Camera trapping as a conservation tool in a mixed-use landscape in East Kalimantan

Deni Wahyudi[1] and **Rob Stuebing**

[1]Conservation Department PT. REA Kaltim Plantations, Hulu Belayan, East Kalimantan, Indonesia

Corresponding author: Rob Stuebing, email: *robstuebing@gmail.com*

Abstrak

Perangkap kamera telah digunakan dari 2008-2012 untuk survey dan pemantauan satwa liar pada perkebunan kelapa sawit di Kalimantan Timur. Sebanyak 40 kamera dipasang secara berotasi pada habitat utama di lebih dari seratus lokasi hutan yang rusak dengan tingkat usia berbeda, di kawasan yang telah ditetapkan perusahaan sebagai kawasan lindung dan di blok kelapa sawit yang berumur 4-12 tahun. Kesemuanya berada atau berdampingan dengan batas areal operasional PT REA Kaltim. Kamera dipasang selama 8628 hari atau sekitar 4.5 tahun (Januari 2008-Juni 2012) disepanjang jalur hewan atau lokasi adanya sarang orangutan atau bukti lainnya dari aktivitas satwa. Sebanyak 36 jenis mamalia dari 21 famili dapat diidentifikasi dari foto yang diperoleh dalam areal studi. Sekitar 54% diantaranya jenis yang dilindungi hukum Indonesia. Jenis yang paling banyak terfoto adalah Beruk, *Macaca nemestrina,* berjumlah 1.450 foto, diikuti oleh babi jenggot, *Sus barbatus*, berjumlah 1.126 foto. Beberapa jenis, seperti *Arctogalidia bivirgata*, tidak pernah terfoto oleh kamera yang dipasang pada permukaan tanah. Hasil ini cukup menggembirakan untuk kegiatan konservasi satwa, terutama relatif besarnya jumlah jenis mamalia yang ditemukan, menghuni mungkin 18% areal hutan yang berbatasan dengan perkebunan. Berikut disajikan sebuah bahasan singkat mengenai rencana pengelolaan oleh REA Conservation Management Plan.

Abstract

Camera traps were used from 2008-2012 to survey and monitor wildlife within an oil palm plantation in East Kalimantan. A total of 40 trail cameras were rotated through major habitats at over a hundred sites in disturbed forests of various ages of the company's designated Conservation Reserves, and in oil palm blocks from 4-12 years old, all within or adjacent to PT. REA Kaltim operational boundaries. Cameras were set for a total of 8628 camera-nights over approximately 4.5 years (January 2008 - June 2012) along animal trails or at sites with orangutan nests or other evidence of animal activity. A total of 36 species of mammals from 21 families could be identified from photographs within the study area. Approximately 54% of species photographed are legally protected in Indonesia. The most photographed species was the Pig-tailed Macaque (*Macaca nemestrina*), total 1450 photos, followed by the Bearded Pig (*Sus barbatus*), total 1126 photos. Some species, such as Small-toothed Palm Civet, *Arctogalidia bivirgata*, were never photographed by ground-based cameras. The results are encouraging for species conservation, primarily because of the relatively large number of mammal species that have been found to inhabit perhaps 18% of the originally forested area of the plantation boundaries. A brief summary of subsequent actions taken under the REA Conservation Management Plan is provided.

Keywords: Camera trapping, oil palm, wildlife conservation, orangutans, East Kalimantan, Borneo

Introduction

The island of Borneo is one of the most biodiverse units of the Sunda Region (Azlan and Engkamat, 2006), but has undergone rapid agricultural development, especially for the oil palm (*Elaeis guineensis*). Palm oil is one of Indonesia's largest foreign exchange earners, with several million metric tons exported, valued at over ten billion US Dollars in 2011. Oil palm plantations continue to expand across landscapes in Sumatra, Kalimantan and most recently, in West Papua.

The PT. REA Kaltim Estates (REA Kaltim), a foreign-owned but Indonesian operated plantation company, occupies an approximately 30,000 hectare site in the upper region of the Belayan River, a tributary of the Mahakam River in East Kalimantan. Prior to 1970 the upper Belayan watershed was densely forested with

Received 31st October, 2013; Revision accepted 12th December, 2013

timber species of commercial diameters ≥ 60cm. Some riparian areas contained regenerating forests derived from old patches of villagers' shifting agriculture plots. Whitmore (Whitmore and McKenzie, 1995) surveyed the area in the mid-1990s and compiled REA Kaltim's earliest environmental impact assessment. They indicated that the forests were rich in both flora and fauna, and he recommended protecting substantial areas within the plantation, along rivers as well as areas too wet (swampy) or steep for productive cultivation (Whitmore and McKenzie, 1995).

The cultivation of oil palm on a large scale is one of the most serious causes of the decline in Southeast Asia's biodiversity in general, with losses of up to 85% by the year 2100 (Koh and Wilcove, 2009; Sodhi, et al., 2010). In 2007 a Conservation Department (REA KON) was activated to address important issues in the area of the PT. REA Kaltim Estates, initially focusing on the conservation of orangutans (*Pongo pygmaeus*). This species was regularly observed in forested areas within the company's land title (Hak Guna Usaha) and had caused damage to palm seedlings, eating the central shoot. In 2007, an adult orangutan allegedly bit an estate worker. The work of REA KON rapidly expanded into a general evaluation, monitoring and assessment of the wildlife of the total plantation area of more than 25,000 hectares, of which just under 20% remained forested, and was subsequently proposed as permanent conservation reserves (CR).

During Whitmore's surveys in 1994, the upper Belayan was still under secondary forests, although substantial damage to the canopy had been caused by intensive timber extraction, particularly along the northern bank. In 1996 oil palm planting began along the south/west bank of the river. By 2007, forest remnants remained only in moist areas of the river's flood plain, as well as peat swamp forests, but even these areas again suffered serious damage in 1983 (Whitmore, 1995) and more extensively during the 1997-1998 El Niño Southern Oscillation (ENSO). Some oil palms were also damaged, but virtually all survived the fire.

REA Kaltim was the first oil palm company to develop extensive plantations the Upper Belayan landscape. Although soil and crop suitability surveys began as early as the late 1980s, the company finally established a presence in 1995 via an office located on a raft at the riverside at a site now known as Pulau Pinang (H.L. Schaefer, Pers. Comm.) Along the banks of the Belayan, its plantations now cover about 30,000 Ha, of which about 18% was set aside for conservation (http://www.rea.co.uk/rea/en/business/history). These CRs consist mostly of riparian forests, areas with unique habitats such as peat swamp or wetlands, and a few steep areas of more than 25° slope. Experience has shown that such formally identified and managed CRs contribute significantly to local species diversity, especially some endangered species still persisting in these forests.

A minimum of 285 mammals species have been identified on Borneo (Earl of Cranbrook, Pers. Com.) of which over half are terrestrial species. A relative modest number are mentioned in environmental reports held by REA Kaltim's management. Since species richness is an important indicator of environmental quality (Kitamura et al., 2010), widespread persistent biodiversity reflects successful conservation management. Loss of original species from the landscape and negative impacts from human disturbance signals significant deterioration in the conservation values of an area.

Mammals are often difficult to detect, even from the most careful walking surveys. Many are cryptic and nocturnal, while others quickly learn to avoid humans. This scenario especially applies to forested habitats outside protected areas.

Rapid development in the use of camera traps over the past decades has improved the ease of detection of both common and cryptic mammal species (Azlan and Sanderson, 2007; Cheyne, et al., 2010). In 1997, WWF-Indonesia introduced the use of camera traps for biological inventories in the hill and submontane forests of Kayan Mentarang National Park in East Kalimantan and, combined with data from walking surveys, reported a total of 94 mammal species (Wulffraat and Samsu, 2000). Research using camera traps at numerous sites in Kalimantan and Malaysian Borneo has been used to inventory mammal species from protected areas (Mohd. Azlan et al., 2003; Kawanishi and Sunquist, 2003, Azlan and Engkamat, 2013) as well as in disturbed areas such as logged forest (Mohd-Azlan and Sharma, 2006, Mohd-Azlan, 2006), tree plantations (Belden, et al., 2007, Giman, et al. 2007; McShea, et al., 2009), and degraded rural habitats occupied by humans (Rustam, et al., 2010).

By implementing long term inventory and monitoring of mammal species within and at the boundaries of REA Kaltim, the purpose of this study was to determine whether the company's permanently forested CRs actually serve their stated purpose as refugia for biodiversity, especially mammal species. This effort

also seeks to provide additional information into the ability of an indigenous mammal fauna, especially Rare, Threatened or Endangered species, to persist in mixed-use landscapes. The present inventory was set up to obtain empirical field data concerning the survival of Endangered biodiversity within REA Kaltim's operational area, especially orangutans (*Pongo pygmaeus*). Camera trapping was more intense and repetitive in areas where orangutans were detected because of their conservation status and the need for long-term monitoring of this species. We hope that the value of the conclusions can be validated over a longer period, as data collection through camera trapping continues at these sites.

Study area

The study took place within riparian and dryland areas within the PT. REA Kaltim Plantations land title boundaries (Latitude : 00 9' 30"N – 00 31' 39"N ; Longitude : 1160 3' 24" E – 1160 27' 33" E), mostly within the approximately 5,000 hectares of its CRs (Fig. 1). These patches of secondary forest remnants lie mostly along small rivers, although some are isolated within oil palm blocks. All have undergone several cycles of licensed mechanical logging, illegal timber harvesting, and in some cases ENSO fires. The canopy is often less than 10m high and frequently dominated by pioneers such as *Macaranga gigantea* and *Melicope glabra*. Large remnant trees of the Dipterocarpaceae are widely dispersed, some species now only surviving as saplings. Of the existing trees >50 cm DBH, only few are dipterocarps. Most are non-timber species such as *Irvinia spp.* and other members of the Euphorbiaceae. Multitudinous gaps of new growth or belukar often connect forest patches. Dayak villagers still claim areas for slash-and-burn agriculture away from the main river and up several kilometers of most navigable streams. These disused plots exist in various stages of recovery from less than ten years, to several decades old. Most are rich in both wild and cultivated fruit trees.

Methods

Camera traps by Trailwatcher© 2035 Digital Scouting System, consisting of a SONY Cybershot 7.1 Megapixel (MP) camera equipped with an external infrared sensor, in a Pelican Model 1020 housing, assembled and sold by David Helmly, Monticello, Georgia USA. This heat sensor based camera is durable and reliable, working well in the humid tropics of Kalimantan.

All but two of the Trailwatchers units used a Sony Cyber Shot 7.1 MP, except for two newer Models (W55) equipped with 12.1 MP SONY cameras. All Trailwatcher cameras are triggered by thermal sensors reacting to the presence of a heat source within a distance of 10-12 meters. The cameras were oriented along a generally North-South axis to avoid "ghost" images caused by direct sunlight or its reflection from the surrounding vegetation. All camera trap positions were recorded using a GPS (Garmin 60CSx), and have a time/date stamp for every image.

A total of 40 trail cameras were rotated through the major habitats of the PT. REA Kaltim operational area (Fig. 1). These included oil palm blocks from 4-12 years old, and disturbed forests of various ages that have resulted from episodes of intense logging, and or fires set either to clear areas for planting oil palm, for slash-and-burn farming or related accidental fires occurring during periods of extended drought. We attempted to obtain a general picture of the distribution of the mammal fauna of these areas based on an assessment of species recorded by the camera traps. The cameras were set in forested areas, 50-200m from the edge of streams/rivers that serve as a buffer for small rivers that traverse oil palm blocks. Camera units were strapped to trees ±50cm above the ground flanking wildlife trails, and a scent lure placed into the crevice of a stick ±3m in front of the camera. During the last few months of the study (424 camera days), 17 camera units were set up in trees within the CRs, 10-12m above the ground.

Commercial lures were used to attract animals to the cameras, including, Blackie's Blend Three Meat scent lure, Carman's Magna Glan and Fox Hollow-Coyote Gland lures; Caven's Cat Passion lure; O'Gorman's Powder River Paste, and Cat Call Lures; Marsyada's Midnight Mist; and a home-made Margarine-Honey mix.

Camera images were downloaded, and batteries checked every two weeks, the latter replaced whenever necessary. Cameras were removed after one month and moved to a new location at least 500m away. All sites where orangutans had been photographed were revisited annually.

Cameras were set in pairs in representative habitat types along animal trails in all the REA Kaltim CRs.

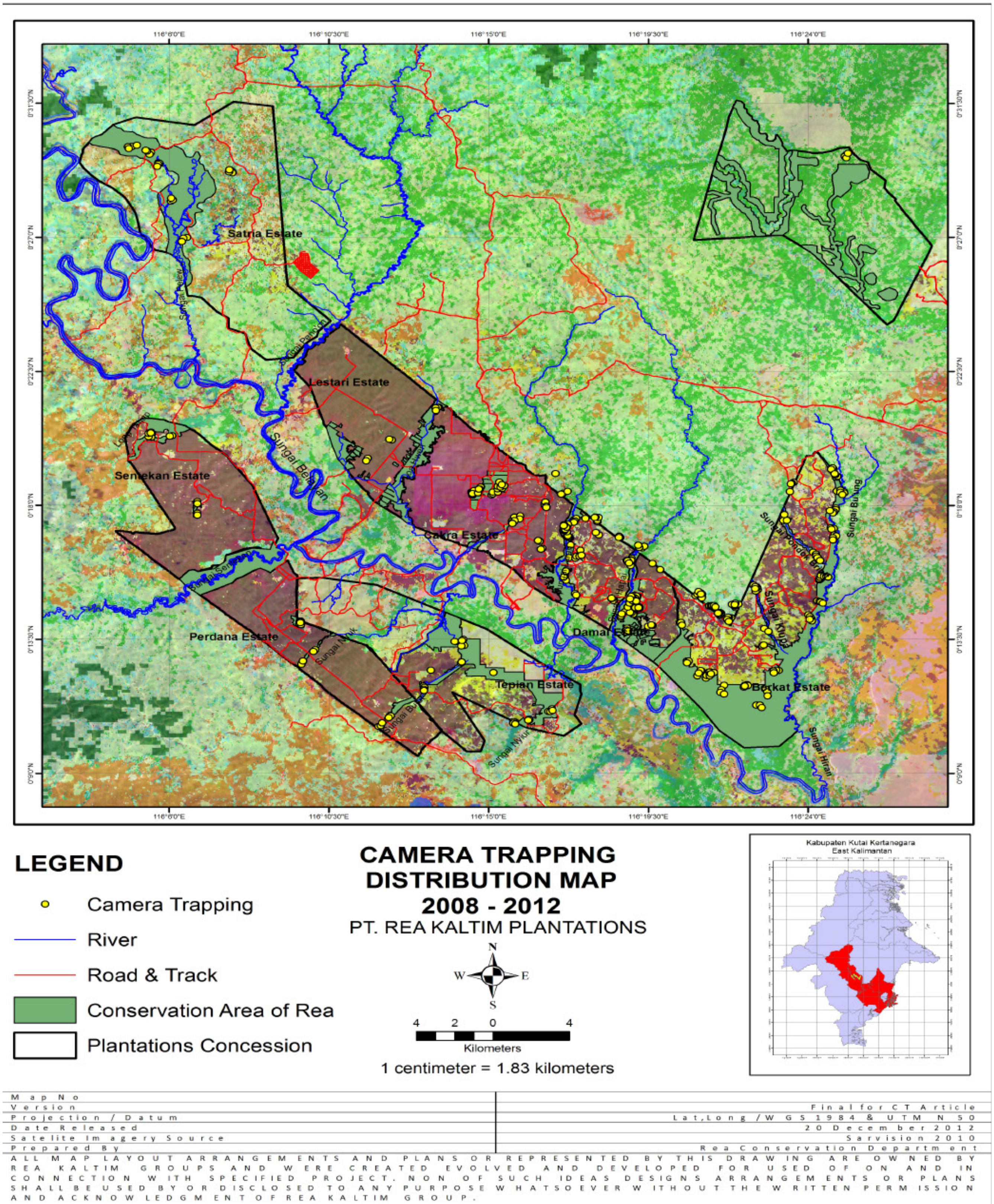

Figure 1. Map of the survey area and camera trap locations. A total of x8628 trap nights over 4.5 years recorded 36 species of mammals from 21 families.

Identifiable habitat types were: Lowland Dry Forests (HDRK), freshwater wetland or Flood Plain Forest (HR), and Peat Swamp Forest (HDRB). Camera traps were installed in oil palm blocks for a total of 19 camera-days. REA KON staff conducted regular surveys for other mammal species to determine their presence and distribution over a majority of the habitats within REA's operational area.

Results

A total of 8628 trap nights over approximately 4.5 years (January 2008 - June 2012) recorded 36 species of mammals from 21 families in the study area (Table 1). Approximately 54% of species photographed are legally protected in Indonesia (Decree 7, 1999). The most photographed species was the Pig-tailed Macaque (*Macaca nemestrina*) total 1450 photos, followed by the Bearded Pig (*Sus barbatus*), total 1126 photos. Carnivora and Pholidota were represented by nine species each (Tab. 1), followed by Primates (seven species) and Artiodactyla (four species) (Tab. 1).

Records of the activity patterns of most mammal species recorded by the cameras were not at variance with any records previously reported. All Primates except for *Tarsisus bancanus* were photographed exclusively during the day (Fig. 2), but were observed to differ in their sleeping habits. *Macaca nemestrina* slept in the low canopy (<10m) of small trees, while *M. fascicularis* slept higher up, in any remaining older emergents. All images of *Manis javanica* were obtained either in the late afternoon, or late at night and *Muntiacus spp*. were mostly photographed in the evening (1700-2100hrs) (Fig. 2), with one pair active just after midnight (0142hrs). *Sus barbatus* was active at virtually all hours of the day or night (Fig. 2).

Orangutans were routinely photographed in the Conservation Reserves of four estates. In Belayan, this species appeared to frequent land with a relatively flat contour containing a variety of freshwater marsh and peat swamp habitat. They were commonly recorded

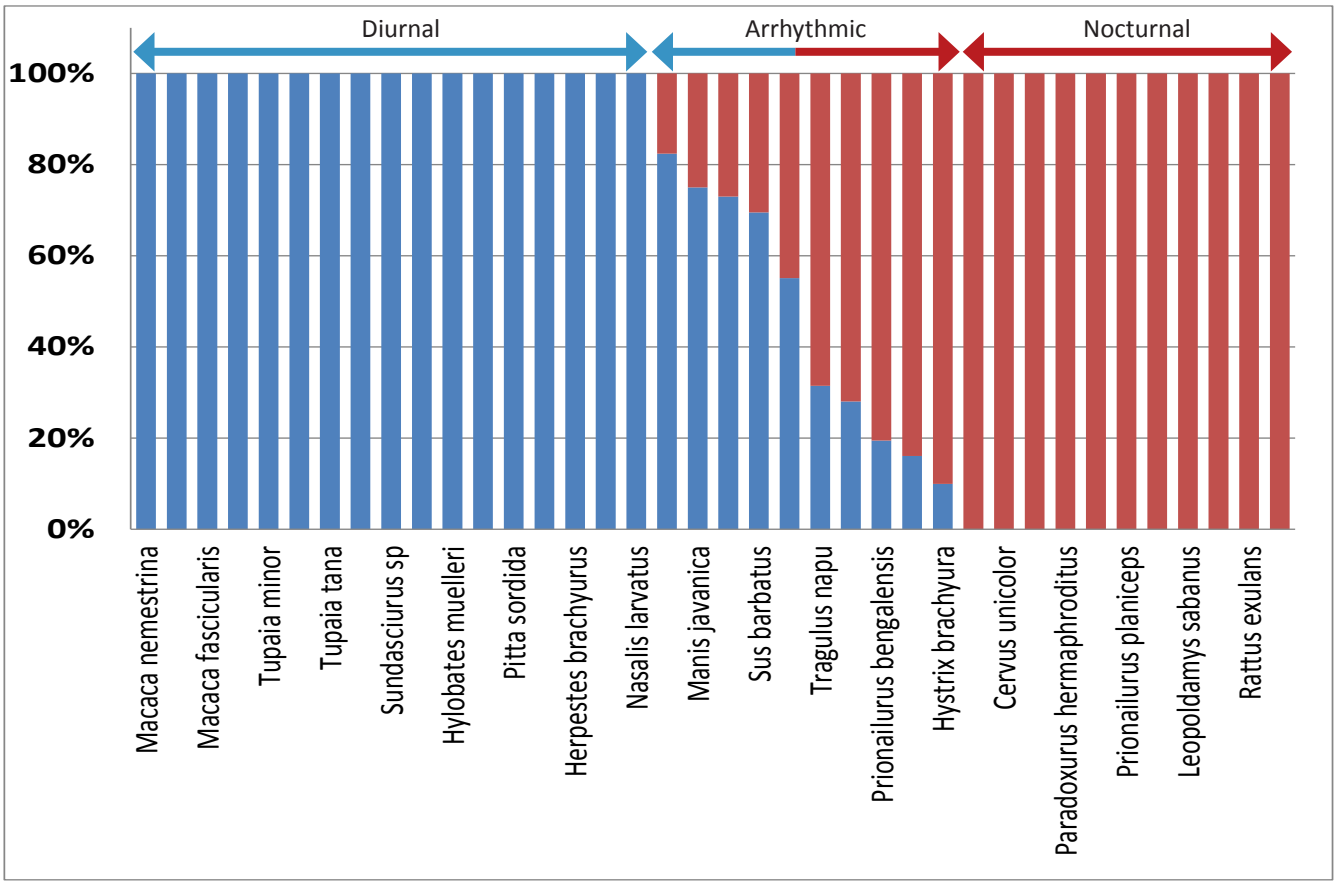

Figure 2. The diurnal rhythm of 19 different species recorded in this study. All primates except for *Tarsisus bancanus* were diurnal, whereas most of the carnivores and rats were nocturnal. The absence of predators like clouded leopard, *Neofelis diardii* may explain why bearded pigs, *Sus barbatus*, were active throughout the day and night.

Table 1. A list of species recorded from the study. DF = dry forest; WF = wet forest; BER =; DAM =; TEP =; etc etc; G = recorded on ground; A = recorded as arboreal.

Family/ Species	Latin name	English name	Num	Estate	Habitat	Pos
INSECTIVORA						
Erinaceidae	*Echinosorex gymnurus*	Moonrat	42	BER, DAM, TEP, SAT	DF, WF	G
SCANDENTIA						
Tupaiidae	*Tupaia gracilis*	Slender treeshrew	21	DAM	DF	A
	Tupaia minor	Pygmy treeshrew	49	BER, CAK	DF	A
	Tupaia tana	Large treeshrew	31	DAM, BER	DF, WF	G
PRIMATES						
Tarsidae	*Tarsius bancanus*	Western tarsier	1	DAM	DF	G
Cercopithecidae	*Presbytis rubicunda*	Red leaf monkey	7	DAM	DF	A
	Nasalis larvatus	Proboscis monkey	1	TEP	WF	A
	Macaca fascicularis	Long tailed macaque	438	TEP, DAM, SEN, PER, BER, SAT, LES	DF, WF	G, A
	Macaca nemestrina	Pig tailed macaque	1450	All estates	DF, WF	G
Hylobatidae	*Hylobates muelleri*	Bornean gibbon	7	BER	DF	A
Pongidae	*Pongo pygmaeus*	Orangutan	178	BER, DAM, CAK	DF, WF	G
PHOLIDOTA						
Manidae	*Manis javanica*	Pangolin	8	DAM, CAK, PER, TEP	WF	G
Rodentia						
Muridae	*Leopoldamys sabanus*	Long-tailed giant rat	5	SAT	DF	G
	Rattus exulans	Polynesian rat	1	DAM	DF	A
	Sundamys muelleri	Mueller's rat	4	BER, DAM	DF	A
Sciuridae	*Callosciurus notatus*	Plantain squirrel	978	BER, DAM, CAK, LES, PER, TEP, SEN	DF, WF	G, A
	Callosciurus prevostii	Prevost's squirrel	13	CAK, SAT, SEN	DF	G
Hystricidae	*Hystric brachyura*	Common porcupine	272	BER, DAM, CAK, SEN, SAT	DF, WF	G
	Trichys fasciculate	Long-tailed porcupine	16	SAT	DF, WF	G
	Thecurus crassispinis	Thick-spined porcupine	274	BER, DAM, CAK, LES, SEN, PER	DF, WF	G
CARNIVORA						
Ursidae	*Helarctos malayanus*	Sun bear	49	BER, DAM, CAK, LES, SAT	DF, WF	G
Mustelidae	*Martes flavigula*	Yellow-throated marten	3	BER	DF	G
Viverridae	*Arctogalidia trivirgata*	Small-toothed palm civet	40	DAM	DF	A
	Hemigalus derbyanus	Banded palm civet	23	BER, SAT, TEP	DF	G
	Paradoxurus hermaphroditus	Common palm civet	39	CAK, DAM, SAT	DF	G
	Viverra tangalunga	Malay civet	239	BER, DAM, CAK, SAT	DF	G
	Herpestes brachyurus	Short-tailed mongoose	4	BER	DF	G
Felidae	*Prionailurus bengalensis*	Leopard cat	113	DAM, BER, CAK, SAT	DF	G
	Prionailurus planiceps	Flat-headed cat	16	TEP, DAM, PER	DF, WF	G
ARTIODACTYLA						
Suidae	*Sus barbatus*	Bearded pig	1126	BER, DAM, CAK, SAT, SEN	DF, WF	G
Tragulidae	*Tragulus napu*	Larger mouse deer	626	BER, DAM, TEP	DF, WF	G
Cervidae	*Cervus unicolour*	Sambar deer	89	BER, DAM, CAK	DF	G
	Muniacus sp	Barking deer	176	BER, DAM, CAK, SAT	DF	G

on the forest floor, although walking surveys indicated that especially younger individuals spend much of their time in the low canopy of the disturbed/logged over or previously farmed regenerating forests.

All four species of the Viverridae were photographed at night only. *Viverra tangalunga* was always recprded on the ground in forested CRs whereas *Paradoxurus hermaphroditus* was photographed in tall oil palm (ca. 12 years old). *Hemigalus derbyanus* were only rarely seen in the study area, based on the number of images acquired, and *P. hermaphroditus* and *Arctogalidia trivirgata* were photographed in trees only.

Prionailurus bengalensis was one of two carnivores (along with *Paradoxurus hermaphroditus*) photographed inside the oil palm blocks. An active predator of rodents, an individual *P. bengalensis* was photographed at the edge of an oil palm block carrying a rat, *Rattus cf. tiomanicus* in its mouth.

Sus barbatus was detected both day and night (24 hours) (Fig. 1), and photographed in all forest types, as well as in the planted blocks. More than 80% of bearded pigs photographed were groups of from two to twelve individuals, on occasion a female with nursing young, or subadult siblings already foraging on their own.

Muntiacus spp. (*Muntiacus muntjac* and *M. atherodes* could not be distinguished) were photographed primarily on the North bank of the Belayan, which is contains larger CRs, and in the at the time undeveloped and mostly forested Satria Eastate across the rive. Camera images indicated a general activity range as late as 21.00 - 01:00 hrs (Fig. 1), overlapping with that of the sympatric *Sus barbatus*. *Muntiacus* were frequently photographed in pairs. Sambar deer, *Cervus unicolor*, was photographed in forested CRs exclusively on the North bank, and never in the older, more populated and developed estates across the river. Sambar deer were active primarily late at night and during the early morning hours (89 total photos, taken between 2200-0400 hrs (Fig. 1).

Discussion

The objectives of this work have inadvertently gone beyond the original purpose, to survey and monitor a small population of orangutans affected by development of the PT. REA Kaltim Plantations in East Kalimantan. Nevertheless, the results are encouraging for species conservation, primarily because of the relatively large number of mammal species that have been found to inhabit 18% of the originally forested landscape (REA Conservation data, PT. REA Kaltim Plantations, 2012). Several species (*Pongo pygmaeus*, *Helarctos malayanus*, *Prionailurus planiceps*) assumed to be seriously threatened by plantation development and rising human population densities, still persist in the area, and have been routinely recorded on camera from 2008-2012. There was no verifiable loss of species from either the REA Conservation Areas or from the adjacent landscape during the study interval, although several species (*Martes flavigula*, *Herpestes brachyurus*) required a time span of continuous camera trapping of almost four years before their existence could be confirmed.

Camera trapping studies outside protected areas in Borneo have generally been conducted for less than one year, recording from 18–21 mammal species (Azlan and Engkamat 2006; Mohd-Azlan and Engkamat 2013). In some cases, the total number of species has not been mentioned since the targets were specific groups, such as small carnivores (Wells, et al. 2005; Brodie and Giordano 2011; Cheney, et al. 2010; Cheyne and MacDonald, 2011; Mathai et al. 2010). Few studies have extended for more than three years, the longest in Sarawak (Belden, et al. 2007) and another in East Kalimantan (Rustam, et al. 2010). Both of these studies were undertaken in areas of degraded forest with scattered human occupation. Both also demonstrated the existence of many more mammal species than might have been predicted based exclusively on the condition and high level of disturbance of the habitat.

In general, more mammal species in Hulu Belayan were photographed along North/East bank of the Belayan River, compared to those seen on the South/West bank. Species recorded exclusively on the north bank totaled 19, exclusively found on the south bank, only two, while a total of 14 species were photographed on both sides of the river. These results were likely influenced by camera trapping effort, with four times more trapping days in the north bank, compared to the south bank. The south bank is also less forested, and has a higher density of human population compared with the north. In any case, surveys restricted to one or the other side of the Belayan would have provided quite differing outcomes.

Orangutans are confined exclusively to the northern side, except for a single unconfirmed report from the SYB Tepian Estate, an area with some stands of original

peat swamp forest across from the Damai Estate, where orangutans are consistently seen.

Orangutans continue to occupy the Damai and Berkat Conservation Reserves, although this population has never been reported in any published survey articles previously on the distribution of the species. Perhaps because of the low canopy in all forests within the operational area, orangutans of all ages, and not just large adults, were photographed on the ground. It has been suggested that the subspecies *Pongo pygmaeus morio* of East Kalimantan spends more time on the ground than other subspecies of orangutan (Ashley Leiman, Pers. Comm.). No orangutans were ever photographed in the heavily forested areas of the Satria estate of the South bank, and little evidence was seen of their presence, possibly because of the proximity of a several villages, and several active coal mining concessions. One encouraging aspect for conservation of this species in the areas adjoining the Damai and Berkat Eastates was that over four years, the cameras photographed four new babies still nursing from their mothers (two in Berkat Estate in 2010, and one in 2011; one in Damai Estate, 2012).

In Lambir Hills National Park, Azlan and Engkamat (2006) identified 11 families and 18 species of mammals. *Macaca nemestrina* was most frequently photographed (63 photos), as was the case in the Belayan study. However, in Lambir Hills photos of large mammals were infrequent, and only a single bearded pig was photographed over 1127 camera trap-nights. Their perceived low densities were attributed to illegal hunting. Such speculations were however not supported by direct evidence (dead animals, carcasses, interviews concerning declining rates of offtake, etc). By comparison, hunting of large mammals (pigs, muntjac and deer) was observable, routine and often intense throughout the REA plantation areas from 2008-2012. Nevertheless, *Sus barbatus* and *Muntiacus spp*. remained abundant. Sambar Deer, *C. unicolor*, were present, though less common. In 1994, deer densities in the old forests of the Lanjak-Entimau Wildlife Sanctuary were low, ironically except in the disturbed areas in the northern portions of the reserve with higher human densities, and where hunting is frequent (Raleigh Blouch, Pers. Comm.). Thus, differences in abundance of large mammals in forested protected areas of Borneo may have less to do with hunting, and more closely tied to the nature of the habitat. For example, bearded pigs in the heavily forested Danum Valley Conservation Area were found emaciated, dead, or in poor condition (ribs showing) in 2000, and this was viewed as related to a dearth of forest fruits (Wong, et al., 2005). Interestingly, in the project area in Hulu Belayan, no emaciated pigs were ever photographed, although ribs were visible in about 20% of the individuals seen in images during an extended month-long drought in 2009. *Sus barbatus* appeared throughout the year in cameras representing all habitats, almost always in groups of two or more, and including sites near human habitation such as worker emplacements and plantation offices.

Carnivores were mostly photographed in low numbers except for *Viverra tangalunga*, which appeared to be especially fond of the scent lures and spent considerable time rubbing itself on the lure stick or on the ground next to the camera. Images of other viverrids and mustelids were low in number, except for photos of *Arctogalidia trivergata* that were obtained quickly upon cameras being set in the tree canopy. *Martes flavigula* photographed in Hulu Belayan in the early morning (6:44), as it was in the Planted Forest Zone near Bintulu Sarawak (Giman, et al. 2007).

Although a subadult *Helarctos malayanus* was killed and eaten by Damai Estate workers in mid 2008, bears were still photographed every year in the estates of the North bank, though never on the south bank of the Belayan. Another photo by the staff of REA KON was provided of a female with two cubs in Damai Conservation Reserve, in mid-2013.

Felids were present, the most common images obtained from *Prionailurus bengalensis* that is widespread, and seen either in forested areas adjacent to estate blocks, or within the planted areas. It is a well-known predator of rats in palm oil plantations (Grassman et al., 2005; Rajaratnam et al., 2007), and its presence was expected. Images of *Prionailurus planiceps* were restricted to wet areas such as the edge of wetlands or from peat swamp forests. *P. planiceps* eats frogs, shrimp and fish (Banks 1949; Erlandson and Moss, 2001).

Identification of most murid rodents is difficult from camera trap images unless certain distinguishing morphological features are clearly apparent. However, it was somewhat startling to have collected 435 images of murid rodents from camera traps set in the tree canopy after 447 camera-nights for 15 months during 2010-2012, employing 18 camera units. Few could be identified to species, but virtually all appeared to be from the Genus *Rattus*.

Whereas none of the recorded species diurnal rhythms

differed significantly from what is previously recorded Azlan and Lading (2006) in Lambir Hills, Sarawak (Malaysia) reported that *Tragulus sp* are active only at night and never recorded in daylight, but in Belayan study area, *T. napu* was photographed feeding around noon (12:32hrs). The explanation for *Sus barbatus'* activity patterns throughout the day may imply an absence of large nocturnal predators, specifically *Neofelis diardii* as discussed by Ross et al (2013).

Interestingly, a water or common Monitor Lizard (*Varanus salvator*) investigated a camera on the ground. These images implied that the lizard's body temperature was higher than its surroundings, a situation known from this group (Traeholt, 1996). On the other hand, the small number of photos of pangolins may not reflect the true abundance. It has been suggested that if their scaly surface is not of sufficiently different temperature from the surrounding environment, it is possible that the infrared sensors of some trail cameras will only rarely detect this species.

Mixed use landscapes are rapidly increasing in area across the lowlands of Borneo/Kalimantan, with inescapable impacts on the original flora and fauna. Some researchers (Stevens, 1968; Payne et al., 1985; Mickleburgh et al.,1992; Nowell and Jackson, 1996; Laidlaw, 2000; Fitzherbert, et al., 2008; Koh and Wilcove 2008; Harrison 2011) have suggested that declines observed in many vertebrate species in wildlife surveys must be attributable to forest clearing for plantation agriculture such as oil palm. However, the results of this study suggest that such sweeping conclusions are not necessarily supported by the evidence, at least in some of the semi-forested mixed-use landscapes where many plantations have been developed.

Unfortunately, there is seems to be much more effort expended in hand wringing and decrying the loss of pristine forested habitats to both plantations (*Acacia* and oil palm) and coal mining than there is in seeking practical solutions that business interests will accept and implement. Although there is a place for appeals for an end to deforestation, the reality is that we know little about the relative survivorship of mammal species in these degraded areas. It is imperative that we understand which species can and will survive, which can disappear and perhaps which will become even more abundant. In view of the continuous modification of the landscape, companies such as plantations and mining must be encouraged to view biodiversity conservation as a rational and necessary component of their operational development. The results of this study imply that with attention paid to an intentional design of the landscape to include both planted and natural areas, and the presence of a science-based conservation program, that a significant portion of the mammal fauna – including so-called endangered "flagship" species such as orangutans, can persist (and breed) over relatively large areas, accompanied by perhaps a majority of the previously existing mammal species of the landscape. As the initial destructive impacts of plantation development die down, some species that may have previously been gone missing, may perhaps reappear at a later date. Finally, monitoring and assessment by a permanently resident conservation team with scientifically valid approaches is key to detecting and analyzing species and population trends.

Acknowledgements

We are very grateful to the Management Rea Kaltim for their continuous and strong support of the conservation programs of the Rea Conservation Department. Our sincere thanks also to Yusuf Lawey, Monica Kusneti, Sunardi, Sebastian Njau, Ingan Njuk, Kahang Aran, Daud Lenjau, Soeimah Darmasyah and Louise Tomsett who were either directly involved in the field efforts, or who provided much support and assistance for this project. We also received much valuable advice, comments and suggestions from Bill McShea and Belden Giman that helped us to improve both the implementation of the work and its eventual success. Other friends assisted us in many ways, and although not named individually, their help is much appreciated. The kind assistance of Carl Traeholt and several anonymous reviewers is also much appreciated.

References

Azlan, M.J. and L. Engkamat (2006). Camera trapping and conservation in Lambir Hills National Park, Sarawak. *Raffles Bulletin of Zoology* **54(2)**: 469-475

Belden, G., R. Stuebing, R., Nyegang, M., McShea, W. and C. Stewart (2007). A camera trapping inventory for mammals in a mixed-use planted forest in Sarawak. *Raffles Bulletin Of Zoology* **55**: 209-215.

Erlandson, J.M. and M.L. Moss (2001). Shellfish feeders, carrion eaters and the archaeology of aquatic adaptations. *American Antiquity* **66(3)**: 413-432.

Giman B., Stuebing, R. and M. Nyegang (2007). Small carnivores in mixed-use forest in Bintulu Division, Sarawak, Malaysia. *Small Carnivore Conservation* **36**: 35-37.

Grassman, L.I., Tewes, M.E., Silvy, N.J. and K. Kreetiyutanont (2005). Spatial organization and diet of the leopard cat (*Prionailurus bengalensis*) in north-central Thailand. *Journal of Zoology* **266**:45–54.

Harrison, R.D. (2011). Emptying the forest: Hunting and the extirpation of wildlife from tropical nature reserves. *Bioscience* **61(11)**: 919-924.

Koh, L.P. and D. Wilcove (2008). Is oil palm agriculture really destroying biodiversity? *Conservation Letters* **1**: 60-64.

Koh, L.P. and D. Wilcove (2009). Oil palm: Disinformation enables deforestation. *Trends in Ecology and Evolution* **24(2)**: 67-68.

MacKinnon J. and K. Phillipps (1993). A field guide to the birds of Borneo, Sumatra, Java and Bali. Oxford University Press, New York, USA.

Mathais, J., J. Hon, J. Ngumbang, Peter, A. and M. Gumal 2010. Small carnivores in a logging concession in the Upper Baram, Sarawak, Borneo. *Small Carnivore Conservation* **42**: 1-9.

Mohd-Azlan, J. and J. Sanderson (2007). Geographic distribution and conservation status of the bay cat *Catopuma badia*, a Bornean endemic. **Oryx 41(3)**: 394-397.

Rajaratnam, R., Sunquist, M., Rajaratnam, L. and L. Ambu (2007). Diet and habitat selection of the leopard cat (*Prionailurus bengalensis borneoensis*) in an agricultural landscape in Sabah, Malaysian Borneo. *Journal of Tropical Ecology* **23**: 209–217.

Ross, J., Hearn, A.J., Johnson, P.J. and D.W. MacDonald (2013). Activity patterns and temporal avoidance by prey in response to Sunda clouded leopard predation risk. *Journal of Zoology* **290(2)**: 96–106.

Rustam, Yasuda, M. and S. Tsuyuki (2012). Comparison of mammalian communities in a human-disturbed tropical landscape in East Kalimantan, Indonesia. *Mammal Study* **37(4)**: 299-311.

Sodhi, N.S., Posa, M.R.C., Lee, T.M., Bickford, D., Koh, L.P. and B.W. Brook (2010). The state and conservation of Southeast Asian biodiversity. *Biodiversity Conservation* **19**:317-328.

Traeholt, C. (1996). A radio-telemetric study of the thermoregulation of free living water monitor lizards, *Varanus S. salvator*. *Journal of Comparative Physiology B* **165(2)**: 125-131.

Wells, K., A. Biun, and Gabin, G. (2005). Viverrid and herpestid observations by camera and small mammal cage trapping in the lowland rainforests on Borneo including a record of the Hose's civet, *Diplogale Hosei*. *Small Carnivore Conservation* **32**: 12-14.

Whitmore, T. and A. McKenzie (1995) Assessment of the environmental impact of the oil palm estate of PT REA Kaltim Plantations, East Kalimantan, Indonesia. Cambridge University/Natural Resources Institute, Chatham, U.K.

Whitmore, T.C. (1984). Tropical Rainforests of the Far East. Clarendon Press, Oxford, U.K.

Wong, S. T., Servheen, C., Ambu, L., and N. Ahmad (2005). Impacts of fruit production cycles on Malayan sun bears and bearded pigs in lowland tropical forest of Sabah, Malaysian Borneo. *Journal of Tropical Ecology* **21**: 627–639.

Wulffraat, Stephan and Samsu, 2000. An overview of the biodiversity of Kayan Mentarang National Park. WWF-Indonesia Programme Kayan-Mentarang Project, Jakarta, Indonesia.