Danau Girang Field Centre

The Bornean Banteng Programme: Conservation and management of the endangered wild cattle *Bos javanicus lowi* in Sabah.

Survey of bantengs in Kuamut Forest Reserve

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This programme is kindly sponsored by Yayasan Sime Darby. Field survey work commenced in October 2012. The programme will culminate in the first international workshop for Bornean bantengs in Sabah in 2017, during which the first Conservation Management Action Plan will be formulated for this species.

Introduction

Taxonomy

Three subspecies of bantengs (*Bos javanicus*) are widely recognised and this is based on phylogenetic analysis of mitochondrial DNA and inferences of their evolutionary history: the Burma or Burmese bantengs (*B. j. birmanicus*) in mainland Southeast Asia, the Java bantengs (*B. j. javanicus*) in Java and possibly Bali, and the Bornean bantengs (*B. j. lowi* or *lowii*), (hereon referred to as *B. j. lowi*) which is endemic to the island of Borneo (Figure 1). The banteng is likely to be a monophyletic species that dispersed across the Sunda shelf (land bridges) connecting the Malayan and Indo-Malayan sub-region during the last glacial period (maximum 22,00-19,000 years ago (Yokoyama et al., 2000). Prehistoric cave paintings in Kalimantan (Indonesia) that date >10,000 years old depict zoomorphic figures, including one animal which is thought to be the Bornean banteng (Chazine 2005; Chazine 2009). Bone fragments of wild cattle, believed to be bantengs, were also found in a cave in Sarawak and were dated to the late-Pleistocene period (Medway 1964), suggesting that the Bornean banteng naturally occurs in Borneo. Phylogenetic reconstruction of bantengs by Matsubayashi et al. (2014), Ishige et al. (2015) and Gardner (2015) indicate the Bornean banteng is most closely related to the wild Indian bison or gaur (*B. gaurus*). This evidence amplifies the importance of conserving the Bornean bantengs separately to other banteng subspecies. The Bornean banteng is morphologically similar to gaur, having starkly white lower legs or stockings with a muscular compact body, however Bornean banteng are smaller in stature than the gaur, they have white buttocks, and a smaller less-pronounced hump between the shoulders (Gardner 2015). Subtle pelage differences are also evident between the three banteng subspecies: *B. j. javanicus*, *B. j. birmanicus* and *B. j. lowi* (Figure 2).

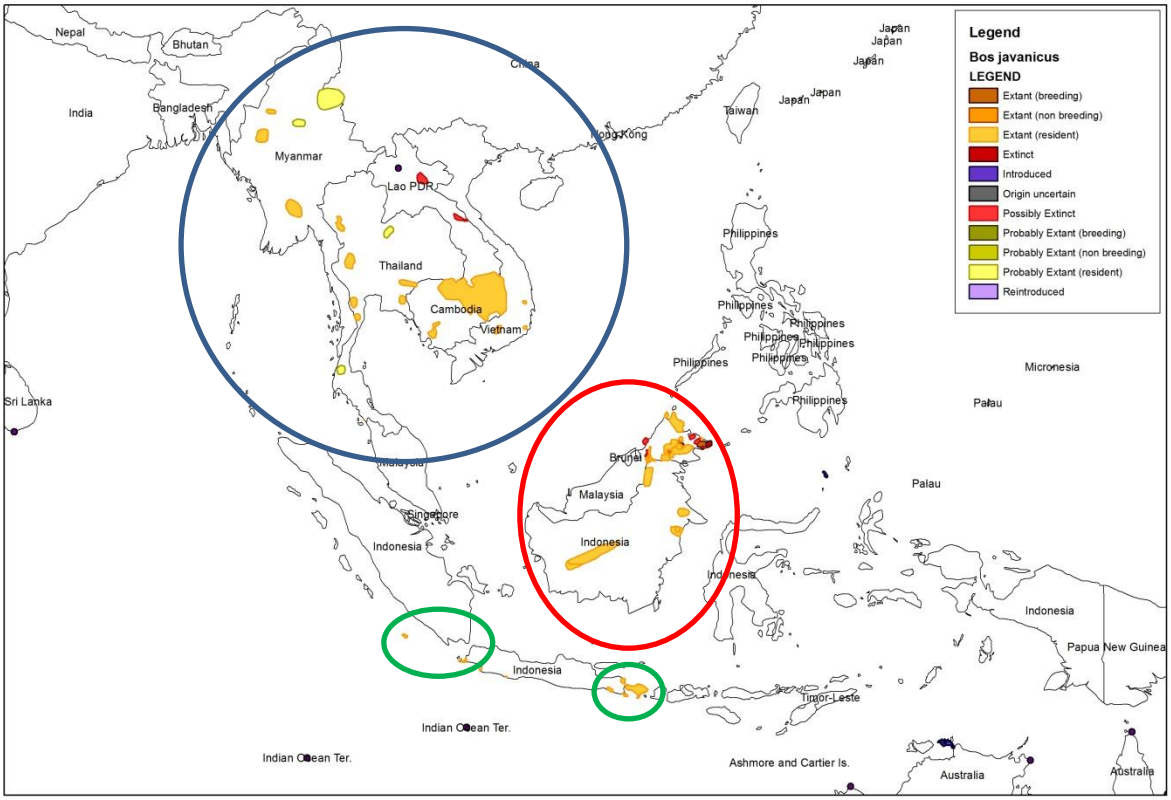

Figure 1: The world-wide distribution of banteng subspecies: Burma or Burmese banteng (*B. j. birmanicus:* blue circle), Java banteng (*B. j. javanicus:* green circle), and the Bornean banteng (*B. j. lowi;* red circle) (Gardner et al. 2016)

Hybridization with domestic cattle remains a serious threat to the genetic integrity of the Bornean banteng. Past observations of abandoned cattle and/or supposedly wild bantengs matching the description of a hybrid (i.e. pronounced dewlap, straight horns and white spotted pelage) have been reported in forest reserves and in agricultural land across Sabah (Deramakot Forest Reserve, Sipitang Forest Reserve, Kalabakan Felda plantation) however genetic introgression has not yet been proven. The use of domestic cattle and buffalo in plantations and within villages inside the forest reserves is not uncommon, and careful management of livestock will ensure interbreeding does not occur. At present, no captive populations of Bornean bantengs persist, and no tissue samples from wild-caught individuals have been obtained. Therefore, establishing the taxonomic description of suspected hybrids using molecular analysis has not been possible during the first study of Bornean bantengs (years 2011-2013) or the state-wide survey of the Bornean bantengs (2013-2016) by the Bornean Banteng Programme/Danau Girang Field Centre.

Figure 2: Photographs of bantengs bulls of the three subspecies with subtle variations in pelage colour and body size: Top left: The Bornean banteng (*B. j. lowi)* with very dark pelage colouration and a stout compact body size, photographed in Kuamut Forest Reserve in the Malaysian state of Sabah as part of this study (© Bornean Banteng Programme/Danau Girang Field Centre). Top right: A banteng bull in Thailand (*B. j. birmanicus)* with a brown pelage and heavy-set facial features (© D. Kohn). Bottom: A herd of Java bantengs (*B. j. javanicus)* photographed on the Indonesian island of Java with the bulls evident by their dark brown/black pelage colour. The facial structure of the Java bantengs shows subtle differences in their elongated facial structure (© S. Pudyamtoko).

Legislation

In accordance with the International Union for Conservation of Nature and Natural Resources (IUCN) Red List of threatened species, the banteng is classified as 'Endangered' due to their collective small population size and declining trend across their distribution (Gardner et al. 2016). Under the Sabah Wildlife Conservation Enactment 1997, the banteng is listed in Schedule 1 as 'Totally Protected' therefore no hunting is permitted. The possession of a live wild banteng, or of banteng meat or body parts carries a penalty of 50,000RM or imprisonment for five years, or both. Despite repeated evidence of banteng hunting (carcases,

police report, photographic evidence, and first account accounts by government staff) as recently as January 2015, no convictions have been made to-date.

Past population trends

The past global population size of the Bornean banteng is difficult to assess due to a lack of research, lack of collaboration between stakeholders within and between the three countries in Borneo, and logistical issues associated with conducting large-scale surveys of a low-density mammal. Within Sabah, reports from the late 19th and early 20th centuries indicated that bantengs were present and perhaps common wherever shifting cultivation was practiced (Davies & Payne 1982). Following World War II, when the use of firearms for hunting increased, the bantengs suffered declines. They were eradicated in multiples areas of Sabah (Davies & Payne 1982). Widespread timber harvesting, followed by the conversion of land for agriculture increased the access to previously remote forest, thereby facilitating armed hunting within banteng habitat and the removal of large carcasses. In 1982 the first non-quantitative survey was conducted by Davies and Payne (1982), which estimated the population to be between 300-550 individuals. Actions to mitigate against the activities that threaten the population were outlined in the report. In 1997, the first quantitative survey of bantengs was conducted in forested areas in the state using sign surveys and camera traps, however despite the use of 127 transects, totalling 62 km in 12 forest reserves, only 20 tracks of bantengs were recorded (Boonratana 1997). The low encounter rate precluded density estimates, and the bantengs were found to be rare in areas where they were previously considered as common by Davies and Payne (1982). The report by Boonratana (1997) highlighted their deteriorated status and outlined actions to prevent further loss. Despite these two reports documenting the endangered status of the Bornean banteng and the immediate threats that have caused their decline, no known actions were ever taken to conserve them or their habitat. In terms of subpopulation sizes, within Sabah, the largest subpopulation can reportedly be found in Kulamba Wildlife Reserve, which is thought to contain over 100 individuals (Gardner et al. 2016). However, quantitative survey methods and data to substantiate this figure are not available or in circulation, and this population size should be considered a crude approximation only (Gardner et al. 2016). The most recent and extensive survey of bantengs in Sabah included the Kuamut Forest Reserve (KMTFR) and was conducted between the years 2014-2015 by the Bornean Banteng Programme. This survey used 31 non-invasive paired camera trap stations positioned inside KMTFR, along abandoned

logging roads, skid trails and along forest trails in closed forest. A total of 2,804 camera trap nights were surveyed between 21st September 2014 to 12th April 2015.

Ecology

Activity patterns

Activity patterns of bantengs and ambient temperature in KMTFR were estimated from 12 of the 31 camera trap stations, which captured 253 events of bantengs. One of these was discounted due to violation of independence assumption, therefore all 252 independent camera trap events of bantengs were captured over a survey period of 2,804 nights. Independence of camera trap events was defined geographically and chronologically; a minimum distance of 100m was maintained between camera trap stations, and multiple events per station were discounted if they occurred within the same hour. Where possible, all individuals were identified using a combination of natural marks (e.g. scars, horn morphology, and cow-calf associations), and multiple events of the same individuals during the same hour were discounted even if arising from different stations, to minimise pseudo-replication. To estimate 95% confidence intervals around activity and temperature data, activity and associated temperature data was aggregated to two-hour intervals and bootstrapped with replacement following the procedure of Gardner et al. (n.d.). Activity was then stratified into activity budgets according to three behaviours (foraging, travel and resting/fighting) and three locations (abandoned logging road, open area and forest trail).

Kuamut was logged as early as 1956 but the larger part of the reserve was harvested in the early 1980s (Sinoh Environmental Sdn Bhd. 2004). Between 1980 to 2003, Kuamut was logged several times using conventional methods by no less than 26 logging operators, and the remaining timber resources were very poor, indicating that the logging operations were not properly controlled or monitored (Sinoh Environmental Sdn Bhd. 2004). Many short-term licences expired in 2003, however in 2004 Kuamut Forest Development Sdn Bhd were carrying out logging activities in four coupes which expired in 2007 (Sinoh Environmental Sdn Bhd. 2004). Logging was thought to continue to as recent as 2014 (Prosser et al. 2016) and during this survey logging activities resumed. No images of bantengs were captured within the newly logged forest or along active logging roads because all camera traps located in these areas were stolen.

Observations of temperature data was captured by camera traps and revealed average ambient temperatures started increasing around 06:01-08:00 hours and reached 29°C (CI =

28-32°C) during the midday period (12:01-14:00 hours), however dropped to ~23°C (CI = 22-25°C) during hours of darkness and the early morning (Figure 3). Maximal temperatures were slightly elevated from ambient temperatures and were approximately ~1°C higher except at midday (12:01-14:00 hours) when a 2°C increase gave a high of 31°C (CI = 28-31°C). Compacted soils following logging activity present unfavourable conditions for seedling recruitment (Pinard et al., 1996), and heavily and extensive logging in the 1990s probably slows rejuvenation of the canopy. Consequently, logging roads and stumping grounds may experience higher ambient temperatures and restricted succession, however an absence of banteng observations in all locations prevents closer examination of this relationship.

Banteng activity was elevated over sunrise and in the two hours preceding it, between 04:01-08:00 hours (Figure 4). Activity then decreased and bantengs were less frequently active until midday (12:01-14:00). After this time, activity increased in frequency and bantengs remained active throughout the night. A Spearman's rank correlation between the bootstrapped activity patterns and ambient temperature indicated a negative response whereby activity frequency decreased when ambient temperatures increased (r_s = -0.44, t = -1.55, 95% CI -0.81 - 0.81) however was not significant.

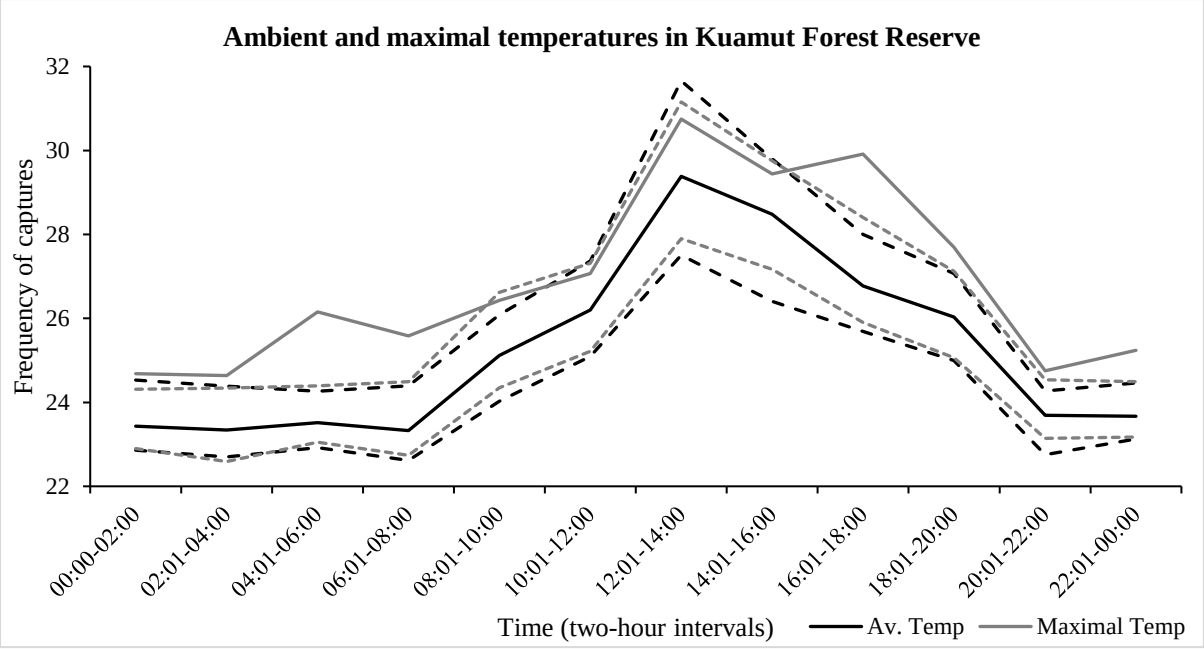

Figure 3: Ambient temperatures and maximal temperatures recorded in Kuamut Forest Reserve (KMTFR), plotted according to two-hour intervals across the 24-hour period and estimated using non-parametric bootstrapping to estimate 95% confidence intervals.

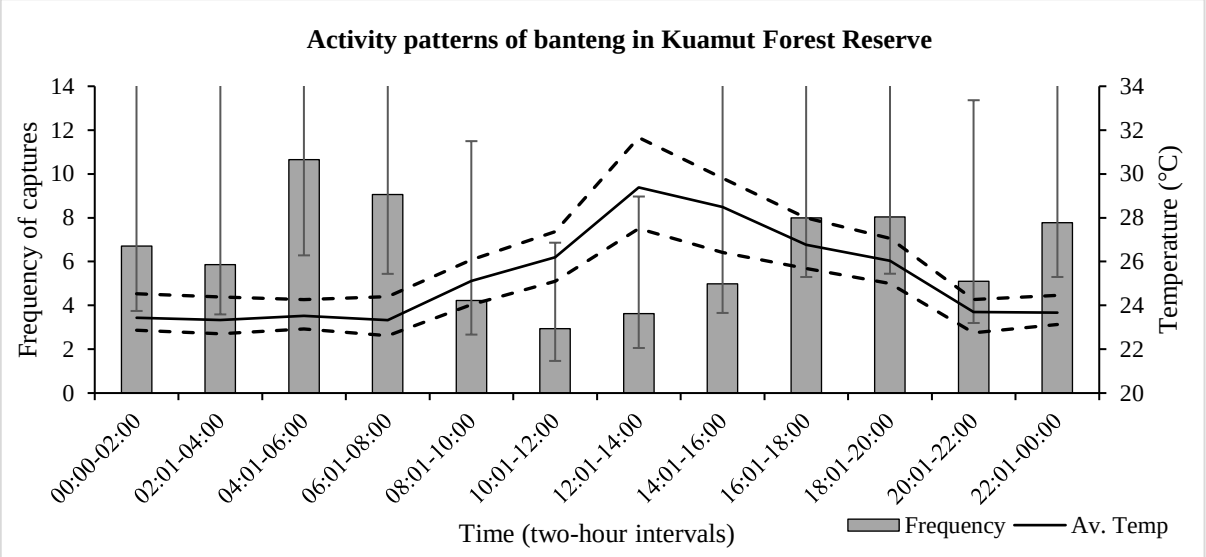

Figure 4: Ambient temperature and activity patterns (all locations combined) of Bornean banteng in Kuamut Forest Reserve (KMTFR) plotted according to two-hour intervals across the 24-hour period using non-parametric bootstrapping to estimate 95% confidence intervals.

Activity budgets

Segregation of activity patterns into three behavioural categories revealed foraging and travelling were the primary behaviours performed throughout the day. Resting/fighting was frequently recorded across the 24-hour period, however was conducted for longer durations during and after sunrise, and during hours of darkness (04:01-06:00 hours and 20:01-22:00 hours). During the midday hours (10:01-16:00 hours) categorised by high ambient temperatures, all behaviours decreased, and only after 14:01-16:00 hours began to resume. Foraging behaviour was negatively associated with an increase in ambient temperature (r_s= -0.66, p= <0.05, t=-2.77, 95% CI= -0.89 - -0.14). Compared to four other forest reserves, bantengs in Kuamut spent a medium amount of time foraging (52% of their time) and travelling (31%), and the most time resting/fighting (17%) (Figure 6).

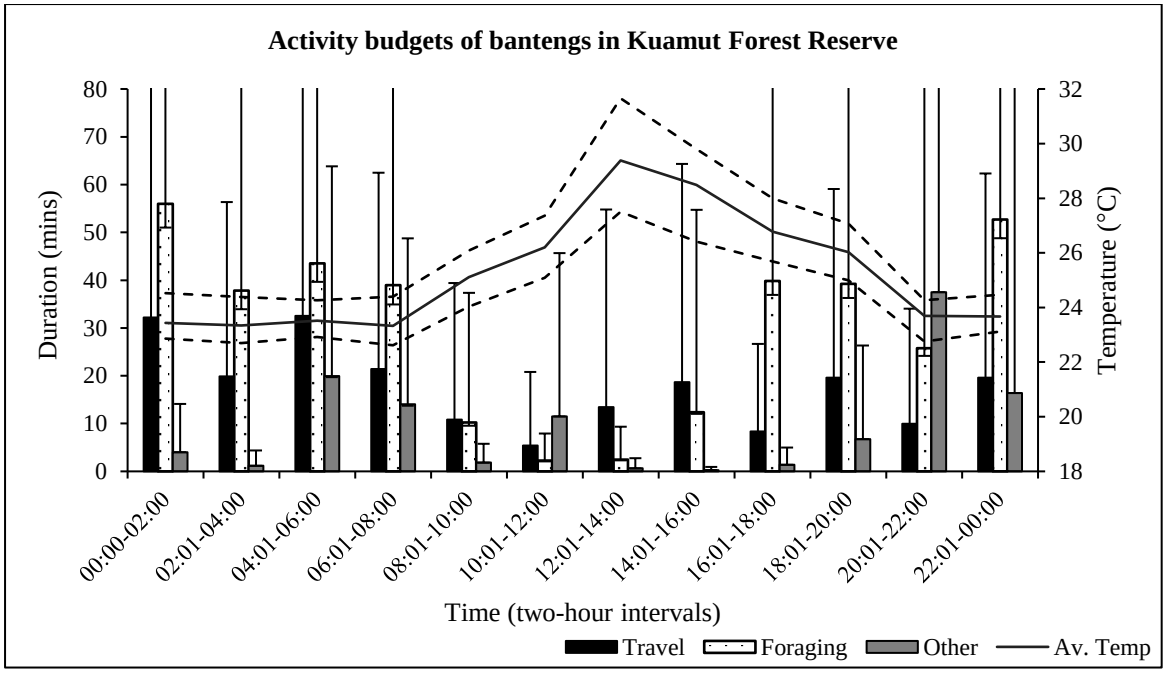

Figure 5: Diel energy budgets of bantengs in Kuamut Forest Reserve (KMTFR) and ambient temperature plotted according to two-hour intervals across the 24-hour period using non-parametric bootstrapping to estimate 95% confidence intervals.

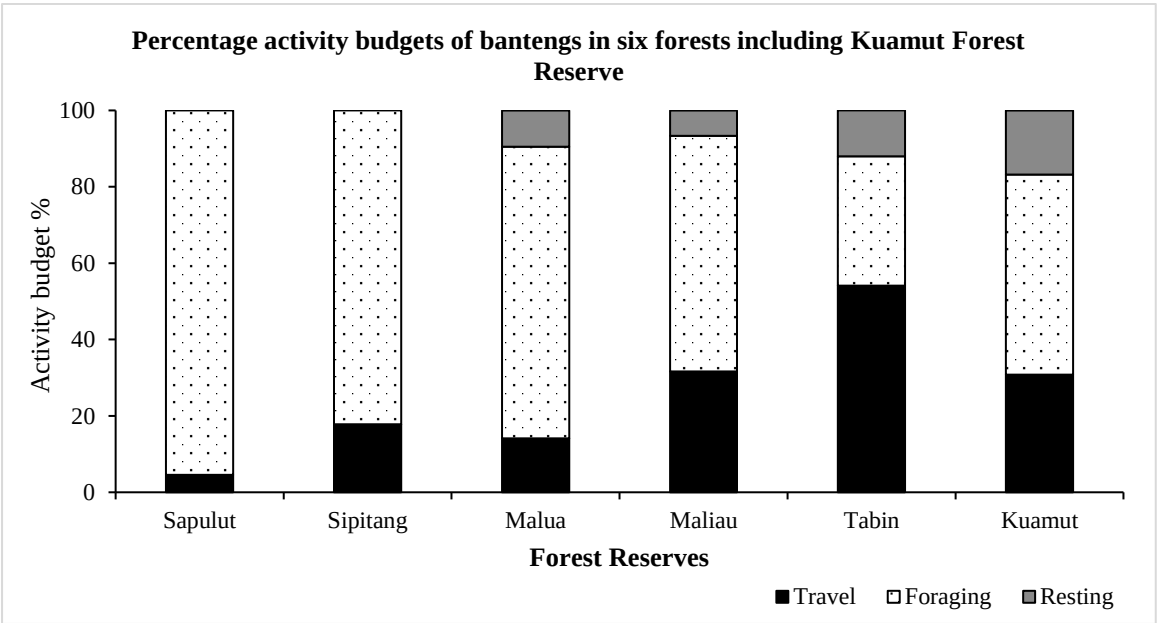

Figure 6: The activity budgets of bantengs expressed as percentage frequencies in six different forests including Kuamut Forest Reserve. The three behaviours which comprised the activities were Travel, Foraging and Resting/Fighting.

Habitat use

Compared to other forest reserves, camera traps were only established along old logging roads, in open areas and along trails, and not along active access roads as the risk of theft was too great. Segregation of activity budgets into three locations revealed that abandoned logging roads were predominantly used, followed by open areas (Figure 7). Bantengs in Kuamut spent long durations utilising abandoned logging roads in the morning and afternoon/evening but reduced their use of these areas during hours 10:01-14:00 with high temperatures (26-29°C CI 25-32°C). Use of open areas and abandoned logging roads were negatively associated with an increase in ambient temperature (r_s= -0.63, p=<0.05, t=-2.56, 95% CI= -0.09 - -0.88 and rs= -0.058, 0.05, -2.23, CI = 0.00 - -0.86, respectively). Compared to other forests, bantengs' use of abandoned logging roads in Kuamut was the second highest (80% of their time), whereas open areas were used the second least (18%) (Figure 8).

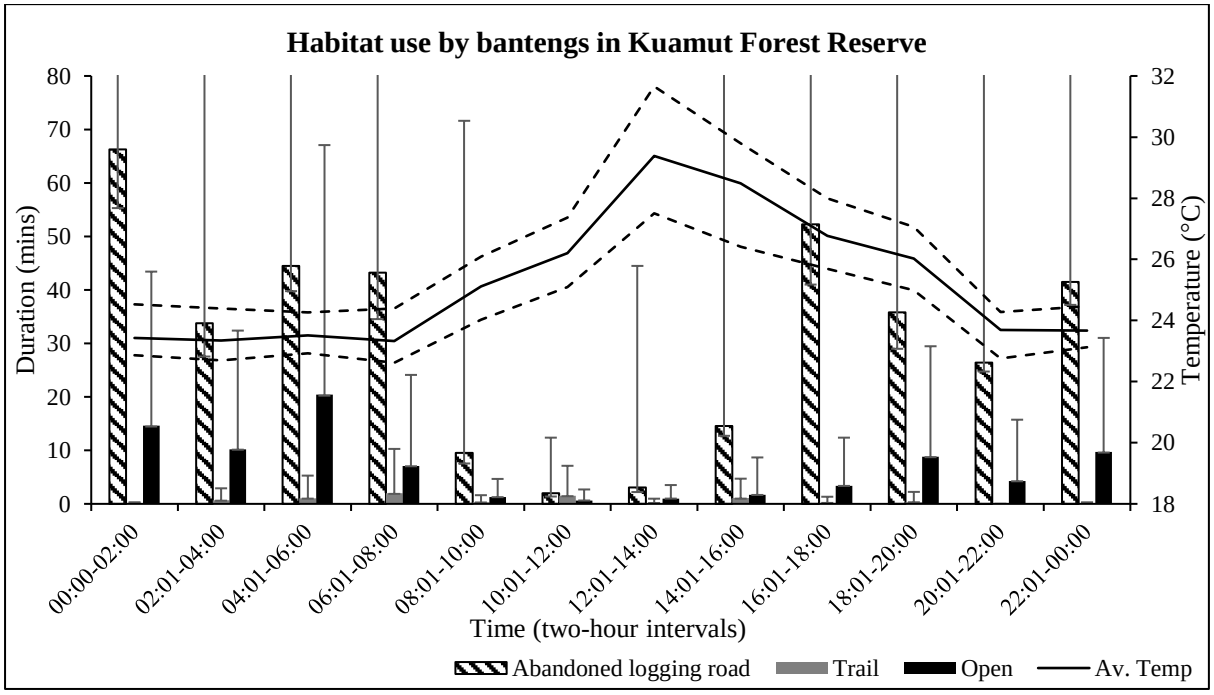

Figure 7: Diel habitat use of bantengs in Kuamut Forest Reserve (KMTFR) and ambient temperature plotted according to three locations and two-hour intervals across the 24-hour period using non-parametric bootstrapping to estimate 95% confidence intervals. Note, active access roads were not monitored due to theft risk.

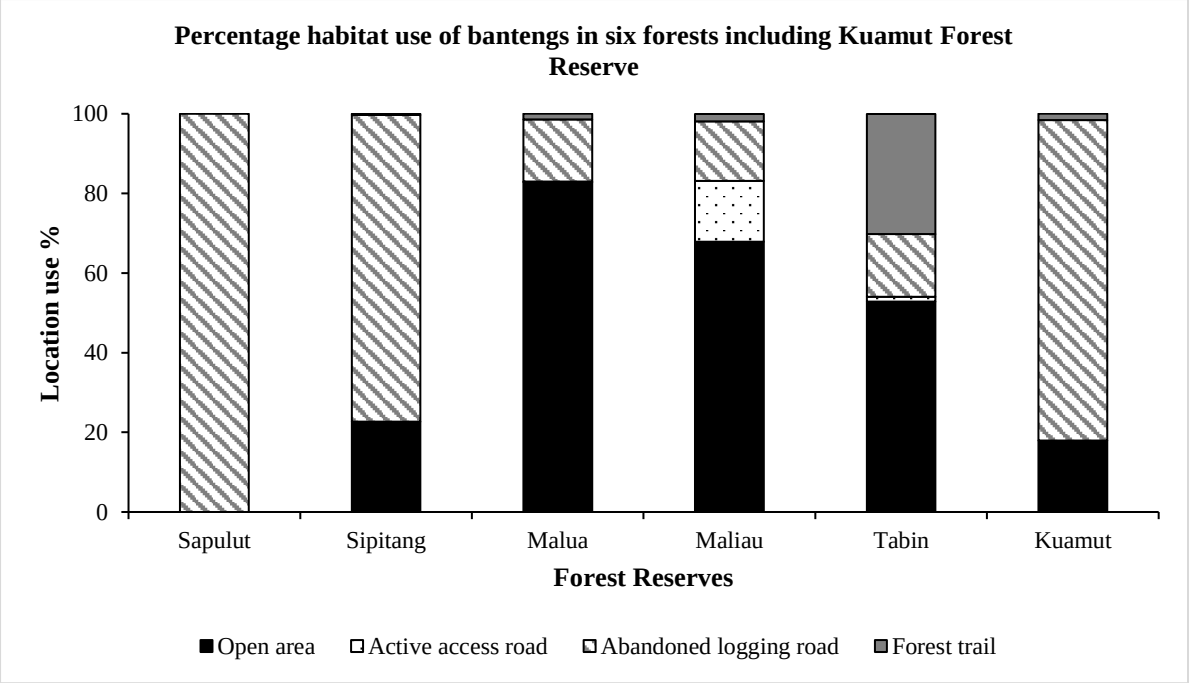

Figure 8: The habitat use budgets of bantengs expressed as percentage frequencies in six different forests including Kuamut Forest Reserve. The four locations were Open area, Active access road, Abandoned logging road and Forest trail. Note: Active access roads were not monitored in Kuamut Forest Reserve or Sapulut Forest Reserve.

Diet and foraging ecology

There is no information pertaining to the diet and foraging ecology of bantengs within Kuamut, however Ridge (2014) conducted a study on the foraging behaviour of bantengs in other forests including the neighbouring Malua Forest Reserve, which is comparable in vegetation type but not in regeneration age. For information on Malua Forest Reserve, please refer to a sister report entitled 'Survey of bantengs in Kuamut Forest Reserve'.

Population status

Distribution

Bantengs were captured at 23 (39%) of the 31 camera trap stations deployed by the Bornean Banteng Programme across Kuamut during the years 2014-2015 (Figure 9). Their distribution was recorded in the east of the reserve (Figure 10) in compartments 1-8, 29, 447 and 449 at elevations ranging from 88-306 metres above sea level.

Within Kuamut, bantengs were observed congregating in herds of up to 20 individuals comprising large mature bulls, bullocks or juvenile bulls, mature cows, heifers or juvenile

cows, and young calves. Photographic captures suggested one new-born calf was born in Kuamut in March 2015 and two older calves, that were estimated to be approximately ~5 months old, were probably born around October 2014 at the same time.

Based on individual identification using natural marks and scars, a recapture history of recognised individuals captured between years 2014 and 2015, indicated that the maximum (straight-line) distance moved within Kuamut was 4.2km by two cows and 5km by a bull. Identification also revealed individuals moving between Kuamut and neighbouring forest Malua over years 2008-2014: capture data from Malua in 2008 was provided by A. Hearn and J. Ross. The maximum (straight-line distance) distance moved by a mature bull between the two reserves was 14.5km.

Bantengs were observed directly by the team during this study, and DSLR photographs and video footage were captured.

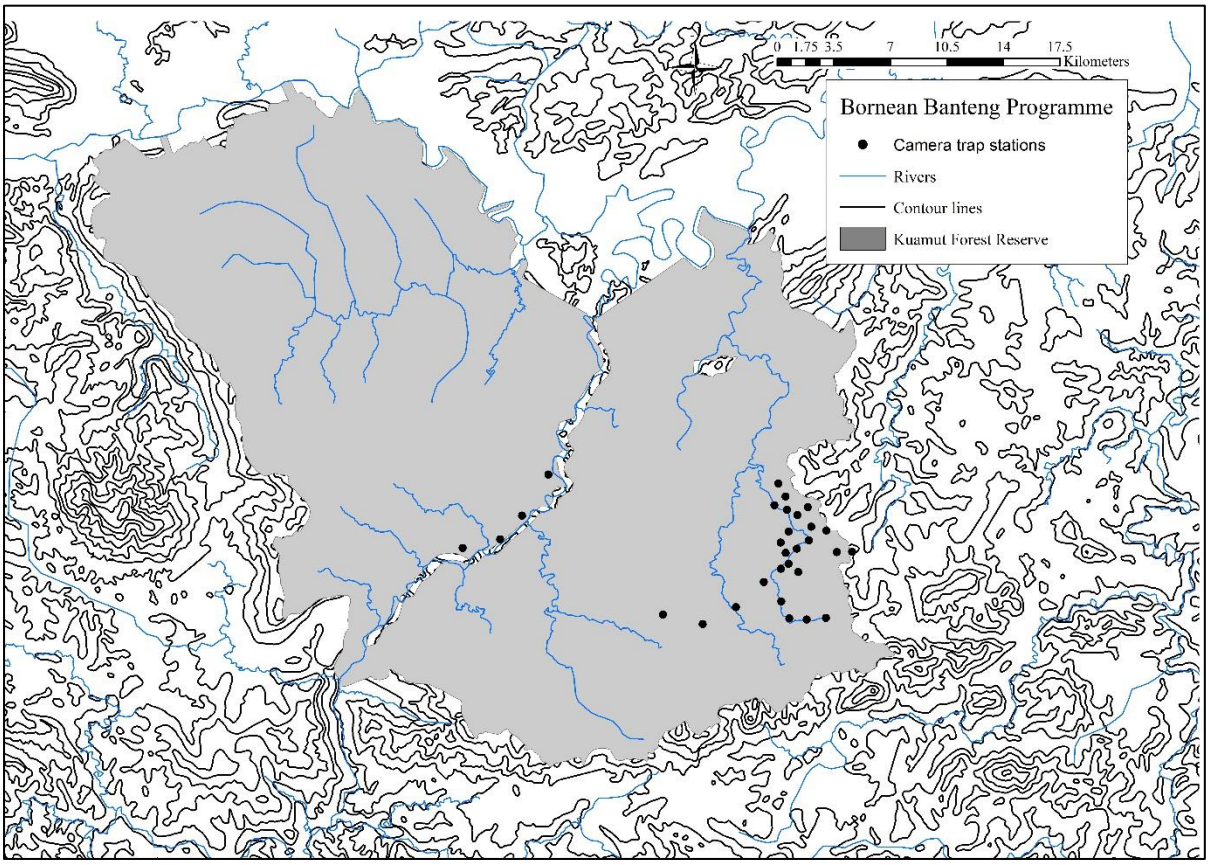

Figure 9: Camera traps deployed by the Bornean Banteng Programme in Kuamut Forest Reserve during years 2014-2015 to collect data on bantengs behaviour and to identify individuals. The population size estimate of bantengs represents these survey points only.

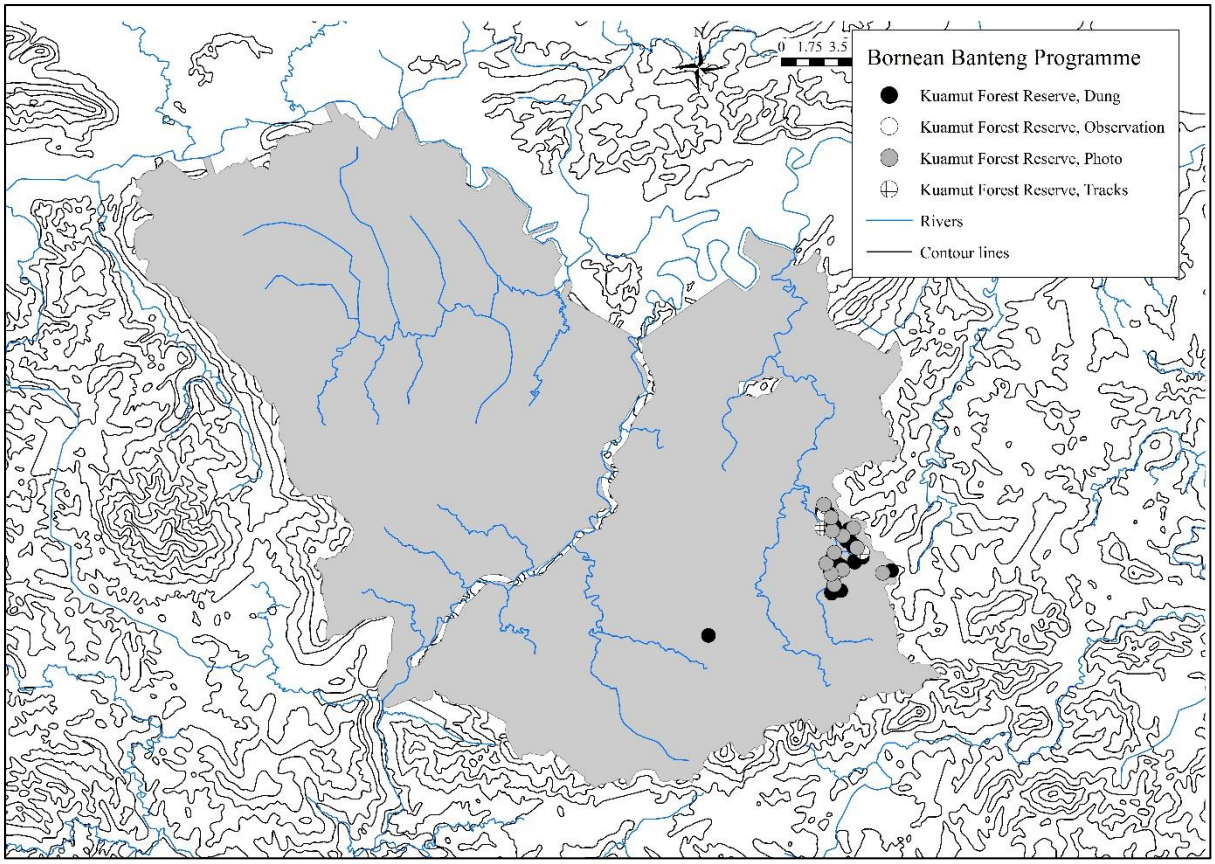

Figure 10: The distribution of banteng signs across Kuamut Forest Reserve using camera traps and encounters of tracks and faecal deposits during surveys conducted by the Bornean Banteng Programme during years 2014-2015. Note, signs are only representative of the survey area and routes covered by the team during the survey.

Population size

Based on recaptures of identified individuals from camera trap data within the Bornean Banteng Programme study areas, a total of 30 individuals were recognisable using scars (Figure 11), markings and cow-calf associations where markings were absent, and many of these were recaptured in multiple areas. The bantengs formed large herds, comprised up to 20 individuals. A large number of captures were not possible to identify due to poor visibility, lack of scars or insufficient coverage of multiple features and angles. The population size estimate of the areas survey is a crude estimate and does not represent the genetic diversity.

Figure 11: A large mature bull recognisable by a damaged left ear and multiple scars on the body. This individual was recaptured on multiple occasions and at four different camera trap stations, indicating a minimum travel distance of ~5km.

Breeding activity

Evidence of breeding and survival of calves was observed in Kuamut using the camera trap data. At least three calves were observed in the duration of the study, one was very young and probably born early March 2015 (Figure 12). Two other calves, which were probably born to the same herd and around the same time were estimated to have been born around October 2014 and were approximately ~5 months old when observed, based on horn length.

Figure 12: A new born calf captured on camera trap on 8th March 2015 in Kuamut Forest Reserve.

Population genetic structure

During camera trap surveys, a total of 11 faecal samples were collected for DNA extraction. Samples and molecular analysis using mtDNA on this subpopulation are currently in progress at the Lok Kowi Laboratory in Kota Kinabalu following the same procedures as those outlined in the PhD thesis of P. Gardner (2015). Due to the small sample size, there remains considerably potential to collect samples from Kuamut in the future, given that access and permission are granted. The distribution of faecal samples collected from Kuamut can be found in Figure 13.

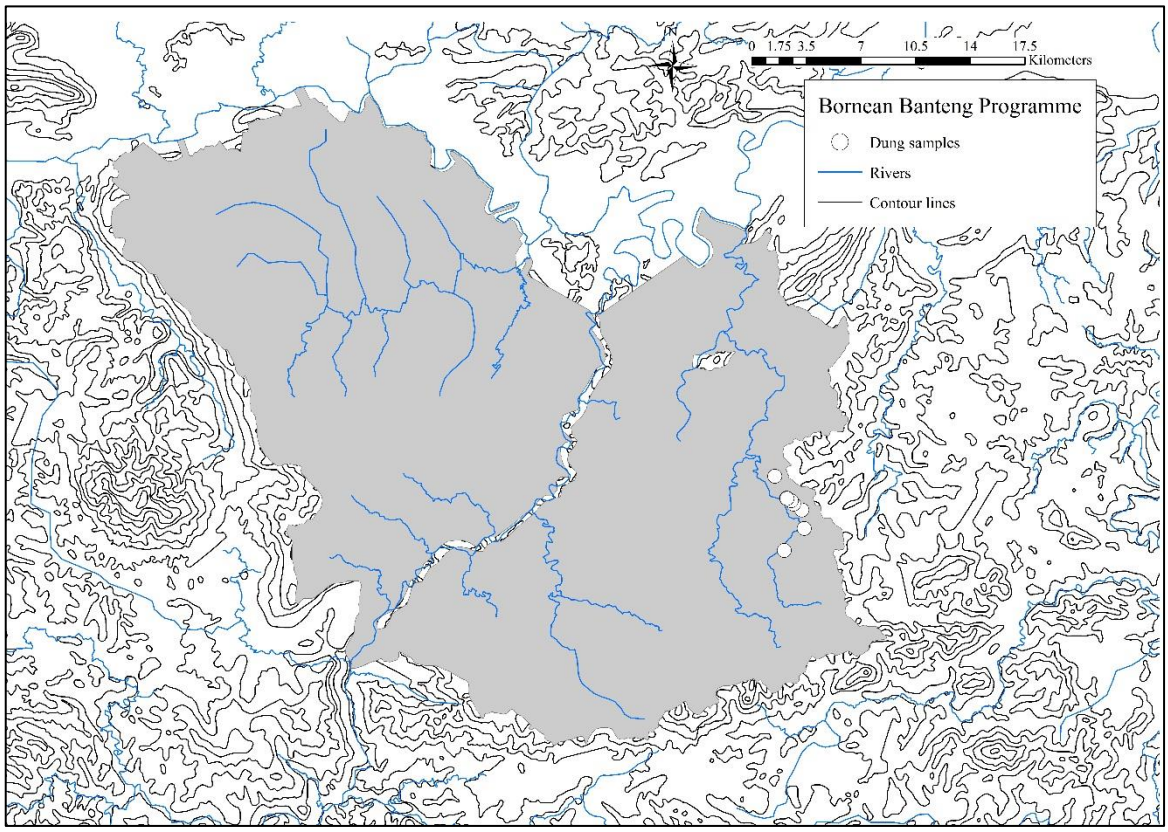

Figure 13: The distribution of dung samples collected for molecular analysis in Kuamut Forest Reserve during field work in 2015-2015.

Major threats

Illegal activity recorded in Kuamut

The number of illegal activity events recorded using camera traps and direct observations were relatively low in Kuamut compared to other forests (27), and comprised (6) events capturing hunting activity including hunters with firearms, (10) stolen camera traps, (5) gaharu harvesting events, (3) rubbish, and (3) events of encroachment with unknown purpose including 4x4 vehicle access. See Figure 14 for the distribution of this activity across the reserve. See Appendix 2 for images of illegal activity.

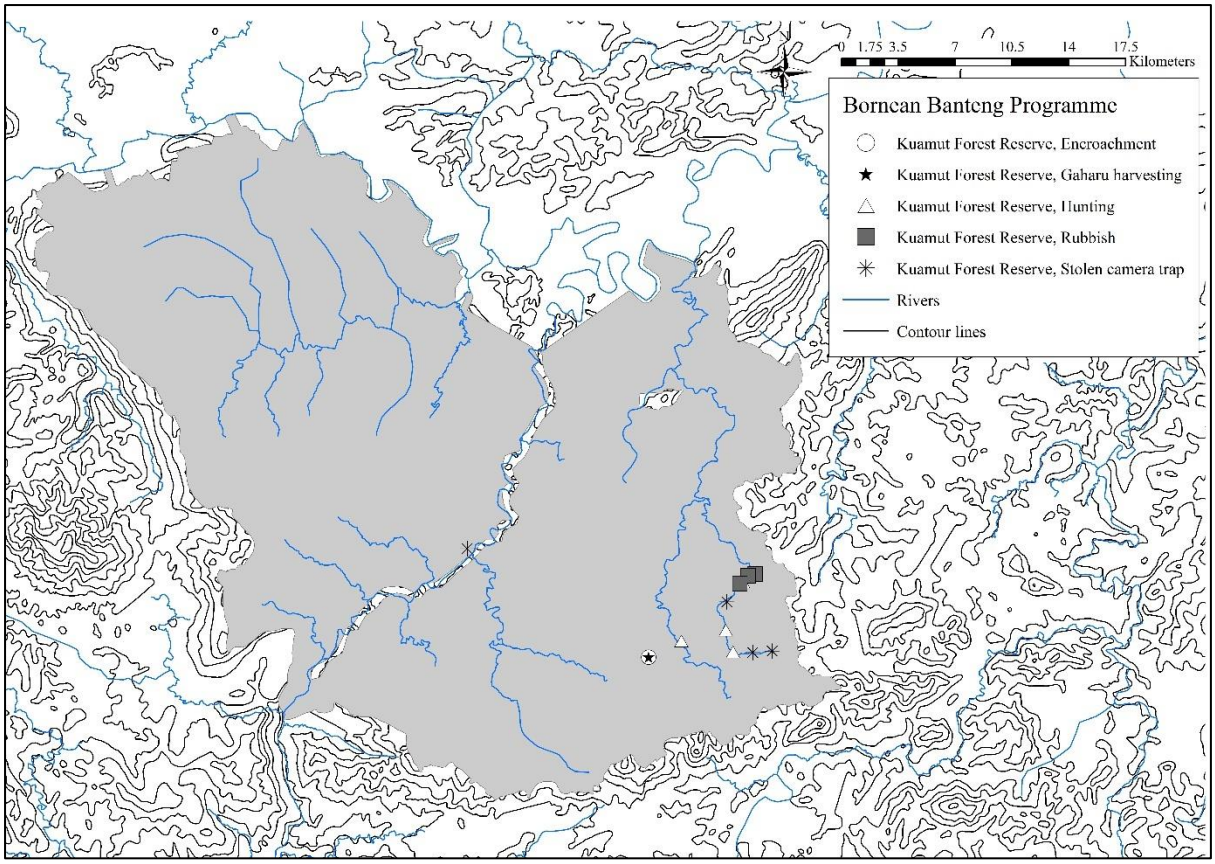

Figure 14: The distribution of illegal activity in Kuamut Forest Reserve displayed according to the nature of the activity recorded.

Strengths and weaknesses of the reserve

Based on the information and observations collected during the banteng survey, the perceived strengths and weaknesses in the security of Kuamut in respect to security of banteng are detailed in Table 1.

Table 1: The security weakness and strengths of Kuamut Forest Reserve as perceived during field work conducted between 2014-2015, which threatens the protection of wildlife including the bantengs but also other game and bird species.

Security weaknesses of Kuamut	Security strengths of Kuamut
Armed poachers enter freely into reserve using motorbikes and on-foot during the night and during the daytime without being apprehended, whilst encroachment seems to also occur using 4x4 vehicles and also possibly staff from Borneo Rainforest Lodge.	Forest officers in nearby Malua are experienced in handling unwanted and aggressive people and there are holding facilities in the ulu-Segama Malua headquarters approx. 2 hours drive away.
SFD staff and Malua BioBank staff have witnessed persons carrying an AK47 within Kuamut in 2011. Hunters regularly use firearms, and were actively removing camera traps within Kuamut Forest Reserve.	There are a relatively large number of forestry staff and researchers operating in Danum, Sabah Biodiversity Experiment and from Malua who could provide backup in emergency situations if communication links and protocols were in place.
Gaharu harvesters were active within the reserve in groups of ~6 people, and may have roamed between Malua and Kuamut due to the ease of access along rivers and logging roads.	Sabah Forestry Department have the capacity to ensure communications are maintained with researchers actively working in the field who may encounter illicit activity, which may facilitate effective conservation work in a commercial forest.
Old logging roads were accessible and visible, and facilitated access by poachers. As wildlife, particularly banteng, heavily utilise logging roads for foraging, they are subject to increased human-wildlife conflict in these areas.	Logging roads provide relatively easy access when bridges are not collapsed and staff could easily patrol these on foot or establish ambushes. Could utilise a monitoring tool like SMART to strengthen and motivate wildlife patrols.
Lack of comprehensive data of illegal activity to identify poaching hotspots and patterns in hunting activity to inform enforcement and patrols within Kuamut.	Data on illegal activities may serve to inform anti-poaching patrols by departments in the future, and provide a basis for conducting further investigations over vehicular access and the activities by contractors and villagers within the reserve.

Other species records

Species diversity

Including banteng, a total of 17 mammals and 4 bird species were recorded in Kuamut by camera traps and by direct observations (Table 2). Refer to Figures 15 for images of banteng and 16 for images of other fauna. Due to the height and positioning of the camera traps, many other species could have been missed, therefore our list is not thought to be exhaustive. There is huge scope for a more thorough wildlife inventory using both ground based direct observations and camera traps.

Figure 15: Bornean banteng in Kuamut Forest Reserve captured on camera trap between 2014 and 2015 by the Bornean Banteng Programme.

Figure 16: Species captured on camera trap in Kuamut Forest Reserve. From top left to right. Bornean elephant and calf, sambar deer and fawn, red leaf monkey, orangutan and bearded pig.

Table 2: List of species recorded in Kuamut Forest Reserve using camera traps an direct observations by the Bornean Banteng Programme between 2014-2015.

Common name	Latin name
Mammals	
Bearded pig	*Sus bartbatus*
Bornean clouded leopard	*Neofelis diardi bornensis*
Bornean pygmy elephant	*Elephas maximus borneensis*
Bornean sun bear	*Helarctos malayanus*
Bornean yellow muntjac	*Muntiacus atherodes*
Borneo banteng	*Bos javanicus lowii*
Brooke's squirrel	*Sundasciurus brookei*
Malay badger	*Mydaus javanensis*
Mongoose	*Urva spps*
Mousedeer	*Tragulus spps*
Orangutan	*Pongo pygmaeus*
Pig-tailed macaque	*Macaca nemestrina*
Porcupine	*Hystricidae spps*
Red langur	*Presbytis rubicunda*
Red muntjac	*Muntiacus muntjak*
Sambar deer	*Cervus unicolor*
Unknown bird	*NA*
Unknown rodent	*NA*
Unknown squirrel	*NA*
Yellow -throated marten	*Martes flavigula*
Birds	
Bornean crested fireback	*Lophura ignita*
Coucal	*Centropus spps*
Great argus pheasant	*Argusianus argus*
Spiderhunter	*Arachnothera spps*

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Appendices

Appendix 1

Appendix 1: From top left to right: A group of men with two 4x4 vehicles numbered 176 and 227, pulling them through the forest at night from 8pm-2am on 23rd November 2014, and who covered up camera traps with mud to conceal their identities. This old logging road was recently reopened by the 24th Imbak Canyon International Off Road Challenge 23rd Oct - 2nd Nov 2014 sponsored by Isuzu.

Appendix 1 continued: Top row: A group of six gaharu harvesters seen on multiple occasions in Kuamut. Middle row (Left to right) Two armed hunters on motorbike, two armed hunters walking together, remains of a sambar deer which was skinned in the forest. Bottom: A man appearing to wear a Borneo Rainforest Lodge t-shirt that was captured within Kuamut covering camera traps with mud to conceal his identity.