of this small, ca. 3–4 kg, cat (Sunquist & Sunquist, 2002; Kitchener et al., 2004). The pelage of the bay cat is a solid reddish (bay) or grey, although grey animals with differing amounts of reddish colouration to their extremities, which provide examples of a gradation between these forms, are common (Fig. 1). Black morphs have also been reported (Banks, 1931) and Ampeng et al. (2015) camera-trapped a particularly dark individual, although reddish colouration is visible to its extremities. Camera-trapping has revealed that these colour morphs live sympatrically in at least part of their range (Ross et al., 2010; Ampeng et al., 2015) although other surveys have detected either only red or grey specimens (e.g., Hon, 2011; H. Samejima, unpublished data). The bay cat appears to be primarily diurnal in nature, although not strictly so (Ross et al., 2010). Nothing is known regarding its reproductive behaviour, diet or spatial ecology.

Knowledge of the distribution of the bay cat is equally scant. Meijaard (1997) collated historical and contemporary records and noted two concentrations of them, one in the Sungai [=River] Mahakam and upper Sungai Barito area, and one in the hilly Sarawak – West Kalimantan border area. Meijaard (1997) presented a number of sightings from outside these core areas, however, and speculated that the bay cat has been, and potentially still is, widely distributed on Borneo, a proposition later supported by Azlan & Sanderson (2007). Historical records and incidental observations (Sunquist et al., 1994; Meijaard, 1997; Bricknell, 2003; Dinets, 2003; Hearn, 2003; Meijaard et al., 2005a), and more recently, camera-trap photographs (Azlan et al., 2003; Yasuda et al., 2007; Mohamed et al., 2009; Ross et al., 2010; Bernard et al., 2012; Brodie & Giordano, 2012a; Wearn et al., 2013; Gardner et al., 2014; Mathai et al., 2014; Ampeng et al., 2015; Sastramidjaja et al., 2015; AJ Hearn, J Ross and DW Macdonald, unpublished data) indicate that this elusive cat exhibits habitat plasticity. Records stem from a range of forest types, including lowland and hill dipterocarp forest – both primary and selectively logged – swamp forest and mangrove. Many records were obtained close to rivers and wetlands, prompting earlier suggestions that the bay cat might



Fig. 1. Bay cat *Catopuma badia* camera-trapped in the Danum Valley Conservation Area, Sabah, Malaysia, on 1 June 2008. (Photograph by: AJ Hearn & J Ross).

be closely associated with such habitats (e.g., Sunquist et al., 2004; Azlan & Sanderson, 2007; Gardner et al., 2014). It remains unclear, however, whether this reflects a habitat preference or merely collector and observer bias such as the preferential use of rivers for transportation in Borneo’s difficult terrain. Despite several incidental reports of the bay cat from swamp habitats, there has been no supporting evidence in the form of camera-trap images, perhaps reflecting a paucity of such surveys in these habitats, although long-term camera-trap surveys of the Sabangau peat-swamps did not detect this species (Cheyne & Macdonald, 2011). It was not recorded during camera-trap surveys of oil palm plantations in Sabah (Ross et al., 2010; Bernard et al., 2012; Yue et al. 2015; AJ Hearn & DW Macdonald, unpublished data), providing support for the earlier suggestion that the bay cat is forest dependent (Hearn et al., 2008).

No estimates of population density for the bay cat are available for any part of its range, but Brodie et al. (2015) estimated that its local abundance was lower in logged than in unlogged forest. The paucity of bay cat specimens collected during the nineteenth and twentieth centuries caused earlier authors to conclude that the species was naturally rare. Since the advent of intensive camera-trap surveys, especially in Malaysian Borneo, there has been a slow but steady rise in the number of bay cat records (Azlan et al., 2003; Azlan & Sanderson, 2007; Yasuda et al., 2007; Mohamed et al., 2009; Ross et al., 2010; Bernard et al., 2012; Brodie & Giordano, 2012a; Wearn et al., 2013; Gardner et al., 2014; Sastramidjaja et al., 2015; AJ Hearn, J Ross & DW Macdonald, unpublished data). Despite most of these surveys being targeted at cats, all have yielded very few bay cat records; photographic capture rates of the species are typically an order of magnitude below those of the sympatric Sunda clouded leopard *Neofelis diardi* (Cuvier), which is estimated to exist at low densities (1–4 individuals per 100 km²; Brodie & Giordano, 2012b; Wilting et al., 2012; Cheyne et al., 2013; AJ Hearn, J Ross and DW Macdonald, unpublished data; B. Loken et al., unpublished data). Such observations have led some authors to hypothesise that the bay cat is found at even lower densities (Azlan & Sanderson, 2007; Mohamed et al., 2009; Ross et al., 2010). Wearn et al. (2013) compared photo-capture rates of the bay

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cat from a number of studies in Borneo and showed that their own random deployment of camera-traps in a disturbed forest in Sabah resulted in a higher capture rate (0.12 photos/100 camera-trap-nights) than that derived from other studies preferentially setting camera-traps along trails, ridgelines, and logging roads (median bootstrap from 34 studies: < 0.01 photos/100 camera-trap-nights); the latter style is typical of camera-trap surveys. Wearn et al. (2013) suggested that the relative abundance of the bay cat may have hitherto been underestimated because of an underlying bias as a result of the use of non-random survey locations, coupled with this species's particular use of space. However, a survey of cats in the Danum Valley, Sabah, which deployed camera-traps according to a conventional (i.e., non-random) approach, reported a bay cat detection rate of 0.12 photos/100 camera-trap-nights (Ross et al., 2010) demonstrating that equally high rates can be obtained by non-random deployment. Whether the apparent elusiveness of the bay cat is a reflection of true rarity or of underlying factors that influence detection probability remains unclear, and warrants further study.

In the meantime, we recommend that a precautionary approach is taken when considering the status of this species. The bay cat's apparent forest dependency combined with past and predicted future loss of forest across Borneo, and the apparent demand from international animal dealers (Sunquist & Sunquist, 2002; Azlan & Sanderson, 2007) suggest strongly that the bay cat faces non-trivial threats. The bay cat is afforded protection status over most of Borneo. Collection and hunting are prohibited in Sarawak, Malaysia, under the Sarawak Wild Life Protection Ordinance (1998) and the species is protected in Kalimantan, Indonesia, under the Government of Republic of Indonesia Regulation No. 7 (1999). In Sabah, Malaysia, the Sabah Wildlife Conservation Enactment (1997) states that this species may only be hunted under license, though no such license has ever been issued. No protection, however, is currently afforded to this cat in Brunei Darussalam. The bay cat is listed on CITES Appendix II, to which all three range countries are parties, and thus sufficient legislation is in place theoretically to control international trade.

In this paper we use the MaxEnt niche distribution modelling approach to make predictions regarding the current distribution of this felid on Borneo (see Kramer-Schadt et al. (2016) for details).

RESULTS AND DISCUSSION

Species occurrence records. Of 71 occurrence records for the bay cat, stemming from all regions of Borneo apart from Brunei and South Kalimantan (Table 1; Fig. 2), 24 were excluded from the analysis because of low spatial precision (over 5 km; Categories 4 and 5). A disproportionately large number of records came from Sabah, and consequently only 22 records were used for the M_1 (Balanced) model; 40 records were used for the M_2 (Spatial Filtering) model.

Habitat associations. The 10 respondents to the questionnaire showed some variability in their assessment of suitable

land-cover for the bay cat, presumably reflecting the general paucity of information about the species, even among specialists (Table 2). All respondents agreed that both lowland and upland forests are important habitats for the bay cat, ranking these above all other land-cover types. Lower montane and swamp forests were considered to be poor habitat, possibly suitable as movement corridors, with forest mosaics (both lowland and upland) falling just short of this designation. All other non-forest habitats, and burnt forest areas, were considered unsuitable for the bay cat.

Habitat suitability index (HSI) model. This general conclusion on the land-cover suitability scores of the respondents is echoed by the predicted distribution offered by the Habitat Suitability Index model (Fig. 3), with the model prediction closely matching that of the current distribution of forest on Borneo. Extreme lowlands, supporting mangrove and swamp forest habitats, are notably absent from this species's predicted distribution, as are the considerable areas of Borneo now converted to oil palm plantations. Much of forested South Kalimantan is also predicted to be unsuitable. However, 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, reflecting 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. 3 A). Thus, unless there are records sufficiently spatially 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. 3 B).

Nevertheless, an extensive, contiguous area of interior Borneo, much of it hill forest, but also containing lowland and submontane forest, is predicted to be suitable for the bay cat, supporting Meijaard's (1997) hypothesis that it is widespread across the island. Our area of predicted suitability matches closely that of the IUCN Red List's range estimate for the bay cat (Hearn et al., 2008), although it includes areas outside the IUCN range. Notable differences from the IUCN range include the incorporation of much of Brunei, a northward extension in Sabah, and an eastward extension in parts of East Kalimantan, including a narrow region along the border with Central Kalimantan. Based on the current predicted distribution the following protected areas and regions are highlighted as priorities for bay cat conservation:

Brunei Darussalam. Despite an absence of bay cat records in Brunei Darussalam, much of the country remains under forest cover, and a large percentage of these forests are predicted as

Table 1. Summary of the occurrence records for bay cat *Catopuma badia* on Borneo.

Spatial Precision	Total No. of Records	No. of Records in M ₁	No. of Records in M ₂	No. of Recent Records 2001–2011
Category 1 below 500 m	24	5	20	24
Category 2 500 m – 2 km	4	2	3	2
Category 3 2–5 km	19	16	17	12
Category 4 above 5 km	19	-	-	4
Category 5 (no coordinates*)	5	-	-	0
Total	71	23	40	42

M₁ = Balanced Model; M₂ = Spatial Filtering Model (2 km); *only coarse location description was available

Table 2. Land-cover reclassification for bay cat *Catopuma badia* based on the questionnaire results of 10 respondents working on carnivores on Borneo

Land-cover Class	Mean of Reclassification	Range of Reclassifications
Lowland forest	3.60	3–4
Upland forest	3.00	0–4
Lower montane forest	2.00	1–3
Upper montane forest	0.86	0–1
Forest mosaics/lowland forest	1.60	*
Forest mosaics/upland forest	1.46	#
Swamp forest	1.86	1–4
Mangrove	1.29	0–3
Old plantations	0.71	0–3
Young plantations and crops	0.29	0–2
Burnt forest area	0.29	0–2
Mixed crops	0.14	0–1
Bare area	0.00	0–0
Water and fishponds	0.13	0–1
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).

of moderate to high suitability for the species. The absence of records reflects the general lack of survey effort in the Sultanate prior to the collection of records for this study. The upland forests of the Sungai Ingei Protection Forest and the Ulu Temburong National Park are both predicted to be highly suitable, the former being contiguous with Mulu National Park in Sarawak (see below), and are thus potentially key areas for the protection of this cat in Brunei.

Sarawak, Malaysia. Extensive, contiguous areas of Sarawak are predicted to be of either high or moderate suitability for the bay cat. Being both contiguous with protected areas in Brunei and predicted as being of optimal habitat suitability, the Mulu National Park is likely to be a key area for bay

cat protection in Sarawak. Similarly, the Lanjak–Entimau Wildlife Sanctuary and Batang Ai National Park, contiguous with Betung Kerihun National Park in West Kalimantan, are probably key bay cat areas in Sarawak. Although not contiguous with other protected areas, the Hose–Laga complex (comprising the proposed Hose Mountains National Park and the proposed Batu Laga Wildlife Sanctuary), although partly already inundated by the Bakun Hydropower Dam, might support an important bay cat population. Hon (2011) recorded the bay cat inside a reduced impact logging concession in Anap-Muput.

Sabah, Malaysia. Both the M₁ (balanced) and M₂ (spatially filtered) model approaches predict similar distributions of

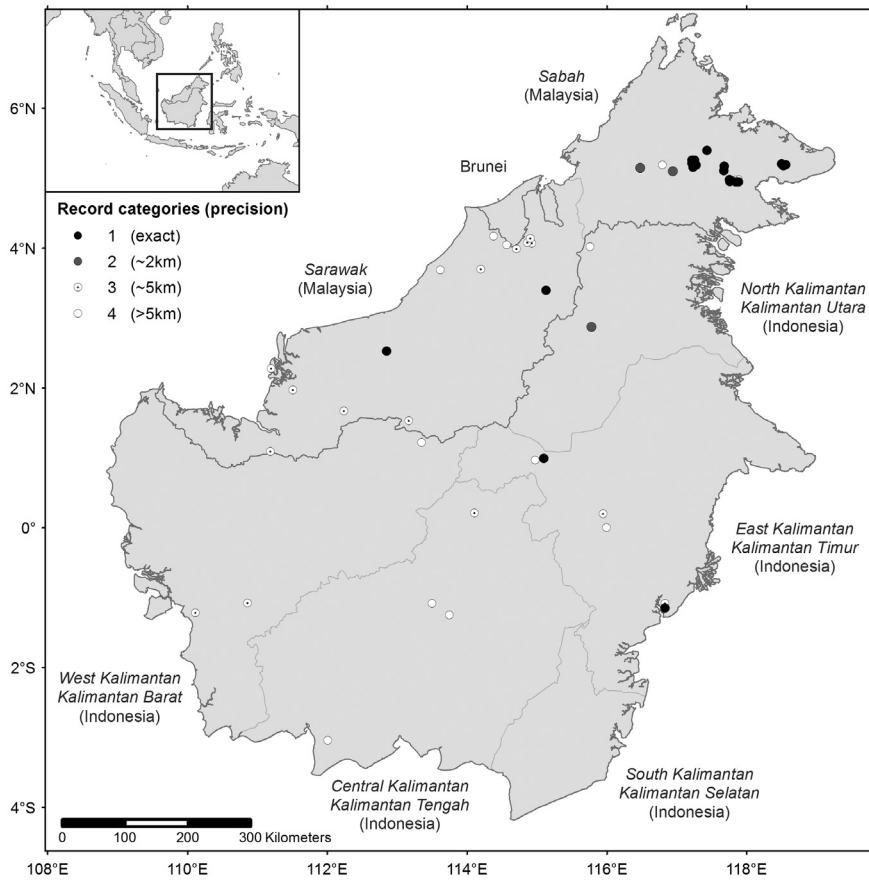


Fig. 2. Location of bay cat *Catopuma badia* occurrence records on Borneo, with categories of spatial precision as well as countries and state boundaries.

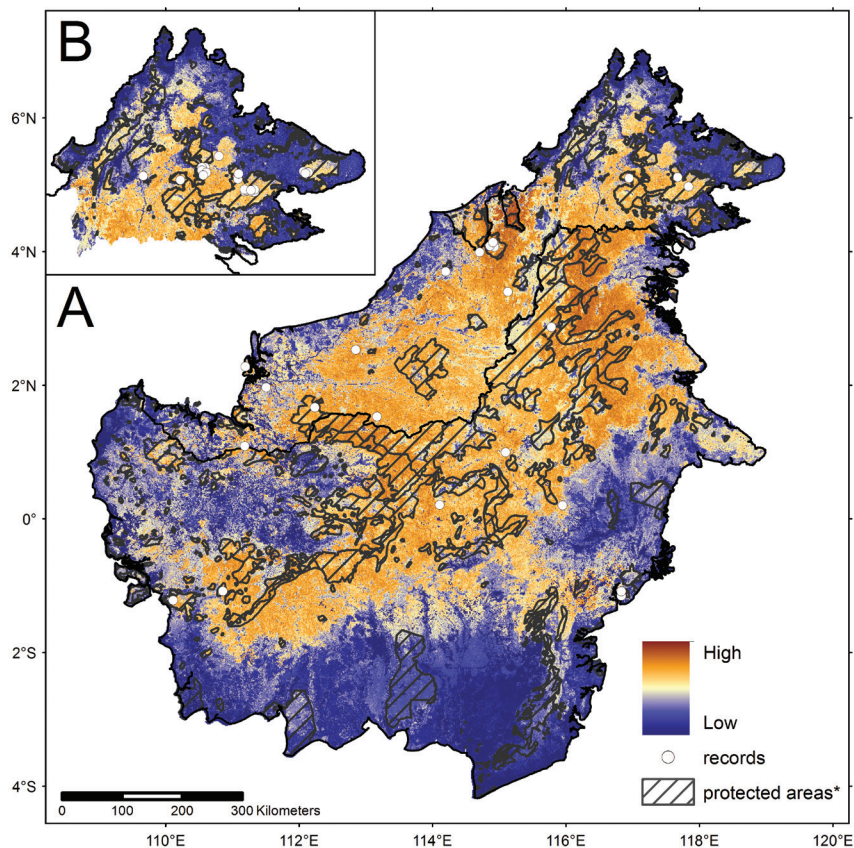


Fig. 3. Predictive Habitat Suitability Index (HSI) models for bay cat *Catopuma badia* including location records used in models. A, Balanced Model for the island of Borneo; B, Spatial Filtering Model for Sabah, Malaysia. Sources for protected area information: see Kramer-Schadt et al. (2016).

the bay cat across Sabah. Much of Sabah's commercial forest reserve system is predicted as of moderate to high suitability. The approximately 1 million ha Yayasan Sabah Forest Management Area (YSFMA; Reynolds et al., 2011), which contains the Danum Valley, Maliau Basin, and Imbak Canyon Conservation Areas, and the Ulu Segama–Malua Forest Reserve, all of which are predicted to be of high suitability, offers perhaps the best chance of long-term conservation for the bay cat in Sabah. Adjacent to the YSFMA, yet separated by the upper Sungai Kinabatangan, lies another contiguous area of high predicted suitability, including the Deramakot Forests Reserve, where the bay cat has been recorded (Mohamed et al., 2009; A Mohamed & A Wilting, unpublished data). The Tabin Wildlife Reserve, and to a lesser extent, the Tawau Hills Park and contiguous Ulu Kalumpang Protection Forest Reserve, are also predicted to be of suitable habitat for the bay cat. A recent survey has confirmed the presence of the bay cat in this protected area (AJ Hearn, J Ross & DW Macdonald, unpublished data). The value of these areas to long-term bay cat conservation, however, might be limited by their apparent isolation from adjacent bay cat populations. The Crocker Range Park, Sabah's largest land National Park, is predicted to be of low suitability for the bay cat, as supported by a faunal survey (Yasuma et al., 2003) and an intensive, cat-focused camera-trap survey in the park's southern portion (AJ Hearn, J Ross & DW Macdonald, unpublished data): neither detected this species.

North Kalimantan and East Kalimantan, Indonesia. A large, contiguous portion of North and East Kalimantan is predicted to be suitable habitat for the bay cat, particularly in the forested uplands which cover extensive portions of these provinces. Within these uplands, at 1,360,500 ha the Kayan Mentarang National Park (KMNP), the largest protected area on Borneo, is predicted to comprise largely suitable to highly suitable habitat. Lying to the east of KMNP the proposed Sungai Kayan National Park and the adjacent Malinau Basin region is predicted to have some of the most suitable habitat for the bay cat anywhere. As a whole, this substantial contiguous region is likely to play a vital role in connecting areas of predicted high suitability in Sabah, Sarawak, and elsewhere in Kalimantan, and as such, is arguably one of the most important areas for the conservation of the bay cat globally. Another area of high predicted suitability for bay cat in East Kalimantan are the Müller mountains, which might act as a natural corridor between the KMNP and Betung Kerihun National Park in West Kalimantan.

South Kalimantan, Indonesia. No bay cat records were traced from South Kalimantan and this province was predicted to contain habitat mostly unsuitable for this species. While this region of Borneo is relatively unusual in its bioclimatic nature, being more seasonally dry (see above) and might thus be largely unsuitable for the bay cat, the comparatively low survey effort in this region might have driven a biased prediction. Unlike elsewhere in South Kalimantan, the Meratus mountain chain, and in particular its northern stretches, which contain the Meratus Hulu Barabai Nature

Reserve, were predicted as containing moderately suitable habitat for the bay cat. The remaining forests along this chain, however, are heavily threatened by forest conversion, mining activities, hunting and encroachment.

Central Kalimantan, Indonesia. Much of southern Central Kalimantan, low-lying in nature, including the extensive peat and freshwater swamp, lowland and heath forests of the Sabangau and Tanjung Puting National Parks, were predicted to be unsuitable for the bay cat. Conversely, the forested areas of the Schwaner Range ranked quite highly and thus the protected areas of the Bukit Baka–Bukit Raya National Park, and, in particular, the sizeable Bukit Batikap I, II and III and Bukit Sepat Haung Nature Reserves are likely to be important areas for bay cat protection within this province.

West Kalimantan, Indonesia. In West Kalimantan, the north western extent of the Schwaner Range complex contains areas of predicted high suitability. Within this region, the Bukit Ronga and Bukit Perai Protection Forests form potentially important areas for the protection of the bay cat, although their isolated nature might somewhat reduce their value in this regard. Of perhaps the highest potential for bay cat conservation in West Kalimantan is the Bukit Batutenobang Protection Forest and Betung Kerihun National Park, which form one of the largest contiguous areas of forest that connect priority bay cat areas in Central Kalimantan with those in Sarawak.

CONCLUDING REMARKS AND CONSERVATION PRIORITIES

This research provides insight into the potential distribution of the bay cat, one of the world's least known wild cats, supports earlier hypotheses that the bay cat is found throughout much of Borneo, and suggests that considerable areas of forest are still potentially suitable habitat for this species. The predictive model is hampered by the apparent rarity and elusiveness of this cat, the uneven survey effort across the island, and consequent small number of records. Furthermore, the habitat suitability index used here is sensitive to the somewhat subjective assessments of habitat associations, particularly in cases where such knowledge may be uneven, as in the bay cat, and these assumptions can have a considerable influence on the end prediction. In addition, while the increasing use of camera-traps throughout Borneo is slowly yielding more detections of this elusive cat, a number of surveys in areas predicted to be of moderate to high suitability for the bay cat failed to detect it (e.g., Tangkulap Forest Reserve; Segaliud Lokan Forest Reserve: A Wilting et al., unpublished data; numerous surveys in Kalimantan: S Cheyne and DW Macdonald, unpublished data). The predicted distribution should therefore be viewed with appropriately weighted caution but provides a scientific basis upon which to test hypotheses about the distribution of the bay cat.

The paucity of location records for the bay cat highlights the consequent need for additional surveys. Borneo has witnessed a significant increase in the number of intensive camera-trapping surveys in recent years, with such studies

showing that the bay cat can indeed be detected, given an appropriate amount of survey effort; it is important that such surveys continue and survey approaches be optimised. Although the bay cat has been recorded in selectively logged areas, it remains unclear what degree of disturbance this species can tolerate and how such changes affect population density. It is important to determine if the bay cat can use oil palm and other monoculture plantations, which are becoming increasingly common in Borneo. More intensive surveys from very degraded, regenerating, and logged forests are needed. A priority should also be made to survey various key areas in Brunei and Kalimantan, particularly the province of South Kalimantan.

A relatively small number (71) of both historical and contemporary bay cat location records were collated for this study, serving to highlight the continued difficulty of detecting this species in the dense forests of Borneo, even with the advent of modern monitoring tools such as remote camera-traps. While the current study is unable to decipher whether this apparent elusiveness is a reflection of true rarity or a consequence of underlying factors that influence detection of bay cats, until further evidence becomes available it is prudent to presume that this cat is as rare as has long been suspected. This study suggests that an extensive, contiguous area of interior Borneo might be suitable for the bay cat, but the distributional model is unable to predict how its density varies across the landscape. Hunting and poaching of wildlife in Borneo is a widespread practice (e.g., Rabinowitz et al., 1987; Bennett et al., 2000; Bennett & Gumal, 2001; Wadley & Colfer, 2004; Meijaard et al., 2005b), and the extraction rates for many large species, the principal target of most hunts, is almost certainly unsustainable (Bennett et al., 2000). Smaller species, such as birds and squirrels, which are likely to form the prey base of the bay cat, are also targeted through the use of mist nets, catapults and blowpipes. Such hunting and/or poaching of bay cat prey, and, indeed, of bay cats themselves, for they are now known to be of considerable value to collectors (Azlan & Sanderson, 2007), is likely to vary greatly across this area and it is possible that many areas, although previously able to support this species, no longer hold it. Thus, the possible low population density and impacts of hunting, coupled together with this species's apparent close association with forest, mean that the bay cat is likely to need very large, contiguous forested areas to persist in the long term. If this is indeed the case it will become increasingly important to ensure that sufficiently large patches of forest remain connected. An understanding of the movement ecology of this wild cat, and in particular its ability to disperse through the increasingly modified landscape of contemporary Borneo, is thus essential.

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