Bornean clouded leopard minimum home range analysis in a peat-swamp forest, Indonesian Borneo

Lynn Pallemaerts[1,*], Adul[2], Ici P. Kulu[3], Karen A. Jeffers[2], David W. Macdonald[4], Susan M. Cheyne[2,5]

[1]Biodiversity Unit, Department of Biology, Lund University, Lund, Sweden; lynn.pallemaerts@gmail.com
[2] Borneo Nature Foundation, Palangka Raya, Indonesia
[3]UPT LLG-CIMTROP, University of Palangka Raya, Palangka Raya, Indonesia
[4]Wildlife Conservation Research Unit (WildCRU), Department of Zoology, University of Oxford, The Recanati-Kaplan Centre, Tubney House, Tubney, OX13 5QL, United Kingdom
[5]Faculty of Humanities, Oxford Brookes University, Oxford, United Kingdom
[*]Current addresses:
Department of Recent Vertebrates, Royal Belgian Institute of Natural Sciences (RBINS), Rue Vautier 29, 1000 Brussels, Belgium
Wildlife Conservation Research Unit (WildCRU), Department of Zoology, University of Oxford, The Recanati-Kaplan Centre, Tubney House, Tubney, OX13 5QL, United Kingdom

Type of article. Original contribution.

Abstract. Little is known about the spatial ecology of the Bornean clouded leopard *Neofelis diardi borneensis* in peat-swamp forests, which account for 32% of the island of Borneo. This study uses data from 10 years of camera trapping to provide preliminary estimates of minimum home range size and overlap in a tropical peat swamp forest in Central Kalimantan, Indonesian Borneo. Home ranges were estimated using minimum convex polygons (MCPs) and fixed kernel utilization densities (KUDs). Since May 2008, we identified a minimum of 12 individual Bornean clouded leopards ($n_{male} = 9$, $n_{female} = 1$, $n_{unknown} = 2$) from a total of 157 independent photo-captures. Estimates of minimum home range could only be calculated for six males that had been recaptured at a minimum of five different camera stations. For these males, the obtained averages of $MCP_{50\%} = 0.7$ km^2, $MCP_{95\%} = 2.2$ km^2, $MCP_{100\%} = 6.2$ km^2, $KUD_{50\%} = 7.7$ km^2, and $KUD_{95\%} = 35.3$ km^2. All home ranges overlapped significantly. Spatial organisation is valuable information not only in understanding the species' behavioural ecology, but also to inform extrapolations to viable Bornean clouded leopard

population size. The use of camera trap data to estimate home range size merits further investigation.

Introduction

Globally, large carnivores are under threat from anthropogenic disturbances. Most species are categorized as threatened by the IUCN, with declining populations and a high risk of local or total extinction (Ripple et al. 2014). The consequence of the decline of large carnivore numbers is a serious concern for conservation, as these carnivores are apex predators and regulate and stabilize the ecosystems they inhabit (Ripple et al. 2014).

In the rainforests of Borneo, the situation is no different. The local apex predator, the Bornean clouded leopard *Neofelis diardi borneensis* (15-25 kg; Hearn et al. 2017) is the largest of a guild of 5 wild cats (Adul et al. 2015; Cheyne & Macdonald 2011) and is listed as Endangered by the IUCN (Hearn et al. 2008). Despite its role as an apex predator within Borneo's ecosystems, until recently the ecology of the Bornean clouded leopard has been scant (Cheyne et al. 2013, 2016; Hearn et al. 2016; Macdonald et al. 2018), even more so in peat-swamp forests, which cover about 32% of the island (Gaveau et al. 2014; Gaveau et al. 2016). Because they are rare and elusive, studying Bornean clouded leopards remains a challenge, and a lot of information on their basic ecology is lacking. For instance, the only studies on spatial ecology for Bornean clouded leopards come from non-peat forests in Sabah (Hearn et al. 2013, 2018). The need to close the gap within the knowledge on Bornean clouded leopard spatial ecology is pressing because of its Endangered status.

Spatial organisation is a key component of a species' ecology and it is crucial information to extrapolate from single individuals in their home ranges to viable population sizes in broader landscapes. Efficient conservation of populations of threatened species, such as the Bornean clouded leopard, starts with a basic understanding of home range size and potential overlap (Johansson et al. 2016), as it defines how many individuals can make up a viable population, and how large a population can be sustained within and outside protected areas.

In an attempt to remedy gaps in the information on this apex predator, we used camera traps to investigate some basic aspects of spatial ecology of Bornean clouded leopards. Using a 10-

year database, our objectives were to (1) generate estimates of minimum home range size, and (2) examine territoriality by determining intrasexual overlap of minimum home ranges.

Methods

The study was conducted in the 550 km^2 Natural Laboratory for Peat Swamp Forest (NLPSF), within the tropical peat swamp forest of Sebangau (Central Kalimantan, Indonesia; Fig. 1). The NLPSF is located at the north-eastern edge of the Sebangau catchment (approx. 5,600 km^2). Sebangau is seasonally flooded, being underwater for nine months out of twelve, and is one of the deepest peat swamp forests in the world, with peat depth varying between 3 and 26 meters (Page et al. 1999). The forest has a history of logging concessions, illegal logging, and wildfires (Cheyne 2010; Cheyne & Macdonald 2011), but has been protected as a national park since 2004.

We conducted an extensive and continuous camera trap survey from May 2008 until February 2018 within the NLPSF. In May 2008, the plan was to place the cameras in a systematic grid in the study area, which was achieved in the forest immediately surrounding base camp (see Fig. 1). However, due to the difficulty of the terrain, such a grid was not practical in the areas further away from base camp, and so, over the years, short expeditions were undertaken to set up several camera stations in areas of interest within the NLPSF (see Fig. 1). As a result of this method, 94 different locations were sampled over the 10-year period. Most locations were sampled for short periods of time during within this 10-year period (i.e. for a minimum of two or three months, but up to one or two years), while other locations have been sampled almost continuously since 2008, with an average sampling duration of approximately 21 months for a single location. Over the years, the cameras covered an area of 104.8 km^2 of the NLPSF (as determined by the polygon formed by the outermost locations), thereby sampling 19.1% of the NLPSF. On average, the cameras were placed at a distance of 2.7 ± 0.6 km of one another.

We used different types of cameras over the years: (1) Cuddeback Expert (Wisconsin, USA), (2) Cuddeback IR (Wisconsin, USA), (3) Cuddeback Ambush IR (Wisconsin, USA), (4) Maginon WK 3 HD (Germany), (5) Crenova RD100 (United Kingdom), and (6) Bushnell NatureView HD (Missouri, USA). Where possible, we placed the camera stations along transects, animal trails, boardwalks, natural bridges, or watering holes. We placed each camera about 50 cm from the ground and was protected from potential damage by sun bears *Helarctos malayanus*, pig-tailed macaques *Macaca nemestrina*, and rainfall by a plastic box. When enough cameras were available, they were set up in pairs, at a distance of 7 to 10 meters from each other, to allow for simultaneous photography of both sides of the Bornean clouded leopards.

We identified individual Bornean clouded leopards from multiple photographs, based on their unique coat patterns on both sides of their body (cf. Karanth & Nichols 1998) and determined sex based on the presence or absence of secondary sexual traits. All photos were saved in a database, so an individual's ID could be double-checked by several observers if necessary. We defined independent photo-captures using two criteria: (1) the same individual was captured at different locations across the camera grid at any given day and time, and (2) the same individual was captured at the same location at least at 10 minutes' interval. The first criterion allowed for all used locations to be represented in the minimum home range analysis, while the time interval of the second criterion was chosen to allow locations which are used for longer periods of time (e.g. resting site, kill site, den site) to be represented in the future analyses.

We checked the independent photo-captures for spatial autocorrelation using Moran's Index I (Sokal & Oden 1978) in ArcMap 10.3 (ESRI 2014). Weights for pairs of neighboring stations were computed using the inverse distance between the respective camera stations.

We used two different estimators to analyze the Bornean clouded leopard data for minimum home ranges: minimum convex polygon (MCP; Mohr 1947) and fixed kernel utilization density (KUD; Worton 1989). These were calculated with the package "*adehabitatHR*" (Calenge 2006) for R (R Core Team 2017). We calculated the MCPs for the 50%, 95%, and 100% percentiles, while the KUDs were calculated using h_{ref} and at the 50% and 95% percentiles. Both methods require a minimum of 5 unique capture locations across the camera trap grid for an estimator to be computed.

We calculated the overlap in minimum home ranges in two different ways: (1) overlap percentages between 50% and 100% MCPs (i.e. *HR*; see Fieberg & Kochanny 2005), and (2) overlap probabilities between 50% and 95% KUDs (i.e. *PHR*; see Fieberg & Kochanny 2005). We did this only for the individuals for which minimum home ranges could be estimated from our data, and only for dyads of Bornean clouded leopards that were present in the study area at the same time (i.e. during at least one and the same year of camera trapping) over the entire study period. The HR percentages for overlapping minimum home ranges were calculated in ArcMap 10.3 (ESRI 2014), while the PHR probabilities for overlapping minimum home ranges were calculated with the package "*adehabitatHR*" (Calenge 2006) in R (R Core Team 2017).

Results

Across the entire camera grid, we documented 157 independent captures of Bornean clouded leopards over more than 55075 trap nights. Eight of these photo-captures could not be attributed to any known Bornean clouded leopard. From the other 149 independent photo-captures, we were able to identify 12 individuals based on their unique coat patterns. Nine were male, one was female, and two have not yet been sexed (Table 1). The number of independent photo-captures for individual Bornean clouded leopards ranged from 1 to 32 (Table 1), with a mean number of detections per individual at 12.4 (SE 3.4).

Camera trap captures were spatially independent at all the stations, with Moran's Index over the entire survey period (2008-2018) being non-significant ($I = 0.043$, $p = 0.87$). Minimum home ranges could be calculated for 6 males which had been captured at minimum 5 unique stations across the study grid (Table 1). For the 6 individuals, the 50% MCP averaged 0.7 km^2 (SE 0.3 km^2), the 95% MCP averaged 2.2 km^2 (SE 0.6 km^2), and the 100% MCP averaged 6.2 km^2 (SE 2.1 km^2; Table 2). For the KUDs, the 50% isopleth spanned 7.7 km^2 (SE 1.7 km^2), and the 95% isopleth spanned 35.3 km^2 (SE 7.7 km^2), on average (Table 2).

Overlap in minimum home ranges was calculated for the 6 males for whom a minimum home range could be calculated. These formed 11 contemporaneous dyads of Bornean clouded leopards. Overlap percentages (HR) for the 50% MCPs ranged from 0% to 59.9%, with a mean at 29.9% (SE 8.4%). For the 100% MCPs, the HR values ranged from 42.5% to 82.7%, with a mean at 61.5% (SE 4.0%). Overlap probabilities (PHR) for the 50% KUD isopleths ranged from 0.25 to 0.51, with a mean at 0.43 (SE 0.02). For the 95% KUD isopleths, the PHR values ranged from 0.74 to 0.94, with a mean at 0.87 (SE 0.02).

Discussion

Our results for minimum home range sizes for our 6 male Bornean clouded leopards varied between the two types of estimators (Table 2). Our mean 50%, 95%, and 100% MCP values are drastically smaller than the MCP results from one female Bornean clouded leopard in Sabah, Malaysian Borneo, obtained through VHF telemetry (Table 3; Hearn et al. 2013). Male felids tend to hold larger home ranges than females (Sandell 1989), yet our mean MCP estimates (for 6 males) are significantly smaller than the estimates for one single female (Hearn et al. 2013). Also, Hearn et al. (2013) cautioned that their estimates are probably an underestimation of the true home range size, since their results are based on only 3-4 months of radio tracking before loss of signal. Mohamed et al. (2009) report a 100% MCP of 45 km^2 for one male in Sabah, based on camera trapping, which is also thought to be an underestimate. We therefore agree with previous studies that estimating home ranges with MCPs from camera trap data is not feasible (Soisalo & Cavalcanti 2006; Gil-Sánchez et al. 2011).

The same cannot be said for our KUD estimates. Our mean and 95% isopleth for 6 male Bornean clouded leopards is of the same magnitude as the 100% MCP reported by Mohamed et al. (2009), as well as larger than the value calculated for the single female in Malaysian Borneo (Table 3). Again, however, the latter is thought to be an underestimate (Hearn et al. 2013), so actual female home range size for Bornean clouded leopards could be closer to our male estimates. We cannot make any statements for female minimum home range sizes for Bornean clouded leopards in our study area, since we have no data on them.

Although we advise treating our MCP and KUD results with caution, we can state that there are no exclusive home ranges for male Bornean clouded leopards in our study area, based on the high levels of contemporaneous overlap between the MCPs and KUDs. This manifested itself from the very beginning of the survey, with several males being caught at the same camera station, a pattern that seems to be common among clouded leopard populations across Borneo (J. Brodie, pers. comm.; A.J. Hearn, pers. comm.; A. Mohamed, pers. comm.). Despite the non-territorial organization of Bornean clouded leopards in the peat-swamp forest of Sebangau, we still record instances of intraspecific communication, which could have a territorial function, on the camera traps. We have records of Bornean clouded leopards spraying urine, rubbing their cheeks against cameras, and possibly scratching trees – all of which have been identified as territorial behavior for Bornean clouded leopards (Allen et al. 2016).

Such a home range overlap in an otherwise solitary species has been noted in some other carnivores (e.g. Wagner et al. 2008, Harmsen et al. 2009, Núñez-Pérez 2011), with the most striking example coming from Costa Rica. Jaguars *Panthera onca* in Tortuguero National Park are known to share home ranges and kills during green turtle *Chelonia mydas* nesting season, since this localised abundance of prey allows for a more flexible spatial organisation (Guilder et al. 2015). For the Costa Rican jaguars, as perhaps the Bornean clouded leopards, high resource availability would allow solitary species to share space to a higher degree than would otherwise be expected. For the NLPSF, one could argue that the location of the study area in comparison to the larger Sebangau catchment (i.e. on the northeastern border) could lead to an accumulation of prey individuals in the study area, due to the hard border formed by the Sebangau river to the north.

Data are still lacking on the level of overlapping home ranges of females and the maximum home range size for males and females. The ranging and movement data, are key when determining overall viable habitat size as well as informing landscape connectivity plans (Macdonald et al. 2018). These are all necessary for conserving Borneo's Endangered apex predator in a rapidly decreasing habitat (Hearn et al. 2008).

Acknowledgements

The authors' sincerest thanks go to the Centre for International Cooperation in Sustainable Management of Tropical Peatland (CIMTROP), to the University of Palangka Raya (UPR), and the Borneo Nature Foundation (BNF). The authors also wish to thank RISTEKDIKTI for supporting the research of KAJ (Surat Izin Penelitian 360/SIP/DIT.KI/IX/2015, 47/EXT/SIP/FRP/E5/Dit.KI/2016 and 55/EXT/SIP/FRP/E5/Dit.KI/IX/2017), who provided data for this paper. LP also wishes to thank Ola Olsson and Yann Clough from the Department of Biology at Lund University for their thoughts on this project. The Robertson Foundation provided funding for the majority of the survey work presented here. Additional funding for different stages of this work was kindly provided by Panthera, Borneo Nature Foundation, The Clouded Leopard Project/Point Defiance Zoo and Aquarium and Fresno Chafee Zoo.

References

Adul, Ripoll B., Limin S. H. & Cheyne S. M. 2015. Felids of Sebangau: Camera trapping to estimate activity patterns and population abundance in Central Kalimantan, Indonesia. Biodiversitas, Journal of Biological Diversity 16, 151-155.

Allen M. L., Wittmer H. U., Setiawan E., Jaffe S. & Marshall A. J. 2016. Scent marking in Sunda clouded leopards (*Neofelis diardi*): Novel observations close a key gap in understanding felid communication behaviours. Scientific Reports 6, 1-9.

Calenge C. 2006. The package "adehabitat" for the R software: A tool for the analysis of space and habitat use by animals. Ecological Modelling 197, 516-519.

Cheyne S. M. 2010. Behavioural ecology of gibbons (*Hylobates albibarbis*) in a degraded peat-swamp forest. *In* Indonesian Primates. Gursky S. & Supriatna J. (Eds.). Springer, New York, NY, USA, pp. 121-156.

Cheyne S. M. & Macdonald D. W. 2011. Wild felid diversity and activity patterns in Sabangau peat-swamp forest, Indonesian Borneo. Oryx 45, 119-124.

Cheyne S. M., Sastramidjaja W. J., Rayadin Y. & Macdonald D. W. 2016. Mammalian communities as indicators of disturbance across Indonesian Borneo. Global ecology and conservation 7, 157-173.

Cheyne S. M., Stark D. J., Limin S. H. & Macdonald D. W. 2013. First estimates of population ecology and threats to Sunda clouded leopards *Neofelis diardi* in a peat-swamp forest, Indonesia. Endangered Species Research 22, 1-9.

ESRI. 2014. ArcGIS version 10.3. Redlands, California, USA. http://www.esri.com/software/arcgis.

Fieberg J. & Kochanny C. O. 2005. Quantifying home-range overlap: The importance of the utilization distribution. Journal of Wildlife Management 69, 1346-1359.

Gaveau D. L. A., Sheil D., Husnayaen**,** Salim M. A., Arjasakusuma S., Ancrenaz M., Pacheco P. & Meijaard E. 2016. Rapid conversions and avoided deforestation: examining four decades of industrial plantation expansion in Borneo. Scientific reports, 1-13. doi:10.1038/srep32017.

Gaveau D. L. A., Sloan S., Molidena E., Yaen H., Sheil D., Abram N. K., Ancrenaz M., Nasi R., Quinones M., Wielaard N. & Meijaard E. 2014. Four decades of forest persistence, clearance and logging on Borneo. PLoS One, 1-11. doi:10.1371/journal.pone.0101654.

Gil-Sánchez J., Moral M., Bueno J., Rodríguez-Siles J., Lillo S., Pérez J., Martín J., Valenzuela G., Garrote G., Torralba B. & Simón-Mata M. 2011. The use of camera trapping for estimating Iberian lynx (*Lynx pardinus*) home ranges. European Journal of Wildlife Research 57, 1203-1211.

Guilder J., Barca B., Arroyo-Arce S., Gramajo R. & Salom-Pérez R. 2015. Jaguars (*Panthera onca*) increase kill utilization rates and share prey in response to seasonal fluctuations in nesting green turtle (*Chelonia mydas mydas*) abundance in Tortuguero National Park, Costa Rica. Mammalian Biology 80, 65-72.

Harmsen B. J., Foster R. J., Silver S. C., Ostro L. E. T. & Doncaster C. P. 2009. Spatial and temporal interactions of sympatric jaguars (*Panthera onca*) and pumas (*Puma concolor*) in a neotropical forest. Journal of Mammalogy 90**,** 612-620.

Hearn A. J., Cushman S. A., Goossens B., Macdonald E. A., Ross J., Hunter L. T. B., Abram N. K. & Macdonald D.W. 2018. Evaluating scenarios of landscape change for Sunda clouded leopard connectivity in a human dominated landscape. Biological Conservation 222, 232-240.

Hearn A. J., Ross J., Bernard H., Bakar A. S., Goossens B., Hunter L. T. B. & Macdonald D. W. 2017. Responses of Sunda clouded leopard *Neofelis diardi* population density to anthropogenic disturbance: refining estimates of its conservation status in Sabah. Oryx, 1-11. doi: 10.1017/S0030605317001065.

Hearn A. J., Ross J., Macdonald D. W., Bolongon G., Cheyne S. M., Mohamed A., Samejima J., Brodie J. F., Giordano A., Alfred R. Boonratana R., Bernard H., Loken B., Augeri D. M., Heydon M., Hon J., Mathai J., Marshall A. J., Pilgrim J. D., Hall J., Breitenmoser-Würsten C., Kramer-Schadt S. & Wilting A. 2016. Predicted distribution of the Sunda clouded leopard *Neofelis diardi* (Mammalia: Carnivora: Felidae) on Borneo. Raffles Bulletin of Zoology 33, 149-156.

Hearn A. J., Ross J., Pamin D., Bernard H., Hunter L. & Macdonald D. W. 2013. Insights into the spatial and temporal ecology of the Sunda clouded leopard *Neofelis diardi*. Raffles Bulletin of Zoology 61, 871-875.

Hearn A. J., Sanderson J., Ross J., Wilting A. & Sunarto S. 2008. *Neofelis diardi ssp. borneensis. The IUCN Red List of Threatened Species 2008*: e.T136945A4351615. http://dx.doi.org/10.2305/IUCN.UK.2008.RLTS.T136945A4351615.en.

Johansson Ö., Rauset G. R., Samelius G., McCarthy T., Andrén H., Tumursukh L. & Mishra C. 2016. Land sharing is essential for snow leopard conservation. Biological Conservation 203, 1-7.

Karanth K. U. & Nichols J. D. 1998. Estimation of tiger densities in India using photographic captures and recaptures. Ecology 79, 2852-2862.

Macdonald D. W., Bothwell H. M., Hearn A. J., Cheyne S. M., Haidir I., Hunter L. T. B., Kaszta Ż, Linkie M., Macdonald E. A., Ross J. & Cushman S. A. 2018. Multi-scale habitat selection modeling identifies threats and conservation opportunities for the Sunda clouded leopard (*Neofelis diardi*). Biological Conservation 227, 92-103.

Mohamed A., Samejima H. & Wilting A. 2009. Records of five Bornean cat species from Deramakot Forest Reserve in Sabah, Malaysia. CATnews 51, 12-15.

Mohr C. O. 1947. Table of equivalent populations of North American small mammals. The American Midland Naturalist 37, 223-249.

Núñez-Pérez R. 2011. Estimating jaguar population density using camera-traps: a comparison with radio-telemetry estimates. Journal of Zoology 285**,** 39-45.

Page S. E., Rieley J. O., Shotyk Ø. W. & Weiss D. 1999. Interdependence of peat and vegetation in a tropical peat swamp forest. Philosophical Transactions of the Royal Society of London. Series B: Biological Sciences 354, 1885-1897.

R Core Team. 2017. R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. https://www.R-project.org/.

Ripple W. J., Estes J. A., Beschta R. L., Wilmers C. C., Ritchie E. G., Hebblewhite M., Berger J., Elmhagen B., Letnic M., Nelson M. P., Schmitz O. J., Smith D. W., Wallach A. D. & Wirsing A. J. 2014. Status and ecological effects of the world's largest carnivores. Science, 1-11. doi:10.1126/science.1241484.

Sandell M. 1989. The mating tactics and spacing patterns of solitary carnivores. *In* Carnivore Behaviour, ecology, and evolution. Gittleman J. L. (Ed.). Cornell University Press, Ithaca, NY, USA, pp. 164-182.

Soisalo M. K. & Cavalcanti S. M. C. 2006. Estimating the density of a jaguar population in the Brazilian Pantanal using camera-traps and capture–recapture sampling in combination with GPS radio-telemetry. Biological Conservation 129, 487-496.

Sokal R. R. & Oden N. L. 1978. Spatial autocorrelation in biology 1. methodology. Biological Journal of the Linnean Society 10, 199-228.

Wagner A. P., Frank L. G. & Creel S. 2008. Spatial grouping in behaviourally solitary striped hyaenas, *Hyaena hyaena*. Animal Behaviour 75**, :**1131-1142.

Worton B. J. 1989. Kernel methods for estimating the utilization distribution in home-range studies. Ecology 70, 164-168.

Figures and tables

Fig. 1. Location of the camera traps in the Natural Laboratory of Peat Swamp Forest (NLPSF) within the Sebangau catchment in Central Kalimantan, Indonesian Borneo.

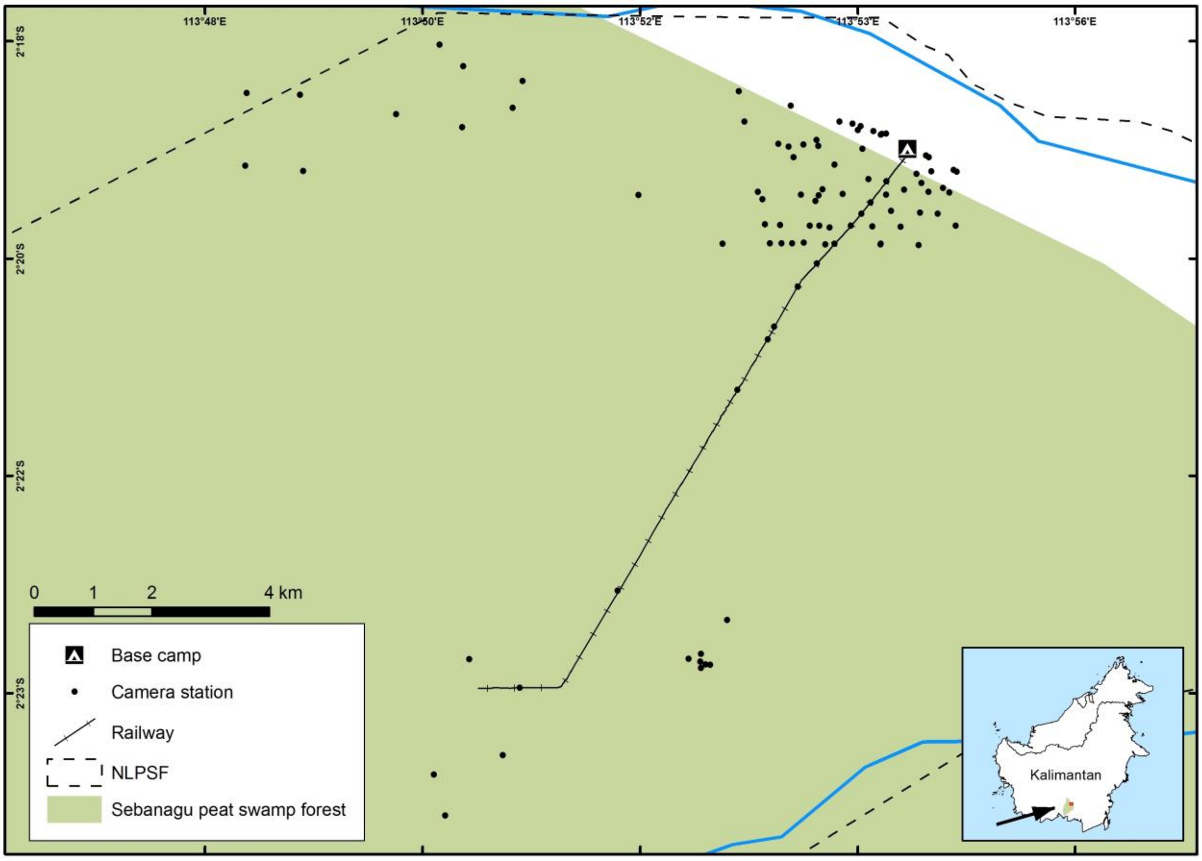

Fig. 2. Fixed kernels (50% and 95%) as an estimation of minimum home ranges for 6 male Bornean clouded leopards in the NLPSF. A) M1, B) M2, C) M3, D) M4, E) M5, F) M8.

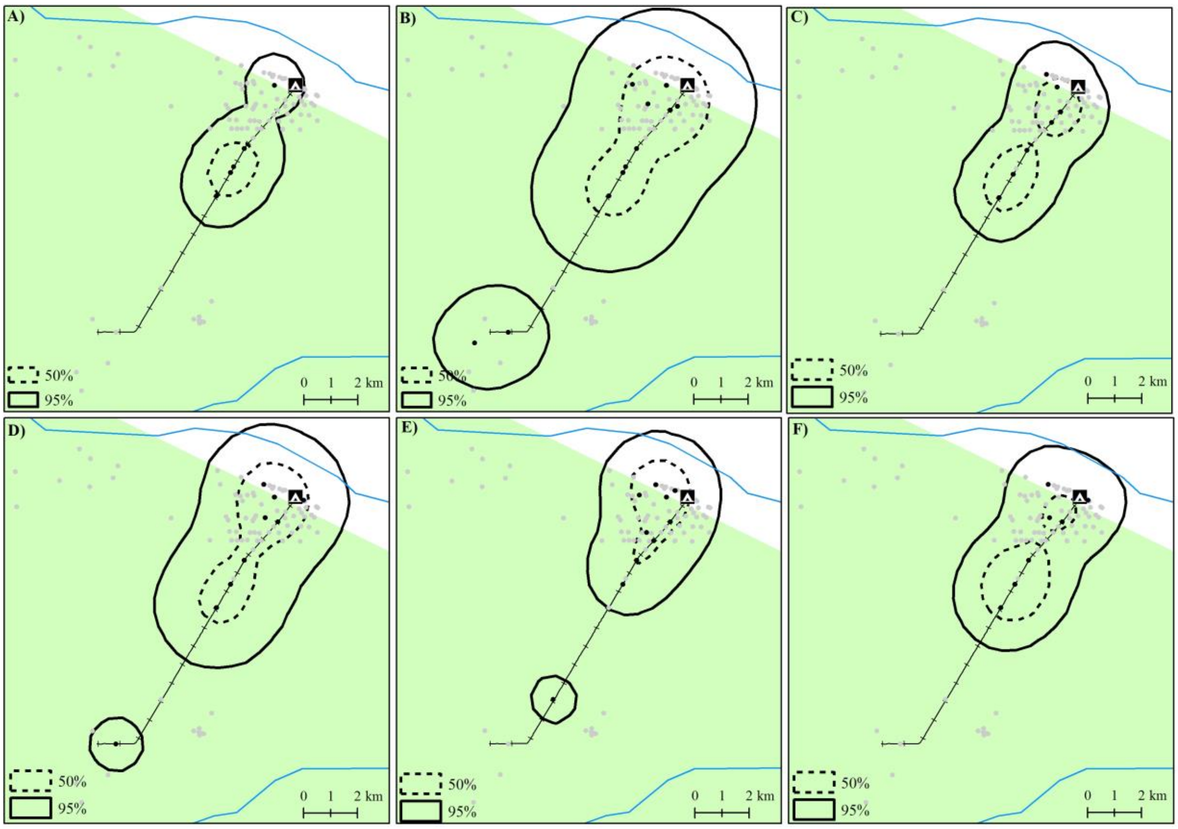

Table 1. Summary of Bornean clouded leopard detections within the NLPSF, from May 2008 until February 2018. (1) A = Adult. (2) To be considered as an independent capture, the photos had to be taken on the same day at different locations, or at the same location after a period of 10 minutes between the first and last detection at that location.

ID	Sex	Age [(1)]	No. of independent captures[(2)]	No. of independent stations	No. of redetection stations	First detection	Last detection
M1	M	A	9	5	1	Jul. 2008	Jul. 2011
M2	M	A	29	11	5	Aug. 2008	Dec. 2011
M3	M	A	20	7	5	Nov. 2009	Oct. 2015
M4	M	A	32	9	7	Nov. 2009	Aug. 2015
M5	M	A	29	10	6	Oct. 2013	Jan. 2018
M6	M	A	3	3	0	Feb. 2014	Feb. 2014
M7	M	A	5	2	1	Dec. 2013	Mar. 2014
M8	M	A	11	7	1	Nov. 2014	Nov. 2016
M9	M	A	3	3	0	Oct. 2016	Dec. 2017
F1	F	A	2	2	0	Oct. 2009	Oct. 2009
ID1	?	A	1	1	0	Oct. 2014	Oct. 2014
ID2	?	A	5	4	1	Dec. 2013	Sep. 2014

Table 2. Home range estimators for 6 male Bornean clouded leopards within the NLPSF.

			Home range estimators (km^2)				
ID	Sex	Age	Minimum convex polygon			Fixed kernel	
			50%	95%	100%	50%	95%
M1	M	A	0.008	0.02	0.3	2.7	16.3
M2	M	A	1.6	4.3	14.7	14.3	68.7
M3	M	A	0.2	1.3	2.5	6.3	24.8
M4	M	A	1.0	2.5	8.7	10.6	45.1
M5	M	A	1.5	2.4	6.8	5.5	26.9
M8	M	A	0	2.4	3.9	6.9	30.2

Abbreviations: A = adult.

Table 3. Comparison of home range estimates for Bornean clouded leopards.

Location	Method	Duration	Sex	Age	Home range estimators (km^2): Minimum convex polygon 100%	Minimum convex polygon 95%	Minimum convex polygon 50%	Fixed kernel 95%	Fixed kernel 50%	Reference
Central Kalimantan	CT	10 years	M	A	6.8	2.4	1.2	26.9	5.6	This study
			M	A	0.3	0.02	0.008	16.3	2.7	
			M	A	2.5	1.3	0.2	24.8	6.3	
			M	A	3.9	2.4	0	30.2	6.9	
			M	A	8.7	2.5	1	45.1	10.6	
			M	A	14.7	4.3	1.6	68.7	14.3	
Sabah	CT	7 months	M	A	45	-	-	-	-	Mohamed et al. 2009
Sabah	VHF	109 days	F	SA	29.9	22.6	5.2	16.1	5.4	Hearn et al. 2013

Abbreviations: CT = camera trapping, VHF = very high frequency; A = adult, SA = sub-adult.