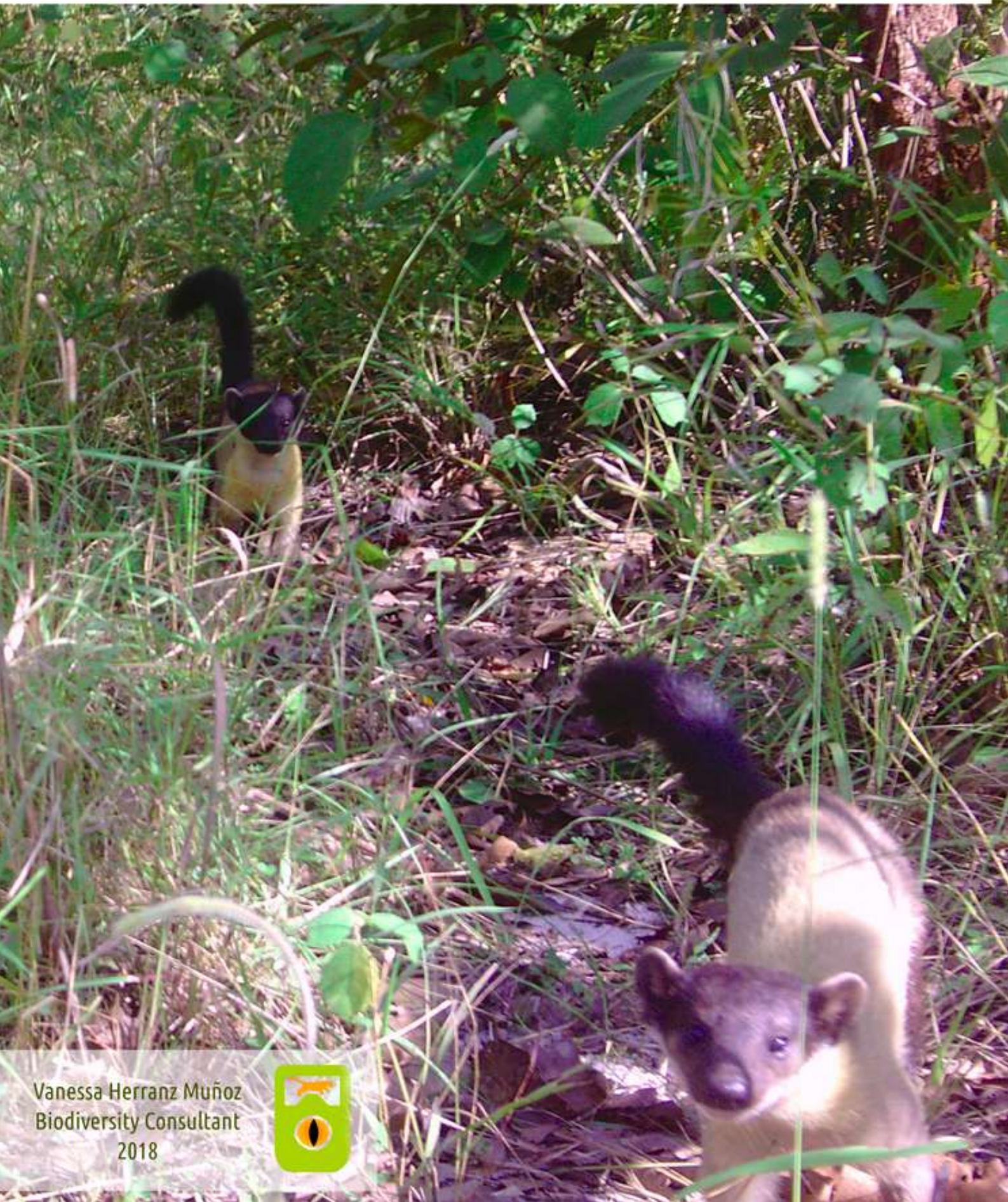


Camera-trapping Biodiversity Survey



GRANDIS
TIMBER Limited



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Executive Summary

Grandis Timber Ltd. manages a 7896.11 ha Economic Land Concession (ELC) for the production of timber (mainly teak, *Tectona grandis*) in Kampong Speu province (south west Cambodia) since 2009. Grandis Timber Ltd. is the only company in Cambodia ever issued a Forest Stewardship Council (FSC™) Certification (FSC™-C109614, 2013). This report details a biodiversity survey (through camera-trapping) and a biophysical survey (on sentinel quadrats) covering the whole ELC, except the western conservation area, conducted between November 2017 and January 2018. Out of 30 camera-traps deployed, 23 provided data over 509 trap-days and photographed 26 animal species (14 mammals, 10 birds and 2 reptiles). The only threatened species identified was Elongated tortoise (*Indotestudo elongata*). Northern Red Muntjac was the species photographed most often at the largest number of sites (26 photo-captures, 39% of sites); analyses provided an estimated occupancy of 50% of the sampled area and habitat preferences related to water courses. Five common carnivore species were identified; their combined estimated occupancy was 60% with extensive use of plantation sites. The biophysical survey revealed disturbance and reduction of plant cover due to drought at 75% of the quadrats; plant cover only increased at non-plantation habitats. Results showed biodiversity is within the parameters of degraded or modified habitats but the conservation areas, buffer zones, some “uncleared” areas and overall management of the ELC are beneficial to biodiversity. Recommendations including update of High Conservation Values assessment to record HCV 1, Species Diversity (Brown *et al.*, 2013), increased patrolling, extension and connection of conservation areas and biodiversity-focused (as well as beneficial for production) actions are provided.

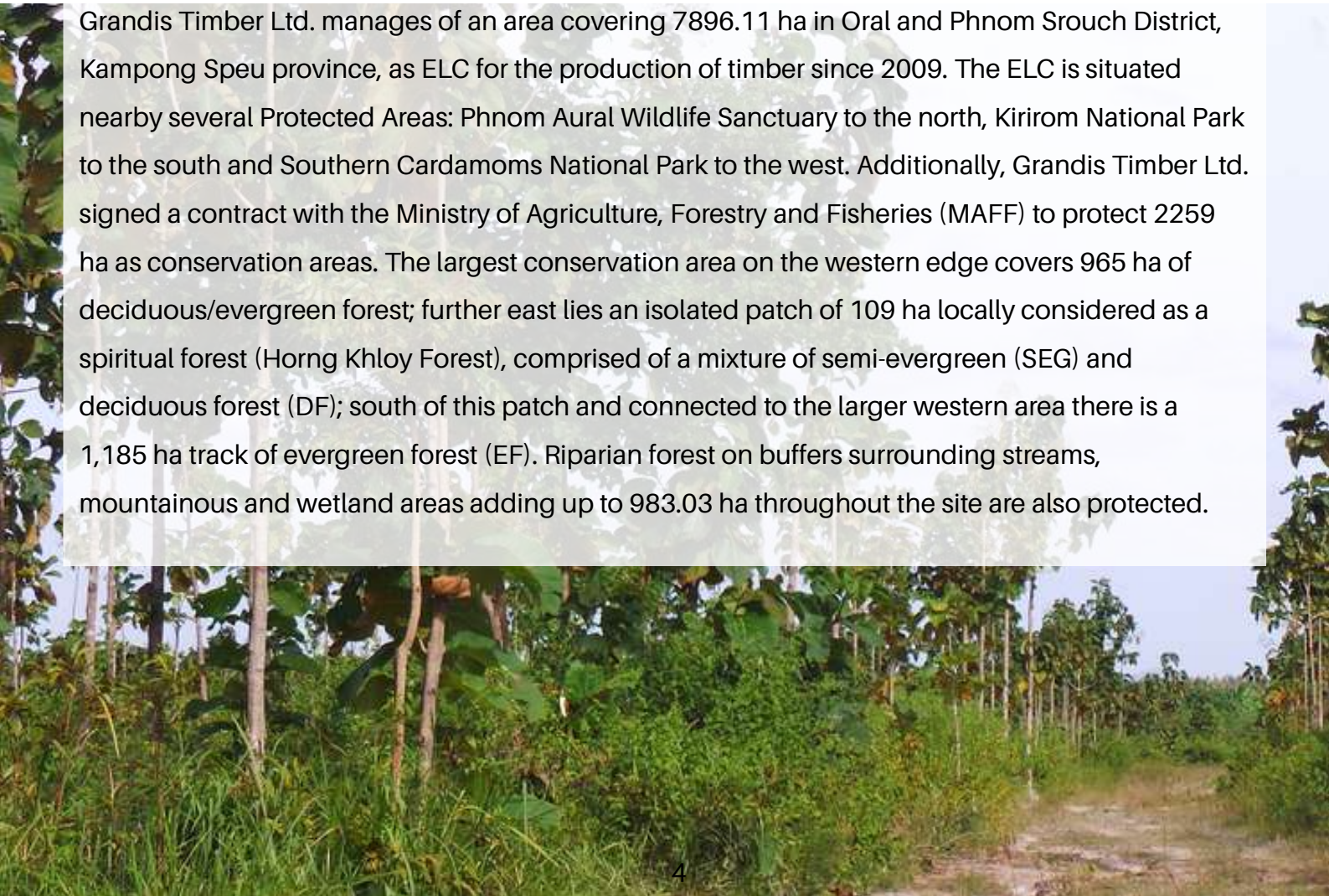


Introduction

Grandis Timber Ltd. is the first company in Cambodia, and to date the only one, to ever be issued FSC™ Certification (License code: FSC™-C109614. Certificate code: GFA-FM/COC-002384), held since 2013. The objective of the current survey was to conduct a biodiversity assessment through camera-trapping covering a representative sample of the Economic Land Concession (ELC) managed by Grandis Timber Ltd., excluding the largest conservation area on the western edge which was surveyed by Conservation International (CI) in 2013. A high conservation value (HCV) assessment on the concession was firstly done by Clark Forestry Consulting in 2013. The assessment was carried out to meet FSC™ certification requirements. For this report, HCVs were assessed based on interviews and literature research; the conclusion stated no HCVs were present in the ELC. The field survey that followed however, documented presence of Endangered Silvered Langur (*Trachypithecus cristatus*), Elongated tortoise (*Indotestudo elongangata*) and several species of Vulnerable tortoises and turtles (CI, 2013). The current camera-trap survey will be used to: (1.) Re-assess the presence of HCV 1 Species Diversity (Brown *et al.*, 2013) based on scientific evidence; (2.) Train Grandis Timber Ltd. staff on camera-trap deployment for monitoring purposes; and (3.) Provide recommendations on how to best protect biodiversity at Grandis Timber Ltd.

Study site

Grandis Timber Ltd. manages of an area covering 7896.11 ha in Oral and Phnom Srouch District, Kampong Speu province, as ELC for the production of timber since 2009. The ELC is situated nearby several Protected Areas: Phnom Aural Wildlife Sanctuary to the north, Kirirom National Park to the south and Southern Cardamoms National Park to the west. Additionally, Grandis Timber Ltd. signed a contract with the Ministry of Agriculture, Forestry and Fisheries (MAFF) to protect 2259 ha as conservation areas. The largest conservation area on the western edge covers 965 ha of deciduous/evergreen forest; further east lies an isolated patch of 109 ha locally considered as a spiritual forest (Horng Khloy Forest), comprised of a mixture of semi-evergreen (SEG) and deciduous forest (DF); south of this patch and connected to the larger western area there is a 1,185 ha track of evergreen forest (EF). Riparian forest on buffers surrounding streams, mountainous and wetland areas adding up to 983.03 ha throughout the site are also protected.

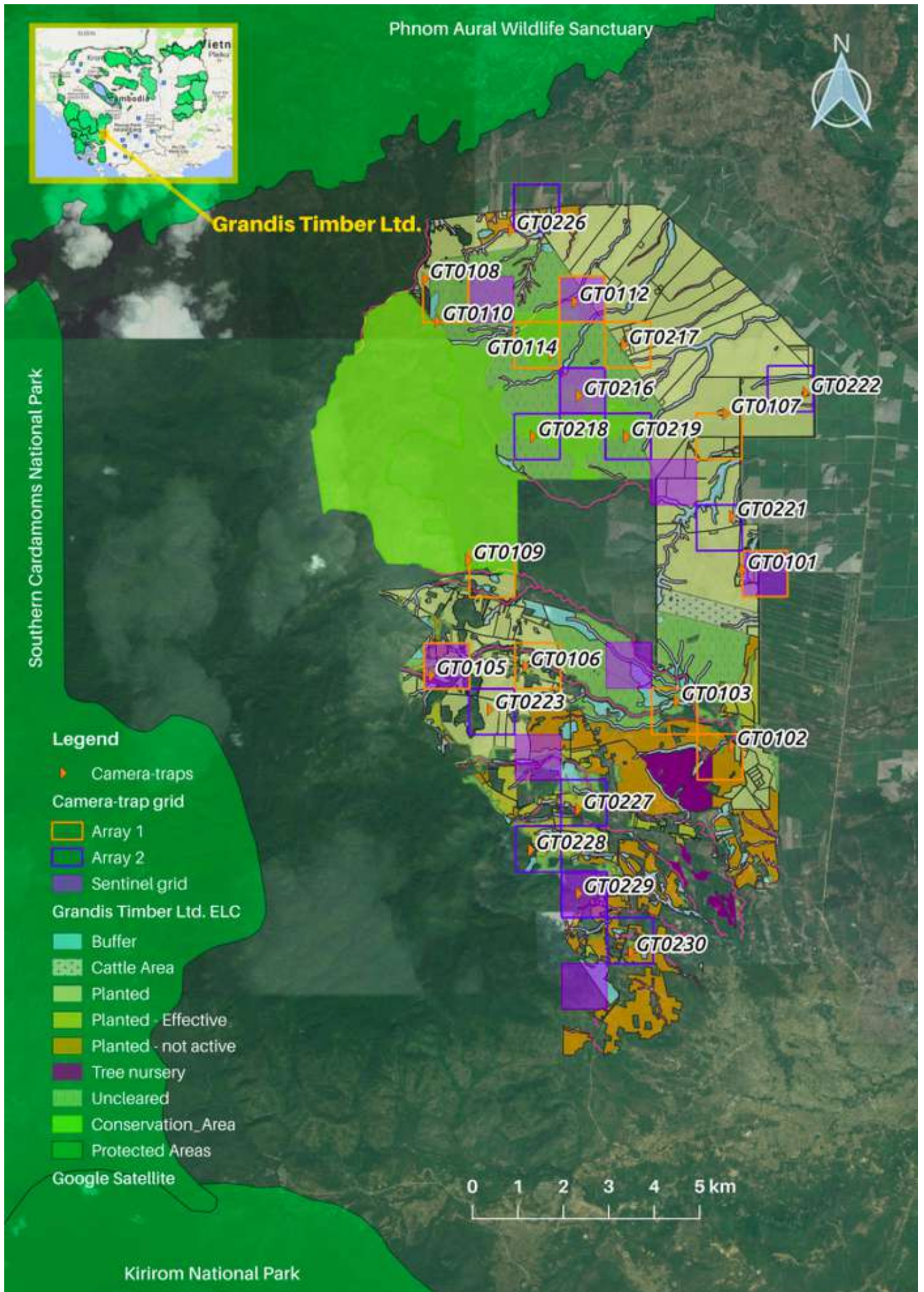




Methods

Camera-traps were placed within 1 x 1 km grid squares at a density of one per 2 km² and at sites of special interest throughout Grandis Timber Ltd. (Figure 1). The deployment consisted of 15 camera-traps on two sequential arrays for a total of 30 survey sites. The survey took place between the 29th of November 2017 and the 29th of January 2018. Survey sites were selected to represent a balanced sample of the available habitat types within Grandis Timber Ltd.: plantation; buffer enveloping streams and wetlands; uncleared areas; and conservation areas excluding the largest tract on the western side. Ten cameras belonged to Grandis Timber Ltd, models Acorn Ltl. 521 and Wildgame Innovations W4E and five cameras belonged to Conservation International Cambodia, models Bushnell Agressor and Moultrie Panoramic. According to their capabilities, Acorn and Bushnell cameras were set to take three photographs and one 30 second video when triggered and Wildgame and Moultrie cameras were set to take three photographs. Cameras were set approximately 50 cm above the ground in order to photograph small to medium size mammals and remained in place at each location during a minimum of 30 days. Habitat data and 360° photographs were take at each camera-trap location. All animals photo-captured were identified to species level when possible. One photo-capture or photo-capture event was considered as any number of photos/videos of the same species separate from the next by at least one hour. Data was analyzed using QGIS mapping software and R statistical analysis software. During the survey, Grandis Timber Ltd. staff were trained in camera-trap deployment and habitat data recording in collaboration with CI staff.

Figure 1. Map of biodiversity survey sites at Grandis Timber Ltd.





Results

Out of the 30 camera-traps deployed, seven malfunctioned or did not provide any data on wildlife and were therefore excluded from the analyses. Data collated from the remaining 23 cameras accounted for 509 camera-trap days in total. Cameras were set at plantation, conservation, buffer, uncleared and outside areas as well as at boundaries between them (see sites table).

Sites Table			
Camera	X	Y	Habitat
GT0101	104.161453	11.526432	Buffer
GT0103	104.148119	11.500501	Buffer
GT0110	104.099978	11.575504	Buffer
GT0109	104.106188	11.528386	Conservation
GT0114	104.123003	11.568851	Conservation
GT0216	104.128442	11.560772	Conservation
GT0218	104.119242	11.552694	Conservation/Uncleared
GT0228	104.118819	11.471132	Outside
GT0229	104.128453	11.462531	Outside
GT0223	104.110525	11.498844	Plantation
GT0105	104.098722	11.505638	Plantation/Buffer
GT0106	104.117693	11.507341	Plantation/Buffer
GT0107	104.158065	11.557232	Plantation/Buffer
GT0217	104.137537	11.570834	Plantation/Buffer
GT0221	104.159342	11.536915	Plantation/Buffer
GT0222	104.174174	11.561321	Plantation/Buffer
GT0226	104.114829	11.593431	Plantation/Buffer
GT0230	104.139012	11.451029	Plantation/Buffer
GT0102	104.159318	11.491682	Plantation/Uncleared
GT0108	104.097406	11.583848	Plantation/Uncleared
GT0227	104.128355	11.479112	Plantation/Uncleared
GT0112	104.127539	11.579340	Uncleared
GT0219	104.138025	11.552703	Uncleared

Photo-captures

A total of 26 animal species were photo-captured (Table 1). Fourteen (14) mammal species were identified including two domestic species (cow and dog), in addition to one capture of an unidentified civet species and four captures on three cameras of unidentified mammal species. Birds identified amounted to nine identifications to the species level, one at the family level and six photo-captures on two cameras of unidentified small passerine birds. Researchers recorded a further 13 bird species during opportunistic sampling (Table 2), making a total of 23 bird species identified. People were photographed on six cameras; three captures on two cameras showed poachers.

Table 1. Species photo-captured at Grandis Timber Ltd.

Species	Scientific name	IUCN Status	# Photo-events	# Cameras	% Cameras
Mammals					
Burmese hare	<i>Lepus peguensis</i>	LC	6	3	13%
Common Palm Civet	<i>Paradoxurus hermaphroditus</i>	LC	4	3	13%
Indochinese Ground Squirrel	<i>Menetes berdmorei</i>	LC	26	6	26%
Large-toothed Ferret-badger	<i>Melogale personata</i>	LC	2	2	9%
Malayan Porcupine	<i>Hystrix brachyura</i>	LC	1	1	4%
Northern Red Muntjac	<i>Muntiacus vaginalis</i>	LC	26	9	39%
Javan Mongoose	<i>Herpestes javanicus</i>	LC	8	6	26%
Small Indian Civet	<i>Viverricula indica</i>	LC	12	7	30%
Variable Squirrel	<i>Callosciurus finlaysonii</i>	LC	2	2	9%
Wild boar	<i>Sus scrofa</i>	LC	2	2	9%
Yellow-throated Marten	<i>Martes flavigula</i>	LC	1	1	4%
Rat	<i>Rattus sp.</i>		15	4	17%
Cow			14	4	17%
Dog			2	2	9%
Unidentified civet			1	1	4%
Unidentified mammal			4	3	13%
			Number of mammal species identified		14
Birds					
Asian Barred Owlet	<i>Glaucidium cuculoides</i>	LC	2	2	9%
Black-browed Reed Warbler	<i>Acrocephalus bistrigiceps</i>	LC	2	1	4%
Chinese Francolin	<i>Francolinus pintadeanus</i>	LC	1	1	4%
Greater coucal	<i>Centropus sinensis</i>	LC	13	5	22%
Green-billed Malkoha	<i>Green-billed Malkoha</i>	LC	1	1	4%
Nightjar	<i>Caprimulgus sp.</i>	LC	1	1	4%
Puff-throated Babbler	<i>Pellorneum ruficeps</i>	LC	2	1	4%
Red Junglefowl	<i>Gallus gallus</i>	LC	34	6	26%
Rufous turtle dove	<i>Streptopelia orientalis</i>	LC	2	1	4%
White-crested Laughingthrush	<i>Garrulax leucolophus</i>	LC	13	4	17%
Unidentified bird			6	2	9%
			Number of bird species identified		10
Reptiles					
Elongated Tortoise	<i>Indotestudo elongata</i>	EN	1	1	4%
Reeves' Butterfly Lizard	<i>Leiolepis reevesii</i>	NA	4	2	9%
			Number of reptile species identified		2
Human			8	6	26%
			Total number of species identified		26

Table 2. Bird species sighted at Grandis Timber Ltd

Bird Sightings		
Species	Scientific name	IUCN Status
Shikra	<i>Acciper badius</i>	LC
Green Bee-eater	<i>Merops orientalis</i>	LC
Hoopoe	<i>Upupa epops</i>	LC
Eastern Marsh Harrier	<i>Circus spilonotus</i>	LC
Oriental Dollarbird	<i>Eurystomus orientalis</i>	LC
Thick-Billed Green Pigeon	<i>Treron curvirostra</i>	LC
Black-Hooded Oriole	<i>Oriolus xanthornus</i>	LC
Crested Honey Buzzard	<i>Pernis ptilorhynchus</i>	LC
Pied Bushchat	<i>Saxicola caprata</i>	LC
White-Throated Kingfisher	<i>Halcyon smyrnensis</i>	LC
Crested Serpent Eagle	<i>Spilornis cheela</i>	LC
Hair-crested Drongo	<i>Dicrurus hottentottus</i>	LC
Olive-backed Sunbird	<i>Nectarinia jugularis</i>	LC
Number of species sighted		13
Total number of bird species identified		23



Crested Serpent Eagle
Photo credit: La Peng Ly

Species richness

The highest numbers of species were found in buffer areas very close to running water (GT0102 and GT0226, 10 species each). The second highest (8 species) were found within and around the conservation areas (GT0216 and GT0112) and on a buffer zone next to water within the largest continuous track of plantation on the northern half of the sampled area (GT0221). The sites with the lowest numbers of species recorded corresponded to cameras that malfunctioned, providing data for only one to four days (GT0117, GT0114 and GT0222) and cameras outside or bordering Grandis Timber Ltd. on the south end (GT0228, GT0229 and GT0230)(Figure 2).

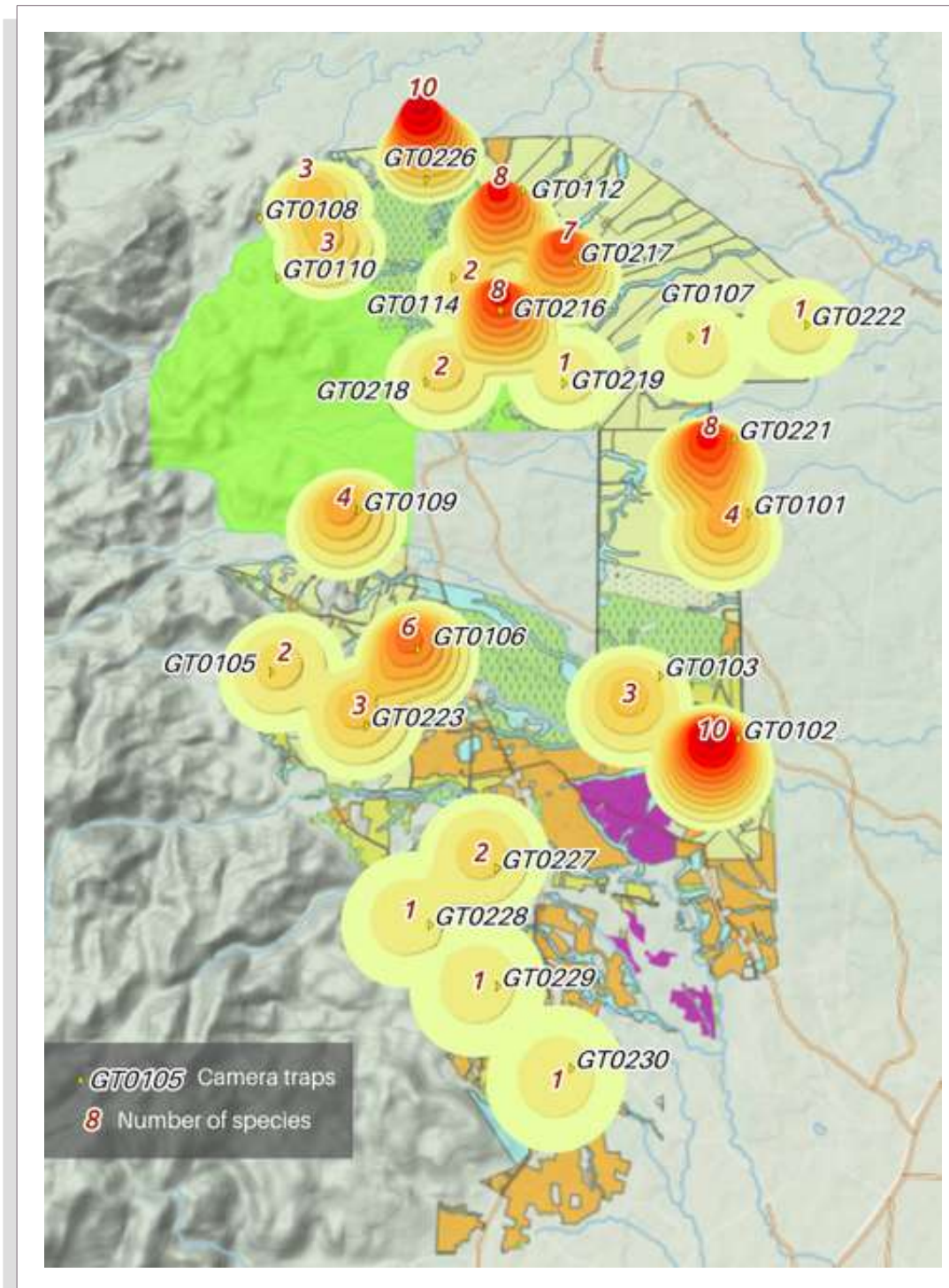


Figure 2. Number of species (red numbers) and number of captures (proportional 3D height) photo-captured during the survey.



Species accumulation curve

To investigate whether the camera-trap survey generated an accurate reflection of the biodiversity present in the study area a species accumulation curve was compared to a species-area relationship model (Dengler, 2009) (Figure 3). The resulting plot shows that the survey reached the maximum number of species identified before the reaching the total 23 sites surveyed, therefore survey effort was enough to obtain an appropriate estimation of the species present.

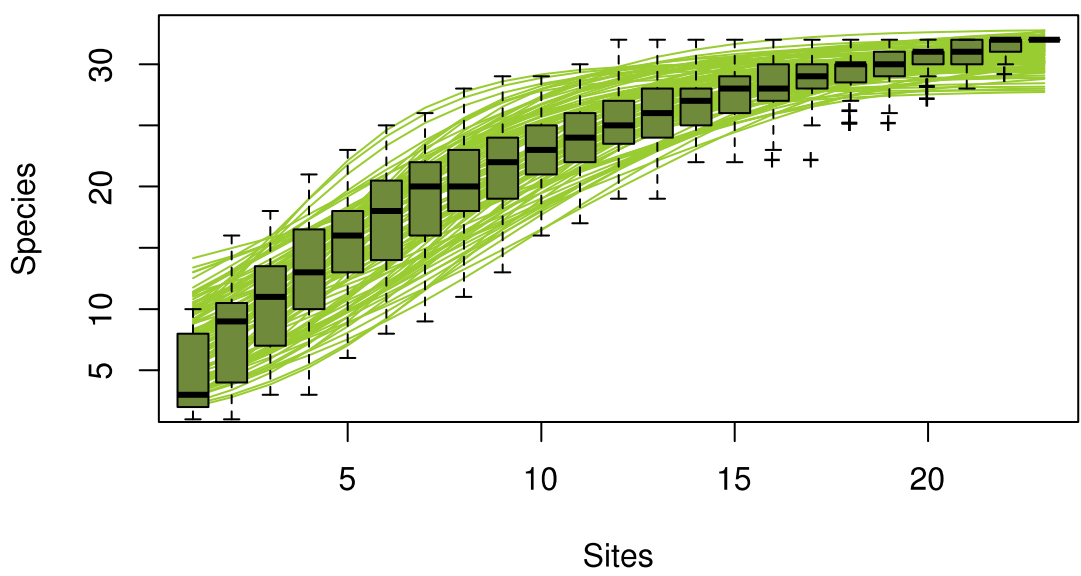


Figure 3: Species-area relationship models (light green lines) and actual observations added incrementally (dark green boxplots).



Northern Red Muntjac

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Northern Red Muntjac (*Muntiacus vaginalis*) was the species photo-captured at the largest number of cameras (9), covering 39% of the sampled area over 26 photo-capture events (Figure 4). Occupancy methods (*sensu* Mackenzie *et al.*, 2006) were used to analyze Northern Red Muntjac data and provided a population abundance estimate of 19 individuals, an estimated occupancy covering 50% of the sampled area and a preference for areas close to water sources.

Analysis of activity patterns shows that muntjacs are most active during morning and early night hours (Figure 5).

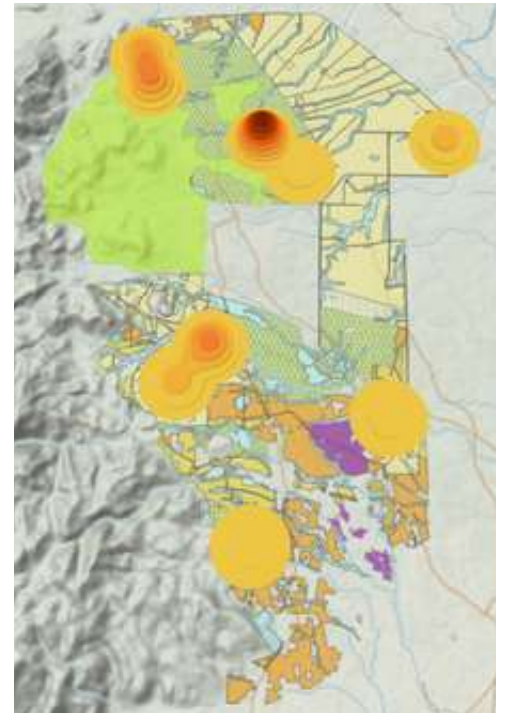


Figure 4. Northern Red Muntjac photo-captures

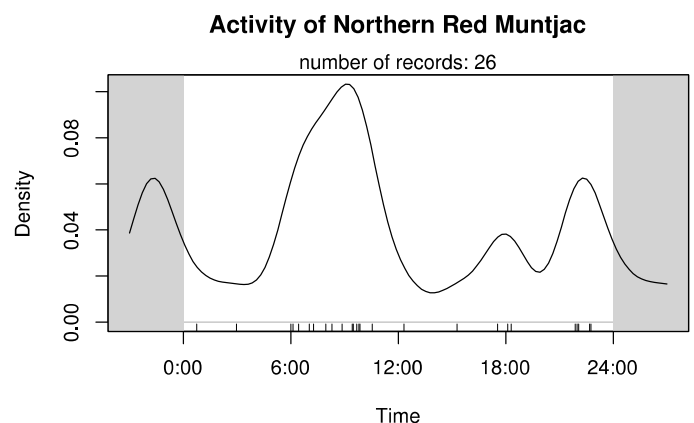


Figure 5. Northern Red Muntjac activity times



Small Asian Mongoose



Ferret-badger



Common Palm Civet

Carnivores

A total of five species of small carnivores were detected during the survey: Yellow-throated Marten, Small Asian Mongoose, Small Indian Civet, Common Palm Civet and Large-toothed Ferret-badger. These are all common, opportunistic and adaptable species.

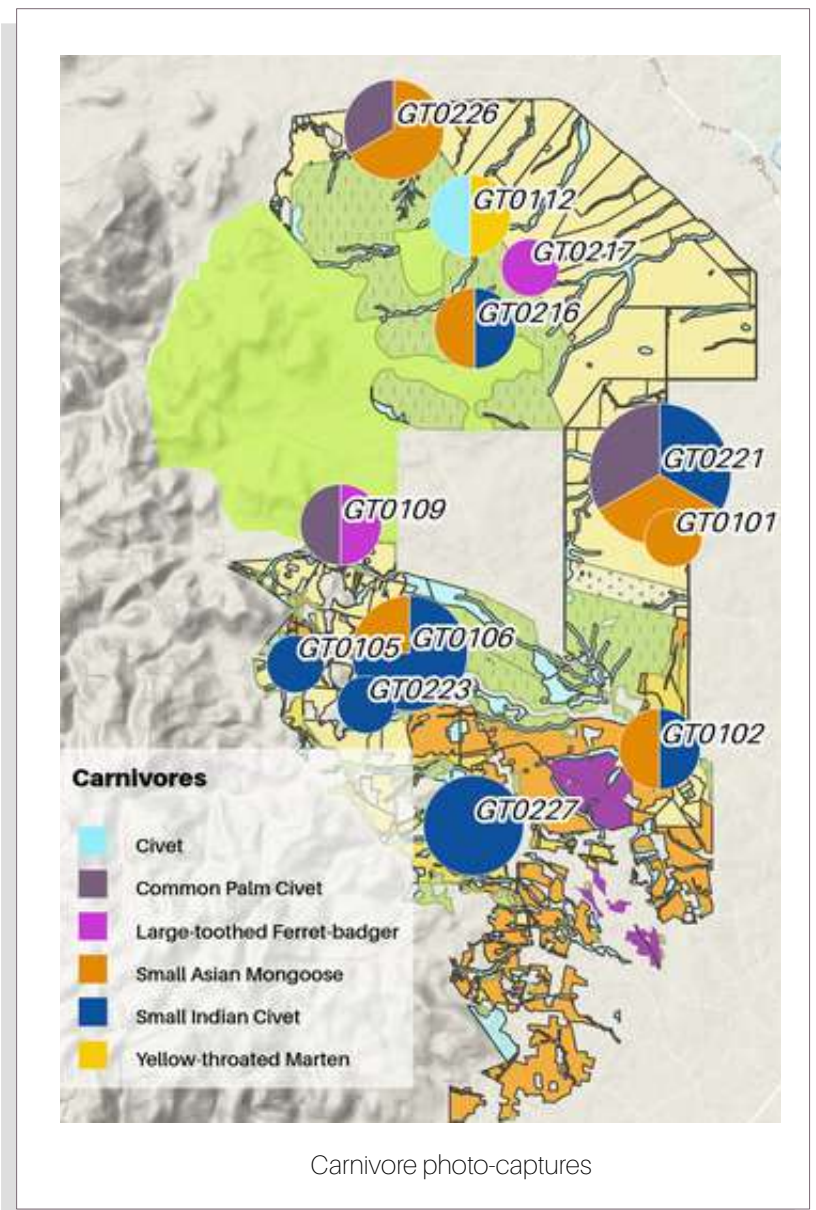
Occupancy methods were used to analyze data on all species of small carnivores pooled together. Results suggest that carnivore species occupy 60% of the sampled area and are making extensive use of plantation zones (Figure 6). These species are possibly providing a valuable ecosystem service in the area by controlling rodent populations, further shown by the low rate of photo-captures of rodents.



Small Indian Civet

Figure 6. Carnivore photo-captures. Pie chart colors distinguish species, (legend); size indicates number of captures (1-6).

The Yellow-throated Marten was the largest carnivore species photographed (a group of three individuals) and might be the “top predator” in the area. Social and highly adaptable to human-dominated landscapes, they have been recorded preying on species of a similar size to muntjac in Russia, but whether muntjac are a part of their diet in tropical forests is unclear (Pierce *et al.*, 2014).





Threatened Species

Two reptile species were identified including the only threatened species according to the IUCN Red List found during the survey: two Elongated Tortoises (*Indotestudo elongata*), classified as Endangered (EN), were photographed being carried by a poacher (accompanied by a dog) on camera GT0112, next to a conservation area .

The species identification was corroborated by the national foremost authority on reptiles, Mr. Neang Thi (Ministry of Environment, Royal Government of Cambodia).

Threats

Two more cameras captured poachers carrying home-made guns (GT0217 and GT0226). More than a dozen snares were found during survey activities at sites in the vicinity of conservation areas within the northern portion of Grandis Ltd.

Threatened species: Species listed at risk under IUCN Red List categories Near Threatened (NT), Vulnerable (VU), Endangered (EN) and Critically Endangered (CR).

Rare species: Under Cambodian Forestry Law (2002), species extinction risk is evaluated into three categories: Endangered, Rare and Common.



Sentinel sites

Photo credit: La Peng Ly

Methods

The CI team led biophysical data gathering during the survey. In order to obtain detailed information on biophysical variables, particularly land cover, a total of 12 sentinel sites were selected randomly throughout the whole area (Figure 7). Within each site, researchers noted land cover type, signs and type of disturbance, percentage plant cover and wildlife signs on seven plots (Figure 8). Variables were recorded on two occasions 2 months apart during November 2017 and January 2018.

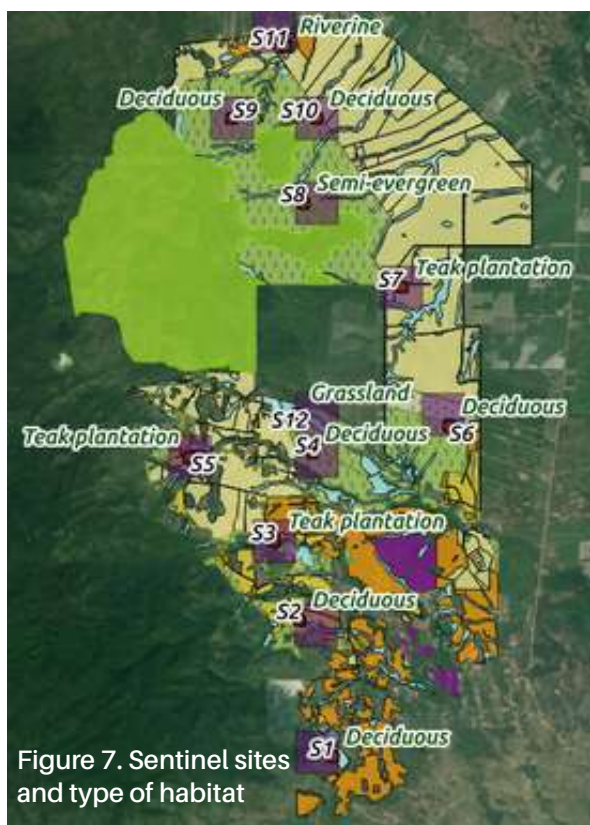


Figure 7. Sentinel sites and type of habitat

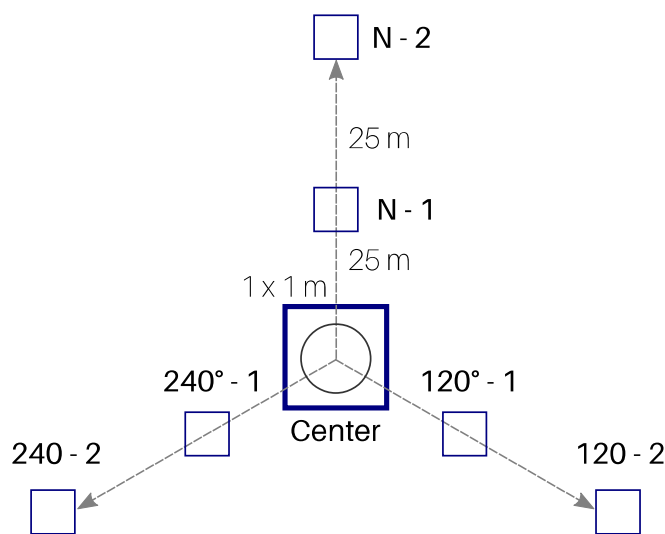


Figure 8. Sentinel quadrat, plots and measurements.

Results

The most common habitat type encountered when randomly selecting the sentinel sites was deciduous forest, found at the areas classified as “uncleared” and bordering the ELC (6), followed by teak plantation (3), semi-evergreen forest within a conservation area (1), grassland (1) and riverine (1) at stream buffers. Signs of cattle grazing was the main type of disturbance recorded in November 2017, only at four sites (Table 3). Data recorded in January 2018 showed a decrease in average plant cover at 9 of the 12 sites (75%), which in most cases coincided with recorded incidences of disturbance due to drought (dry season conditions). The only three sites that experienced small increases in plant cover over the survey period were situated in the riverine and semi-evergreen habitats and at one site close to the grassland habitat (Figure 9).

Table 3: All data gathered at sentinel sites in November 2017 (T1) and January 2018 (T2).

Sentinel point	Quadrat ID	% cover T1	% cover T2	Difference	Disturbance T1	Disturbance T2	
S1 Forest cover type: Deciduous Elevation: 178m	Center	5%	5%	0%		Drought	
	N - 1	90%	90%	0%			
	N - 2	70%	40%	-30%			
	120 - 1	70%	30%	-40%		Drought	
	120 - 2	75%	40%	-35%		Drought	
	240 - 1	90%	3%	-87%		Drought	
	240 - 2	90%	30%	-60%		Drought	
	S2	Center	50%	40%	-10%		
	N - 1	70%	70%	0%			
Deciduous Elevation: 133m	N - 2	80%	60%	-20%			
	120 - 1	65%	75%	10%			
	120 - 2	65%	20%	-45%			
	240 - 1	50%	5%	-45%		Drought	
	240 - 2	30%	10%	-20%		Drought	
S3 Forest cover type: Teak plantation Elevation: 154m	Center	30%	20%	-10%	Road	Road	
	N - 1	50%	50%	0%			
	N - 2	70%	20%	-50%			
	120 - 1	40%	15%	-25%		Path	
	120 - 2	40%	50%	10%			
	240 - 1	15%	5%	-10%	Cattle	Cattle	
	240 - 2	40%	80%	40%			
	S4	Center	10%	10%	0%	Cattle	Cattle
	N - 1	25%	40%	15%		Drought	
Deciduous Elevation: 148m	N - 2	60%	60%	0%			
	120 - 1	20%	20%	0%			
	120 - 2	10%	30%	20%	Old track	Old track	
	240 - 1	60%	80%	20%			
	240 - 2	60%	40%	-20%			
S5 Forest cover type: Teak plantation Elevation: 169m	Center	80%	40%	-40%			
	N - 1	30%	30%	0%			
	N - 2	80%	90%	10%			
	120 - 1	30%	40%	10%			
	120 - 2	20%	40%	20%	Old track	Old track	
	240 - 1	60%	30%	-30%			
	240 - 2	80%	80%	0%			
	S6	Center	90%	80%	-10%		
Forest cover type: Deciduous	N - 1	40%	10%	-30%			
	N - 2	100%	80%	-20%			
Elevation: 141m	120 - 1	40%	30%	-10%		Cattle	
	120 - 2	20%	20%	0%	Cattle + old track	Cattle + old track	
	240 - 1	80%	60%	-20%			
	240 - 2	40%	70%	30%			

Sentinel point	Quadrat ID	% cover T1	% cover T2	Difference	Disturbance T1	Disturbance T2
S7 Forest cover type: Teak plantation Elevation: 104m	Center	3%	5%	2%		
	N - 1	10%	20%	10%		
	N - 2	20%	30%	10%		
	120 - 1	15%	10%	-5%		
	120 - 2	100%	90%	-10%		
	240 - 1	40%	10%	-30%		
	240 - 2	60%	20%	-40%		
S8 Forest cover type: Semi-evergreen Elevation: 133m	Center	60%	40%	-20%		
	N - 1	20%	20%	0%		
	N - 2	3%	40%	37%	Logging	
	120 - 1	30%	20%	-10%		
	120 - 2	20%	10%	-10%		Drought
	240 - 1	5%	10%	5%		Drought
	240 - 2	5%	10%	5%		Drought
S9 Forest cover type: Deciduous Elevation: 162m	Center	80%	20%	-60%		Drought
	N - 1	70%	30%	-40%		Drought
	N - 2	60%	40%	-20%		Drought
	120 - 1	40%	10%	-30%		Drought
	120 - 2	100%	50%	-50%		Drought
	240 - 1	20%	3%	-17%		Drought
	240 - 2	40%	40%	0%		
S10 Forest cover type: Deciduous Elevation: 125m	Center	10%	2%	-8%		
	N - 1	20%	3%	-17%		
	N - 2	20%	30%	10%		
	120 - 1	35%	30%	-5%		
	120 - 2	80%	4%	-76%		
	240 - 1	20%	30%	10%		
	240 - 2	60%	35%	-25%		Drought
S11 Forest cover type: Riverine Elevation: 96m	Center	70%	60%	-10%		Drought
	N - 1	10%	50%	40%		
	N - 2	10%	30%	20%		
	120 - 1	1%	70%	69%		Drought
	120 - 2	50%	70%	20%		
	240 - 1	30%	40%	10%		Drought
	240 - 2	20%	2%	-18%		
S12 Forest cover type: Grassland Elevation: 135m	Center	90%	90%	0%	Cattle	Cattle
	N - 1	70%	40%	-30%		Cattle
	N - 2	70%	50%	-20%	Cattle	
	120 - 1	100%	100%	0%		
	120 - 2	100%	100%	0%		
	240 - 1	90%	90%	0%		
	240 - 2	45%	50%	5%		

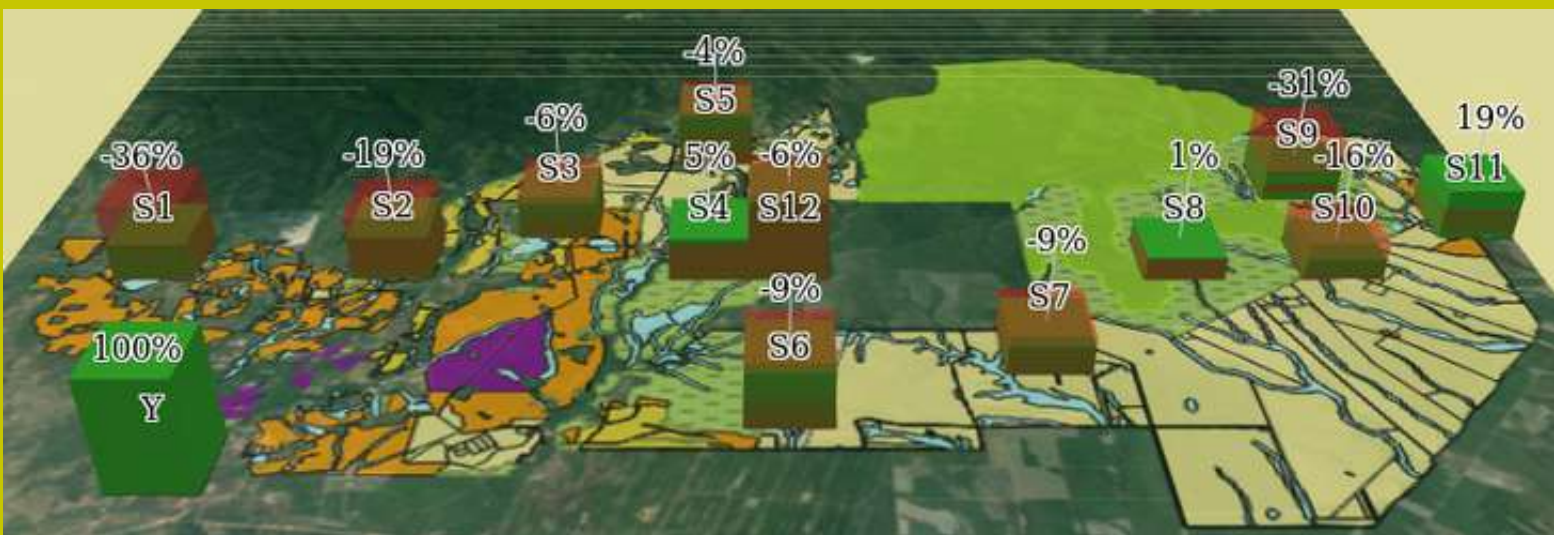


Figure 9: Sentinel sites and change in plant cover percentage (labels) between November 2017 (T1) and January 2018 (T2). Height of 3D features shows percentage plant cover at T1 (transparent red) and T2 (solid green).



Discussion

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Sampling size of the current survey (23 sites, 509 trap days) can be deemed appropriate for a superficial exploration of the mammal biodiversity present in the area, but it is too low to be able to carry out an accurate biodiversity assessment. The presence of a few more and at least some rare and threatened species can not be ruled out by the current results.

Mammal species richness in the area (12 species) is generally low and consistent with degraded forests and production landscapes (Chaudhary *et al.*, 2016). Very few studies have been conducted on mammal diversity within timber plantations; the only similar mammal diversity study (McShea *et al.*, 2009) was conducted in a Malaysian Acacia plantation and yielded more than twice (27) the number of species, although only 18 species used both plantation and secondary forests patches. Area and sample sizes were wildly different as well; more than 200 sample sites within 644 km² compared to the current 23 sites entailing only part of the 98.2 km² covered by Grandis Timber Ltd.

In comparison, a recent study at a potentially similar but almost intact ecosystem also consistent of semi-evergreen forest and dry dipterocarp forest (Chhep Wildlife Sanctuary in northern Cambodia) recorded 30 mammal species (Suzuki *et al.*, 2017). There are no comparable biodiversity studies available at two of the nearest protected areas (Phnom Aural Wildlife Sanctuary and Kirirom National Park), but a recent compilation of camera-trap data-sets from all protected areas covering the Cardamom mountains reports 30 species in total and 27 within the Southern Cardamoms National Park (Gray *et al.*, 2017) which begins only 5 km away from Grandis Timber Ltd.

The previous camera-trap survey carried out at the conservation areas of Grandis Timber Ltd. by Conservation International Cambodia (2013) identified 13 species of mammals, including one Endangered primate (Silvered Langur). This result indicates that areas surveyed in the current study harbor almost as many mammal species as the largest conservation area with the exception of primate species for which the habitat is less suitable.

On the other hand, results must be viewed in light of surrounding or potentially alternative land uses; slash and burn, monoculture agricultural lands and other types of plantations (e.g. oil, rubber) support much lower levels of biodiversity (Chaudhary *et al.*, 2015). Sugar cane, rice and other monocultures are found intertwined and bordering Grandis Timber Ltd. on the south and west edges and would have contrastingly lower levels of biodiversity. North and south of Grandis Timber Ltd. lie Phnom Aural Wildlife Sanctuary and Kirirom National Park respectively. The western edge of Grandis Timber Ltd. where the largest conservation area is situated borders with a small tract of evergreen forest that looks relatively intact (according to current satellite imagery) and beyond that lies the newly declared Southern Cardamoms National Park. This geographical location situates Grandis Timber Ltd. as a potential corridor between protected areas as well as a complement to them, since it holds different ecosystem types (SEG and DF) which are increasingly rare and under-represented within protected areas. The ELC could therefore potentially provide a refuge for species specialized in these ecosystems such as Banteng (*Bos javanicus*, Endangered) and Eld's Deer (*Rucervus eldii*, Endangered), which have not been recorded but were reported during interviews for the CI report (2013) and suspected based on tracks during the current survey.

Numbers of species recorded at and near the conservation areas and on the buffer areas surrounding water sources indicate that these are providing benefits to biodiversity. The current results indicate that biodiversity is higher within the northern 60-70% of the ELC, throughout the largest continuous area without human settlements. Northern Red Muntjac and carnivore occupancy analyses point at healthy populations of these species that use all habitat types including plantation areas. The muntjac population could eventually attract threatened predators such as Dhole (*Cuon alpinus*, Endangered).



Thick Billed Green Pigeon

However, the record of only five very common carnivore species and the lack of records of other common carnivores such as Leopard Cat (*Prionailurus bengalensis*) or Large Indian Civet (*Viverra zibetha*) may indicate the presence of threats (hunting) as well as a successional ecosystem that is still recruiting species.

One significant finding is the record of two Elongated Tortoises, the only Endangered species found during the survey, being carried by a poacher near a conservation area. Recording this species highlights a High Biodiversity Value and underlines the value of the conservation areas for rare species. On the other hand, the fact that they were being carried by a poacher indicates that conservation patches are being targeted for extraction of valuable species. Two more cameras photographed poachers carrying home-made guns and more than a dozen snares were removed from the vicinity of conservation areas. These findings call for increased patrolling and protection of conservation areas by Grandis Timber Ltd. management. Illegal hunting is the most pervasive threat to all biodiversity in Cambodia and South-East Asia (Grey *et al.*, 2017a). Protection from hunting through patrolling and collaboration with local authorities might be one of the most important actions Grandis Timber Ltd. can take to conserve biodiversity.



The value of timber plantations for biodiversity is connected to the amount of secondary forest retained, the availability of corridors and the length of the harvesting cycle (McShea *et al.*, 2009). From this point of view, teak plantations with long harvesting cycles, retention of large tracks of secondary forest and protection of the integrity and quality of corridors could provide the most beneficial conditions for biodiversity.

To some extent, these conditions are already present at Grandis Timber Ltd. which can therefore be viewed as an operation that has taken steps to retain and promote conservation value.

Furthermore, McShea *et al.*, (2009) propose that the High Conservation Value Forest classification (Forest Stewardship Council, 1996) should be applied to plantations that consistently monitor biodiversity and retain and promote ecosystem functionality.

In addition, the recording of one Endangered species (Elongated Tortoise) in the current survey and another in the previous survey (Silvered Langur), given the high pressure experienced by threatened species in Cambodia and South East Asia, immediately calls for the reporting of High Conservation Value Type 1 (HCV 1) according to current guidance (Brown *et al.*, 2013) and in contradiction to the HCV report previously supplied to Grandis Timber Ltd. which found no HCVs (Clark, 2014. Provided).



Silvered Langurs in the main conservation area.
Conservation International, 2013



Conclusion

Biodiversity levels are within the parameters of degraded or modified habitats but the high occupancy of muntjac and carnivore species shows that the whole area is permeable and usable for wildlife. Conservation areas, buffer zones and some “uncleared” areas are important for biodiversity and have the potential to attract and sustain higher numbers of species and possibly populations of threatened or rare species if managed and protected appropriately (see recommendations). Overall (biodiversity) management practices, particularly patrolling and excluding cattle and non-employees from the northern portion of the area are generally beneficial to biodiversity. However, records of poachers, snares found during the survey and specially, of an Endangered species being extracted, call for an increase in patrolling effort. Evidence of two Endangered species populations (Elongated tortoise and Silvered langur) should be considered to update the High Conservation Value assessment to report HCV 1 “Species Diversity” and manage conservation areas accordingly.





Recommendations

1. High Conservation Value and biodiversity monitoring

Update HCVs assessment to include HCV1 "Species Diversity" based on the recording of Endangered Elongated tortoise and Silvered langur, documented threats and importance of threatened species populations, given the high pressure they experience nationally and regionally.

1. 1. Continue biodiversity monitoring

Furthering staff training and establishing a monitoring protocol for the area would be highly beneficial to obtain more accurate data on biodiversity and integrate it with management plans.

2. Extend conservation area status to corridors

It would be highly beneficial to biodiversity to connect the isolated patch of conservation area furthest north to the largest tract on the west. These areas are already connected by two streams either side of the isolated patch running from the western tract; the "uncleared" area between the streams provides a naturally defined wildlife corridor that should also be protected. Furthermore, ideally conservation area status should also be extended to the "uncleared" area running south from the isolated patch to the conservation area tract extending east from the largest conservation area in order to create a continuous block.

2. 1. Provide conservation area status to wetland areas.

Wetland, grassland and connected buffer areas immediately south of the Korean mango cutout are also significant for wildlife and should be retained for conservation purposes.

3. Increase protection of conservation areas.

Evidence of poaching calls for increased patrolling of the conservation areas to protect threatened species such as the Elongated Tortoise. Evidence of poaching (photograph and coordinates) should be reported to the Wildlife Rapid Rescue Unit of Wildlife Alliance and the Ministry of Environment for potential further investigation and record keeping.

4. Buffer restoration

Buffers enveloping streams throughout the whole area of operations have been shown to be highly beneficial to biodiversity. Any expansion of these buffers would be highly recommended and should be complemented by restoration with native plant species that provide benefits to wildlife (e.g. rare trees already present within the buffers, trees and shrubs that provide nectar, seeds and fruits). Active restoration is also recommended to avoid rapid expansion of unproductive secondary growth and invasive species.

5. Enhance habitats to actively benefit biodiversity

The low numbers of species recorded are evidence of how modified landscapes such as plantations are generally detrimental to biodiversity. However, creating features that mimic elements of natural habitats would attract wildlife and enhance the quality of the landscape for biodiversity.

5.1. Construct “bat farms”

Bat farms are traditional Cambodian artificial bat roosts which provide shelter for insectivorous bat colonies in order to harvest bat guano to use or sell as organic fertilizer. Additionally, bats provide a highly effective pest control service. The bat guano could be used directly in planting operations or for roosts set near local farms, provide an alternative source of income to villagers. More information on bat farms can be found in the Mekong Ecosystem Environmentally Sensitive Development Manual (Thi *et al.*, 2015).

Currently, Cambodia-based bat expert Dr. Neil Furey and Conservation International are collaborating to test experimental approaches to the development of bat farms; Grandis Timber Ltd. could benefit greatly from joining the project and getting advice on the most appropriate bat farm design for the area.

5.2. Provide habitat features for birds

The current study was not focused or appropriate to survey birds effectively, however, opportunistic sampling suggest bird diversity is considerably high in the area. Creating features designed to enhance habitats for birds would benefit populations already present, potentially attract rarer species and benefit migrating species that use the area greatly. Recommended features would be: nest boxes within plantation areas, nest platforms and perches on high posts for birds of prey in open areas (as well as ensuring retention of high trees), retention of diverse, native under-story plants.

5.3. Experimental “wildlife-assisted restoration”

Research shows wildlife actively contributes to ecosystem restoration through seed dispersal (Montoya *et al.*, 2008) and might be one reason why natural regeneration is often more effective than replanting (e.g. Sampaio *et al.*, 2007).

I would like to propose Grandis Timber Ltd. conducting an experimental study into “wildlife-assisted restoration”. The experiment would essentially entail providing feeders for birds and mammals with native species seeds and fruits to enrich habitats and encourage seed dispersion while monitoring outcomes. This approach could potentially be tested in the restoration of expanded buffer areas and in combination with other enrichment features mentioned above. If the proposal is accepted, funding for research and monitoring will be sought and research will be undertaken by national students through collaboration with the Center for Biodiversity Conservation of the Royal University of Phnom Penh.

6. Agro-forestry for patchwork of farms in the southern area

The southern-most quarter of Grandis Timber Ltd. is integrated within a patchwork of small farms and, while this arrangement is beneficial for local farmers, the intense human presence in the area renders it unsuitable for high levels of biodiversity to persist.

One system which could potentially benefit all parties involved would be to find options for integration of the timber plantation and farmed trees through agro-forestry techniques.

7. Livestock management

Current management practices limit the access of livestock to the northern portion of the ELC which benefits wild ungulate species such as Northern Red Munjac. This practice should continue to increase the probability of colonization by threatened ungulates (Banteng and Eld’s deer) which might persist in the surrounding PAs.

Livestock seemed to be present throughout the southern portion of the ELC and might be providing a valuable service by controlling invasive shrubs. Coordination with livestock owners might be useful to tackle areas of excessive invasive plant growth. Temporal management of livestock access to different areas (i. e. livestock move on from one area to another over time, allowing for increased use by wildlife) might help enhance value of this area for biodiversity.





Recommended next steps

1. Review HCVs and conservation area demarcation (Recommendations 1 and 2).

2. Develop biodiversity management/monitoring plan (BioM), considering known and potential HCVs and including:
 - Survey methods and areas
 - Data analysis protocol
 - Patrolling
 - Staff training needs
 - Collaboration with external entities: on surveying with CI; on law enforcement/patrolling support and training with WA and appropriate authorities.
 - Local stakeholder engagement
 - Adaptive management mechanisms (how information gathered and lessons learned as activities develop feedback into continuous fine-tuning of BioM)

3. Develop restoration/habitat enhancement plan including potential implementation of Recommendations 4 to 7.

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