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Preliminary assessment of abundance and distribution of Dholes *Cuon alpinus* in Rimbang Baling and Tesso Nilo landscapes, Sumatra

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Abstract. Dholes (*Cuon alpinus*) are categorised by IUCN as Endangered since 2004. Their global range is believed to have rapidly shrunk and their current distribution on Sumatra Island is greatly reduced. Despite the situation, dholes have received much less conservation attention than other charismatic carnivores. As a consequence, knowledge on their basic ecology is poorly documented. Using camera trap results from tiger and prey studies, we aimed to describe the activity pattern, abundance, and distribution of dholes in the lowland and hilly forests of Rimbang Baling and Tesso Nilo landscapes. Six sampling blocks within four major protected areas in southern Riau Province were sampled from 2012 to 2015, covering a total area of 935 km^2 with a total effort of 14,013 effective trap nights across 148 camera stations. We obtained 275 images of dholes with 37 independent pictures or 0.26 independent pictures of dholes per 100 trap nights. This study confirmed that Tesso Nilo, Rimbang Baling, Bukit Bungkuk, and Bukit Betabuh are occupied by dholes. Bukit Bungkuk had a relatively high trapping success rate (0.44 independent pictures per 100 trap nights), followed by northeastern and northwestern parts of Rimbang Baling (0.40 and 0.30, respectively). Dholes were recorded mostly active during the day, and in times between night and dusk or dawn. The Maximum Entropy model showed that distribution of dholes was mainly determined by land cover (percent contribution of 83.3%), followed by road (8.7%), river (6.5%), and elevation (1.5%). Information from this study, including the distribution model, can be used to update the management strategy and actions on the ground, in protecting and restoring forests to conserve this species in Sumatra.

Key words. canid conservation, connectivity, habitat determinants, MaxEnt, spatial analysis

INTRODUCTION

Dholes, *Cuon alpinus*, are an endangered animal and the only remaining member of the *Cuon* genus in the world. Information pertaining to this taxon is very limited, especially in Sumatra (Kamler et al., 2015). Based on their basic ecological characteristics and considering the high rate of deforestation and poaching of potential prey in Sumatra, their populations are believed to be seriously threatened (Uryu et al., 2010; Margono et al., 2012, Risdianto et al., 2016). Although very limited documentation is available, it is likely that they also suffer from interspecific competition, persecution due to livestock predation, and disease transmission from domestic dogs (Iyengar et al., 2005, Uryu et al., 2010; Jenks et al., 2012b; Margono et al., 2012, Kamler et al., 2015, Sunarto et al., 2015). Basic and robust ecological information such as population, distribution, and habitat use are crucial as the basis of dhole conservation to ensure their survival in the wild (Pearce & Boyce, 2005; Jenks et al., 2015). This study aims to fill our knowledge gaps and provide information on the dhole's basic ecology in Sumatra. We produced information on the abundance, activity patterns, and distribution of dholes by analysing data from systematic deployment of camera traps, set mainly to study tigers and their prey in the Rimbang Baling and Tesso Nilo landscapes. It covers Bukit Rimbang Bukit Baling Wildlife Reserve, Bukit Bungkuk Nature Reserve, Bukit Betabuh Protection Forest, and Tesso Nilo National Park. Information from this study may serve as a baseline of dholes in the region and support the conservation of this species in Sumatra and globally.

MATERIAL AND METHODS

Study sites. This study was conducted from 2012 to 2015, in six sampling blocks within four major protected areas in southern Riau Province, namely: Bukit Rimbang Bukit Baling Wildlife Reserve (BRBB WR), Tesso Nilo National Park (TNNP), Bukit Bungkuk Nature Reserve (BBNR), and Bukit Betabuh Protection Forest (BBPP) (Fig. 1). The biggest of these, and where sampling efforts were mainly allocated,

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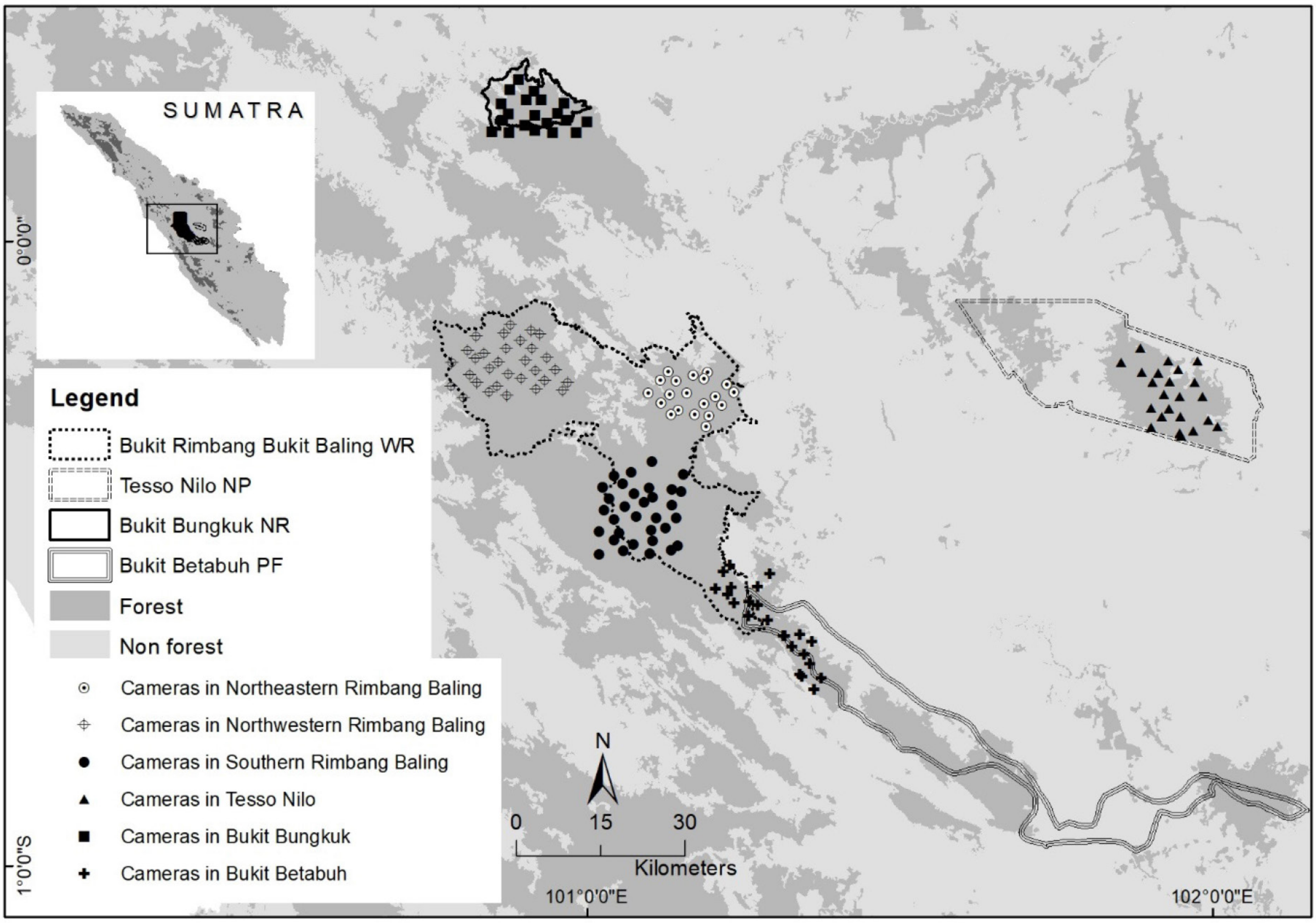

Fig. 1. Map of sampling blocks and camera stations in Bukit Rimbang Bukit Baling Wildlife Reserve, Bukit Betabuh Protected Forest, Bukit Bungkuk Nature Reserve, and Tesso Nilo National Park.

was BRBB which covers around 141,000 ha. Dominated by lowland hills with an average elevation of around 400 m asl and slope ranges from 25% to 100%, RBWR has the highest elevation of ±1,070 m asl. The reserve has a long border with forestry concessions currently planted with *Acacia* spp. or *Eucalyptus* spp. for pulp-and-paper plantation, agricultural concessions mainly planted with oil palms and rubber, as well as community lands planted with a mixed variety of commodities including rubber and oil palms. Coal mining was occasionally active in some spots around the reserve. We sampled three sections of BRBB with camera traps: the northeastern part (2012), northwestern part (2014), and southern part of the reserve (2015). Tesso Nilo has been a national park since 10 July 2004, measuring ~83,000 ha. We sampled this area in 2013. The national park area faces large scale encroachment, with more than 70% of the national park area having been (illegally) converted to oil palm plantations (Uryu et al., 2010). Bukit Bungkuk Nature Reserve measures around 20,000 ha. We sampled this area in 2012. Bukit Betabuh was sampled in 2013.

Collecting data on dholes. We used camera traps as the primary tool of this study. Such tools have been used to confirm the presence of elusive carnivores including the dhole in the form of photographic evidence (Sunarto et al., 2013b; Thapa et al., 2013). This study used “by-catch” data from previous studies which mainly focused on tigers and their prey. Hence, we followed the closed-population Capture-Mark-Recapture (CMR) framework for tiger studies (Karanth et al., 2006; Sunarto et al., 2013a). We deployed camera traps in every other 2×2 km grid cells within a three-month sampling period in each sampling block. We placed camera traps in pairs at each camera station following possible animal trails or good spots which had a high possibility of obtaining images of the target animals. We deployed a pair of cameras at each station that could capture many terrestrial species including dholes.

We used several brands and types of camera traps including Bushnell® Trophycam and Natureview as well as Reconyx® HC600 and PC800 set to capture both still image and video. Sensor sensitivity was set on medium, medium-high, and high depending on circumstances at the camera location; for instance, we set the sensor to medium if the canopy was relatively open. Cameras were installed at a height of 30–40 cm, assuming level ground, according to the size of tigers and main prey species. Camera angle was slightly tilted to avoid the cameras triggering each other at the same station. We did not use any baits to attract animals. We secured the camera from possible theft by attaching chains with padlocks and adding a persuasive information label to prevent destructive actions.

Table 1. Land use types and size information of the study area in Central Sumatra, with nine different variables.

No.	Land use type	Size (ha)	Percentage (%)
1	Cleared area	208,124	6.15
2	Cleared area with some vegetation	44,721	1.32
3	Cloud	83	0.00
4	Mixed oil palm plantation	146,480	4.33
5	Natural forest	937,449	27.71
6	Oil palm plantation	559,610	16.54
7	Pulpwood plantation	319,042	9.43
8	Water body	33,604	0.99
9	Others	1,133,427	33.51
	Total	3,382,540	100

Trapping Success Rate (TSR). To investigate the relative abundance of dholes, we used the trapping success rate (TSR), also known as Relative Abundance Index (RAI; O'Brien et al., 2003). We calculated TSR by using number of independent pictures per 100 trap nights of camera sampling. We followed the definition of independent pictures as (1) consecutive photographs of different individuals of the same or different species, (2) consecutive photographs of individuals of the same species taken more than 0.5 hours apart, or (3) non-consecutive photos of individuals of the same species (O'Brien et al., 2003). Trap success rate was calculated by dividing the number of independent photos (i.e., photographic events of distinct animals within 30-minute time intervals regardless of the number of photographs) by sampling effort (per 100 trap nights) (O'Brien et al., 2003; Sunarto et al., 2015). We compared TSR values of dholes among sampling blocks.

Activity pattern. We categorised main active periods of dholes into diurnal, nocturnal, or crepuscular based on camera trapping photographic records. The activity period of each species was assessed based on the following three divisions of time of day: night-time/nocturnal (1900–0500), day-time/diurnal (0700–1700), and dawn/dusk/crepuscular (0500–0700 and 1700–1900) (Azlan & Sharma, 2006; Pusparini et al., 2014). We did not use independent pictures within 30-minute intervals to calculate activity patterns of dholes from all sampling blocks that are not considered to be independent, but instead used kernel density estimation (KDE) implemented in package 'overlap' version 0.3.2 in R version 3.6.3 to determine activity patterns of dholes (Linkie & Ridout, 2011; R Core Team, 2016; Meredith & Ridout, 2018).

Distribution model. We developed a species distribution model to generate robust prediction of the distribution patterns and factors' level of contribution on the dhole's habitat suitability within each study site. We used MaxEnt (Maximum Entropy) software, which is an open-source software that is also the newest and one of the most widely used methods that use presence-only species records (Pearce & Boyce, 2005; Elith et al., 2011).

We used GPS coordinates of each station while placing camera traps in the field and sought to characterise environmental conditions associated with the presence records (Pearce & Boyce, 2005). We inserted dholes' locations together with a set of environmental variables that can describe some influential factors to the species distribution (Phillips et al., 2006). We used four predictor variables such as land cover, with nine different variables (Table 1) as categorical variables, and distance to river, elevation, and road density as continuous variables. We used a forest cover map from 2011, available from WWF-Indonesia (Setiabudi, 2015), as land cover variable. River, elevation, and road variables were obtained from Badan Informasi Geospasial (2013). We used Euclidean distance to produce raster data and density for road layer. We used ArcGIS 10.1 (ESRI, 2012) to produce any layer of GIS data. The distribution model was developed using 37 dhole presence coordinates. We set 25 of a random test percentage with 100 replicates and 1,000 maximum iterations.

RESULTS

We spent a total effort of 14,013 effective camera trap nights across 148 camera stations. Dhole images were captured in 30 locations. We obtained a total of 275 images of dholes, of which 37 were independent. That is a trap success rate of 0.26 independent pictures of dholes per 100 trap nights. We covered a total area of 935 km^2 from six different sampling blocks. Majority of samples were from Bukit Rimbang Bukit Baling Wildlife Reserve, where we covered three different sampling blocks in the northeast in 2012, northwest in 2014, and south of the reserve in 2015. The greatest number of dhole photographs was in northwestern Rimbang Baling with 106 captured images and 10 independent pictures. All sampling blocks had different levels of relative abundance based on trap success rate. The trap success rate of dholes in Bukit Bungkuk was relatively high (0.44 independent pictures per 100 trap nights), followed by northeastern and northwestern Rimbang Baling (0.40 and 0.30, respectively) (Table 2). Dholes were recorded mostly active after mid-day and in between night and dawn or dusk across all sampling blocks (Fig. 2). Kernel density estimate (KDE) graphs suggest similar activity patterns in each sampling block (Fig. 3).

Table 2. Summary of sampling effort and results including independent pictures and trap success rate (TSR) information from six different sampling blocks in protected and conservation areas in Southern Riau Province, Sumatra. *: Trap polygon size by using Minimum Convex Polygon (MCP) of camera stations with total size.

	Northeastern Bukit Rimbang Bukit Baling	Northwestern Bukit Rimbang Bukit Baling	Southern Bukit Rimbang Bukit Baling	Tesso Nilo	Bukit Bungkuk	Bukit Betabuh	Total
Survey period	16 November 2011 – 25 February 2012	12 February – 10 June 2014	28 August – 19 December 2015	18 July – 2 November 2013	9 June – 17 September 2012	11 January – 25 April 2013	
Status of the area	Wildlife reserve	Wildlife reserve	Wildlife reserve	National park	Nature reserve	Protected forest	
Trap polygon size (km^2)	95	195	208	177	99	161	935*
Station altitude range (m)	102–830	378–1,247	291–886	41–110	158–572	64–580	
Station points	20	31	32	25	20	20	148
No. of trap nights	1,688	3,169	3,268	2,335	1,762	1,791	14,013
No. of pictures	41	106	18	35	70	5	275
Independent pictures	9	10	3	4	8	3	37
Location records	7	9	3	3	6	2	30
Trap success rate (TSR)	0.40	0.30	0.09	0.16	0.44	0.17	

MaxEnt analysis showed that the average AUC test for the replicate runs is 0.903 and the standard deviation is 0.025 (Fig. 4). The distribution of dholes was predicted to be higher in forested areas mainly inside designated conservation and protected areas (Fig. 5). Based on MaxEnt analysis using four predictor variables, land cover had the highest contribution to dhole distribution (83.3%) and the lowest contribution was from elevation (1.5%) (Fig. 5). Forest cover had the highest contribution in the distribution model (Fig. 6). Natural forest cover was 937,449 ha (27.71%) of total land area (Table 1).

DISCUSSION

This study is useful to corroborate and update information on dholes in several protected and conservation areas in Sumatra where the presence of dholes has been previously reported (Kamler et al., 2015). Based on this study, we confirmed that Tesso Nilo, Bukit Rimbang Bukit Baling, Bukit Bungkuk, and Bukit Betabuh were occupied by dholes. The most likely site where we can find dholes, based on trap success rate, was Bukit Bungkuk (TSR = 0.44; Table 2). This is the smallest of all protected and conservation areas in the study area, but the forest is still relatively intact and well-connected to the neighbouring reserves, including Rimbang Baling. We believe the intactness of the connection allows the species to thrive in this area. Unfortunately, the forest areas outside of the reserve can, at any time, be converted legally as they currently do not have any protection status. Upgrade in protection status will likely help secure the forest from future legal conversion. Alternatively, the area can also be sustainably managed through alternative schemes such as by gazetting it as an Essential Ecosystem Area (Kawasan Ekosistem Esensial/KEE) status which can be protected and managed by the Ministry of Environment and Forestry, along with the adoption of Better Management Practices (BMP) by the community or companies to support species conservation. Generally speaking, dholes had lower trapping success rates compared to other predators such as tigers which had trapping success rates of 4.5 in Tesso Nilo and 2.59 in Rimbang Baling (Sunarto et al., 2013a; Widodo et al., 2017), clouded leopards which had a trapping success rate of 1.32, and leopard cats which had trapping success rates of 3.09 in Tesso Nilo and 2.24 in Rimbang Baling (Sunarto et al., 2015). The number of photographic events of dhole in this study (0.26 independent pictures per 100 trap nights) is lower than a study in Nepal which had 1.02 dhole pictures per 100 trap nights (Thapa et al., 2013). Pack size of dholes in tropical forest is smaller due to prey scarcity (Kamler et al., 2012; Nurvianto et al., 2015), which may explain these results.

Although there are variations, this study confirms the ability of dholes to be active basically at any time of day and night (Figs. 2, 3). Dholes in this study were mostly active during the day, although they are also confirmed to be active at night and during dusk and dawn. The patterns of crepuscular and nocturnal activity were reported from other studies such as in India (Fox, 1984; Ramesh et al., 2012), Thailand (Grassman et al., 2005; Jenks et al., 2012b), and Baluran National Park

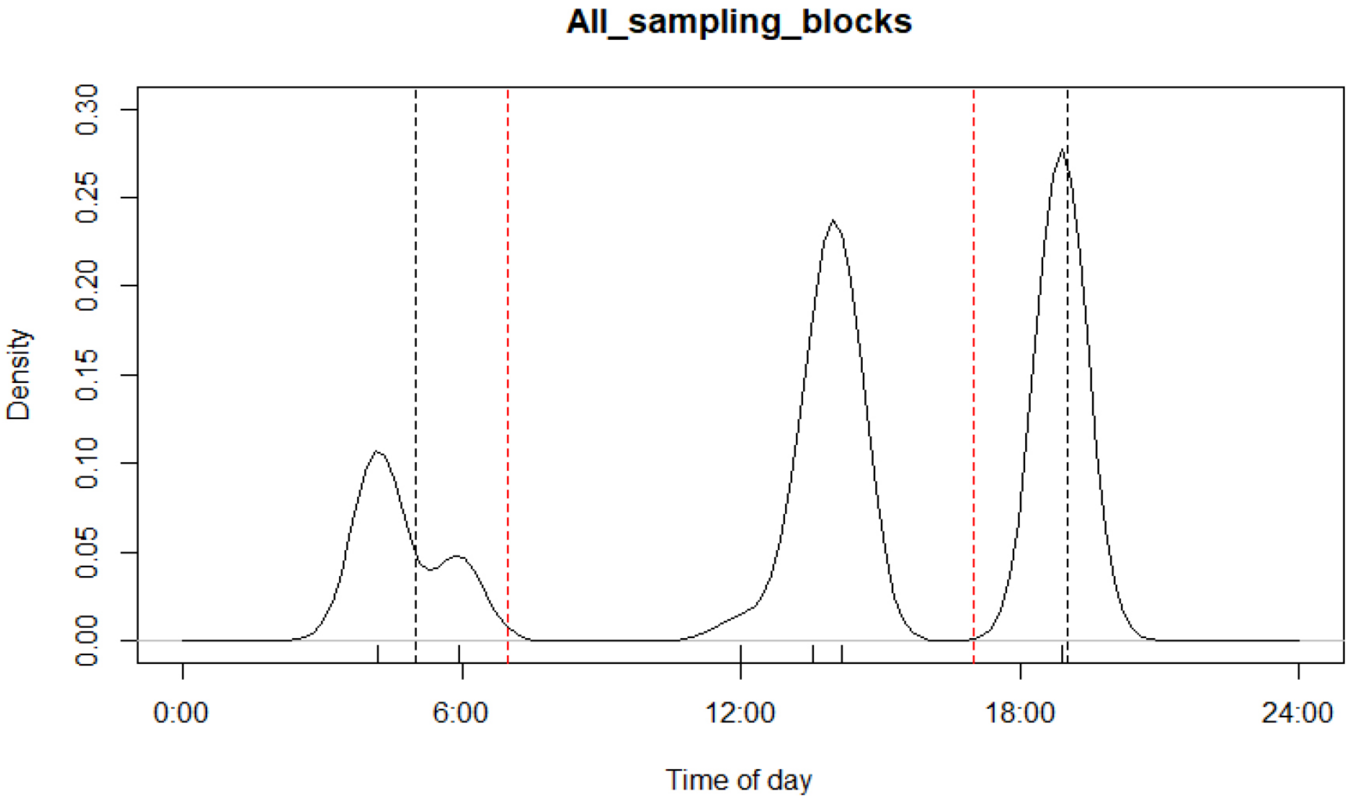

Fig. 2. Activity pattern graph of dholes (n=275) in all sampling blocks in Sumatra based on density estimates of the daily activity patterns by using kernel density estimation following Linkie & Ridout (2011). Black-dashed lines indicate the approximate edge of night and dusk or dawn. Red-dashed lines indicate the approximate edge of both dusk or dawn with nights and day. The solid black line is the kernel density of dholes. X-axis indicates the time of individual photographs and Y-axis indicates the kernel density.

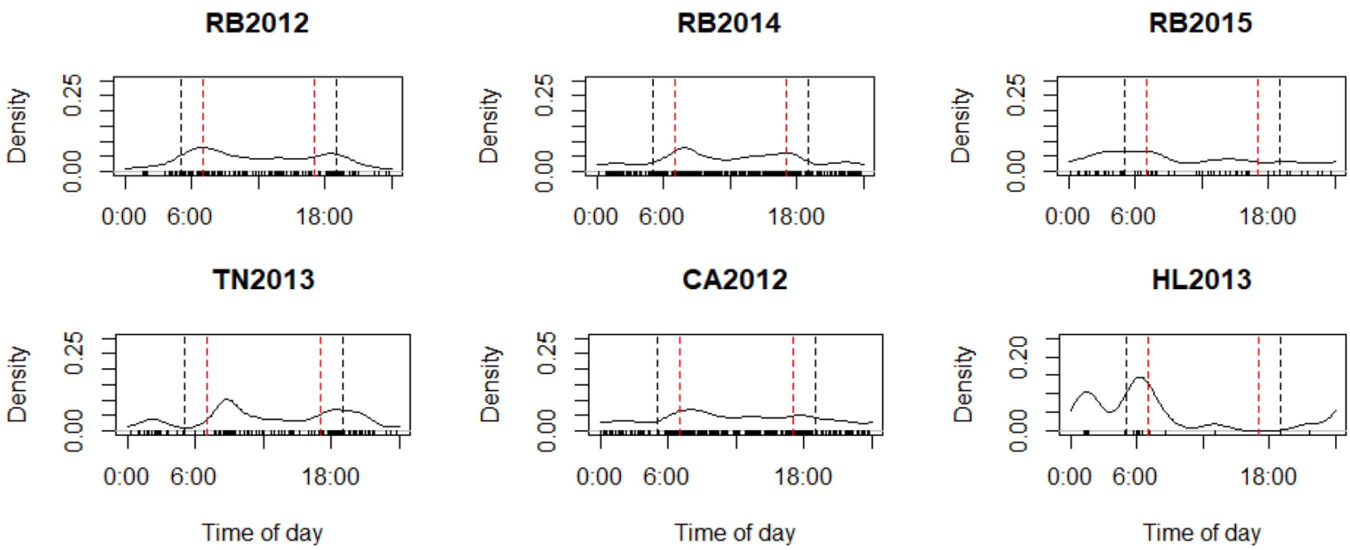

Fig. 3. Activity pattern graph of dholes in each sampling block based on density estimates of the daily activity patterns by using kernel density estimation following Linkie & Ridout (2011). RB2012 is northeastern Rimbang Baling (n=41), RB2014 is northwestern Rimbang Baling (n=106), RB2015 is southern Rimbang Baling (n=18), TN2013 is Tesso Nilo (n=35), CA2012 is Bukit Bungkuk (n=70), and HL2013 is Bukit Betabuh (n=5). Black-dashed lines indicate the approximate edge of night and dusk or dawn. Red-dashed lines indicate the approximate edge of both dusk or dawn with nights and day. The solid line is the kernel density of dholes. X-axis indicates the time of individual photographs and Y-axis indicates the kernel density.

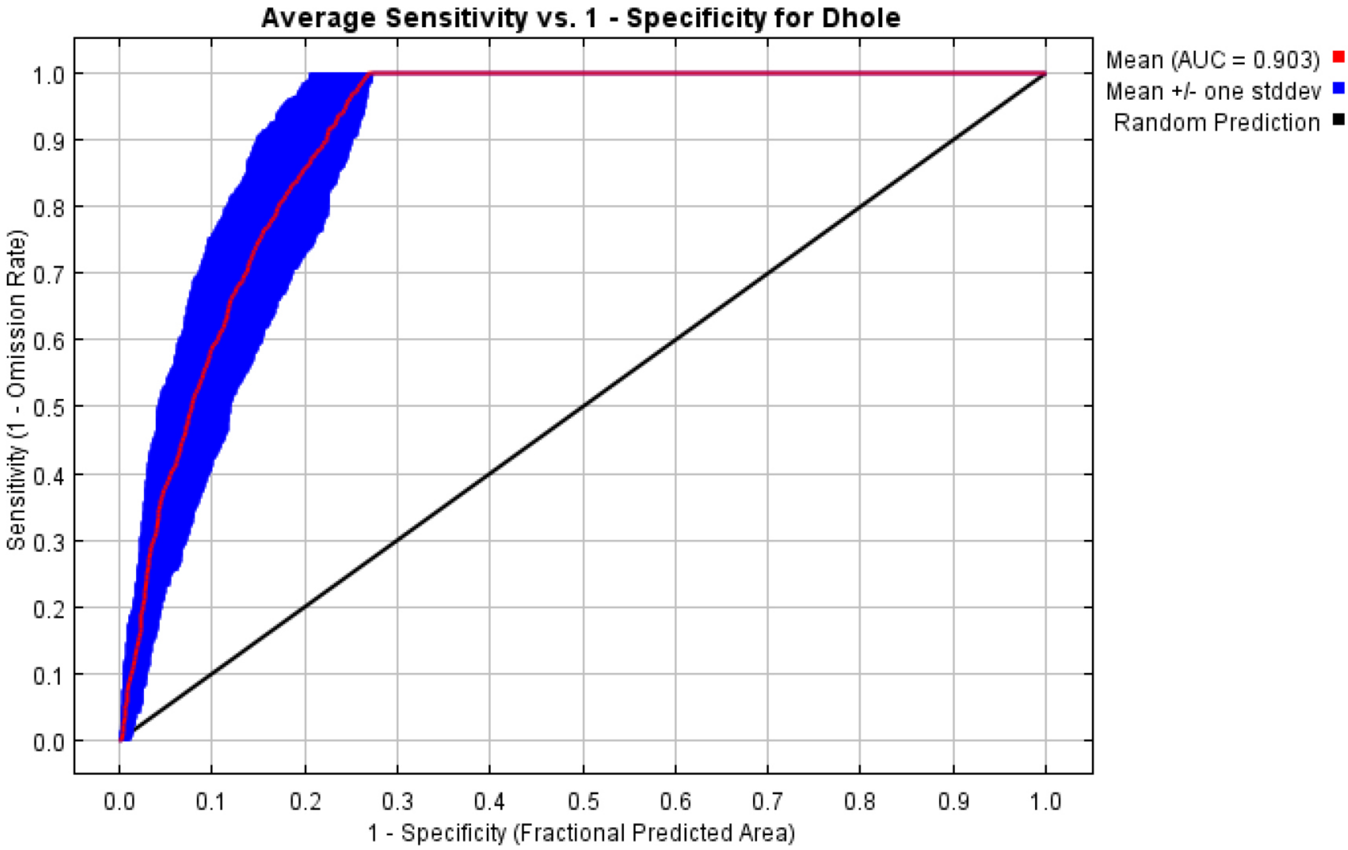

Fig. 4. Curve of the receiver operating characteristic (ROC). The average test AUC for the replicate runs is 0.903 and the standard deviation is 0.025. This graph was generated by modelling in MaxEnt from 30 dhole locations with four habitat variables: land cover, road, elevation, and river. The random test percentage was 25 with 100 replicates and 1000 maximum iterations. The AUC result of the study was closer to 1 which indicates better model performance. The best AUC has an AUC of 1. The maximum AUC is therefore less than one and is smaller for wider-ranging species (Phillips et al., 2004).

in Java, Indonesia (Nurvianto et al., 2015). Dholes tend to avoid larger predators such as tigers based on another study from India (Karanth & Sunquist, 2000). Activity patterns of dholes could also be primarily driven by prey activity (Ramesh et al., 2012; Nurvianto et al., 2015). In Baluran National Park, dholes were also reported to hunt at night, and most activities in the den that intensified at dawn and dusk became less intensive in the middle of the day (Nurvianto et al., 2015). Dholes in our study sites were mostly active during the day-time, unlike in Baluran, and this is possibly due to the much denser canopy cover as compared to that of Baluran National Park, which is mostly a savannah and would have had higher temperatures during the day. Future studies can investigate this further.

Potential prey species of dholes include ungulates like the sambar *Rusa unicolor*, barking deer *Muntiacus muntjak*, wild boar *Sus scrofa* (see Johnsingh et al., 2007; Kamler et al., 2012; Hayward et al., 2014; Timmins et al., 2016), and jungle fowl *Gallus gallus* (see Shahid & Khan, 2016). Dholes hunt sambar deer, the largest prey of dholes, diurnally in Thailand (Jenks et al., 2012b). The presence of potential prey species in our study sites was confirmed by other studies in Tesso Nilo Riau Province, such as sambar deer which was the largest mammal prey, barking deer, and wild pigs (Sunarto et al., 2013a). However, the trapping success rate of sambar deer was very low (0.1) in Tesso Nilo (Sunarto et al., 2013a). Prey availability could possibly be influencing dhole distribution and abundance across study sites. We did not record any dhole conflicts with humans at our study sites, despite dholes reportedly killing livestock in Bhutan because of low prey availability (Johnsingh et al., 2007). We assumed prey availability of dholes in our study sites was still sufficient. We conducted the study only in forest areas designated as conservation areas or protected areas. Conflict is less common in protected areas and more common in human disturbance areas such as multiple-use forests (Nyhus & Tilson, 2004). As communal predators, dholes usually live in packs of 5–10 individuals, or even more; camera trap surveys in Peninsular Malaysia recorded a maximum pack size of four individuals (Durbin et al., 2004; Kawanishi & Sunquist, 2008; Xue et al., 2015), but our camera traps captured only one or two individuals as the maximum number of dholes recorded in each station. This study was designed for tigers and prey so that we believe dholes passing the camera will still have a good probability of being captured. The characteristics of the target species are important factors to be considered in designing camera trap sampling in tropical forest areas, including the movement range of target species (Sunarto et al., 2013b). To specifically study dholes, the camera placement should be monitoring their activity centre such as water holes or locations where dhole signs (prints and faeces) were detected, to improve the probability of detection (Jenks et al., 2012b). Additionally, a longer duration of video might be needed to capture the full size of the dhole pack. Pack size of dholes in rainforest is,

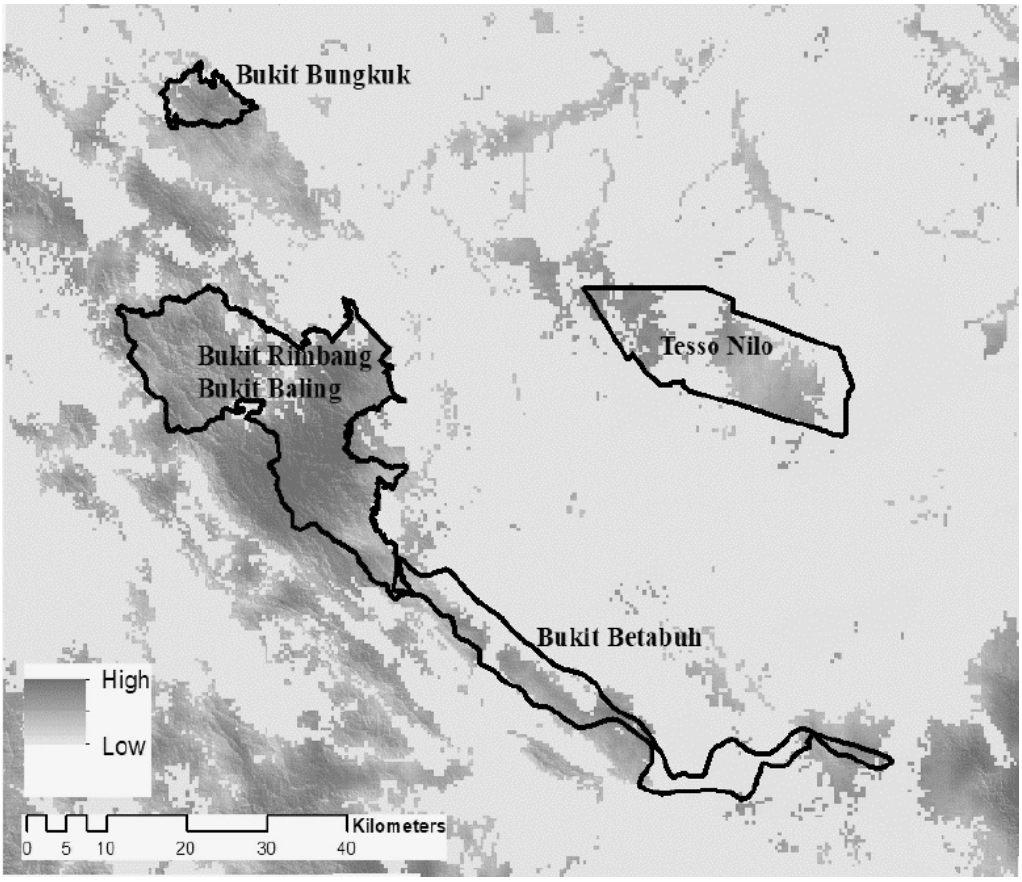

Fig. 5. Map of predicted distribution model of dholes generated by MaxEnt, with median summary grids and percent contributions of variables which were 83.3% for land cover, 8.7% for road, 6.5% for river, and 1.5% for elevation.

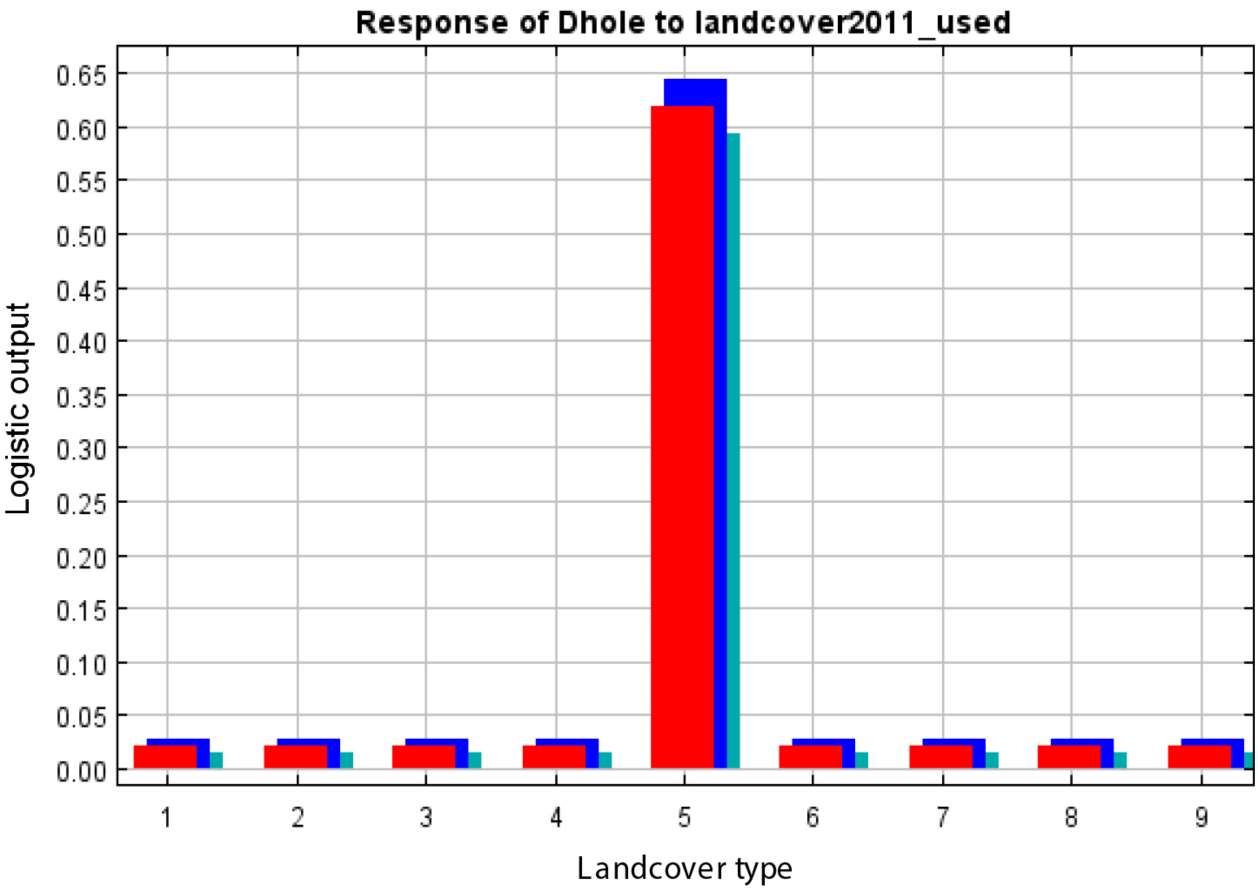

Fig. 6. The land cover chart above shows the mean response of the 100 replicate Maxent runs (front) and the mean +/– one standard deviation (two shades for categorical variables). Number 5 is the forest cover variable (details of variables can be seen in Table 1).

however, believed to be smaller as an adaptation to resource availability where large prey species are scarce (Kamler et al., 2012; Nurvianto et al., 2015).

This study focused within the forest areas only. For future study, we suggest sampling other habitat types. Furthermore, monitoring of the trend at the same sampling blocks will be useful to understand the changes that may possibly occur. This study strongly suggests that forests are an important habitat to dholes, however, forests in Sumatra have been experiencing loss, degradation, and fragmentation (Uryu et al., 2010; Margono et al., 2012). Such conditions become a big threat to the survival of forest-dependent wildlife including dholes. Protection of the remaining forests is crucial in supporting the survival of dholes in the future (Jenks et al., 2012a). Restoration of the degraded and deforested areas that used to be inhabited by dholes in Sumatra is equally important. This species deserves more conservation attention as it represents a unique kind of predator that we believe plays a pivotal yet unknown role in their ecosystem, and is the only species from the *Cuon* genus.

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