FIELD EXPEDITION

ORANGUTAN SURVEY IN LOWER KAWAG

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Executive Summary

This report presents the major findings of the orangutan and biodiversity surveys conducted between August 6th and 15th, 2025, in Lower Kawag Gibon Forest Reserve (LKG FR). This extreme lowland landscape, characterized by slightly undulating terrain, exhibits severe degradation following decades of intensive timber harvesting. Approximately half of the forest compartments currently lack sizable trees. These open areas are dominated by grasses, bushes, wild-climbing bamboos, and other creeping vegetation that suppresses natural forest regeneration. See the pictures above and below. A conservation intervention currently underway in this area is active restoration through various initiatives, including one supported by a grant from MPOGCF.

While orangutans can persist in disturbed forests, the extensive fragmentation and degradation within LKG FR pose a serious threat to the long-term viability of the orangutan population. The primary objective of our survey was to assess the current conservation status of orangutans living in LKG. Our preliminary results indicate an orangutan density of 1.22 ind/km² (95% CI: 0.42-3.51), which falls within the range of previous density estimates by Hutan, WWF, and SFD. We also confirm that orangutan abundance decreases toward the eastern portion of the survey area (approaching Taliwas).

Another objective is to develop new survey methodologies using thermal drones for nocturnal orangutan detection. This approach has not yet been applied to orangutan surveys, and the current MPOGCF-supported project provides an opportunity to pioneer its development.

We took the opportunity of this field work to also collect information about other wildlife taxa, including small and medium-sized mammals, gibbons, birds, and other. Overall, wildlife assemblage documented in LKG is characteristic of extreme lowland habitat. We recorded the presence of nine carnivore species, 181 bird species and four Critically Endangered species including Bornean orangutan, Sunda pangolin, Banteng and Helmeted hornbill.

Background Information about the Orangutan Survey Project

Understanding the distribution and size of orangutan populations in Sabah is crucial for effective conservation strategies for the species. Over time, the Sabah Wildlife Department (SWD) and its collaborators have conducted multiple surveys in the State to establish reliable size estimates of the orangutan populations across Sabah. Continuous monitoring of population size and dynamics is essential for evaluating the sustainability of orangutan populations in Sabah and assessing the effectiveness of conservation efforts by the SWD and other stakeholders.

The Overall project funded by MPOGCF and entitled "Orang-utan surveys in Sabah" follows the following objectives (see detailed proposal):

- Surveying orangutan nests in key protected and non-protected areas in Sabah.
- Finalising what we know about the orangutan metapopulation in Kinabatangan.
- Collecting practical and detailed information using mixed bio-social methods to document orangutan conservation status in at least two other agricultural landscapes.
- This project serves as a vehicle for the capacity building of relevant stakeholders and a training platform.

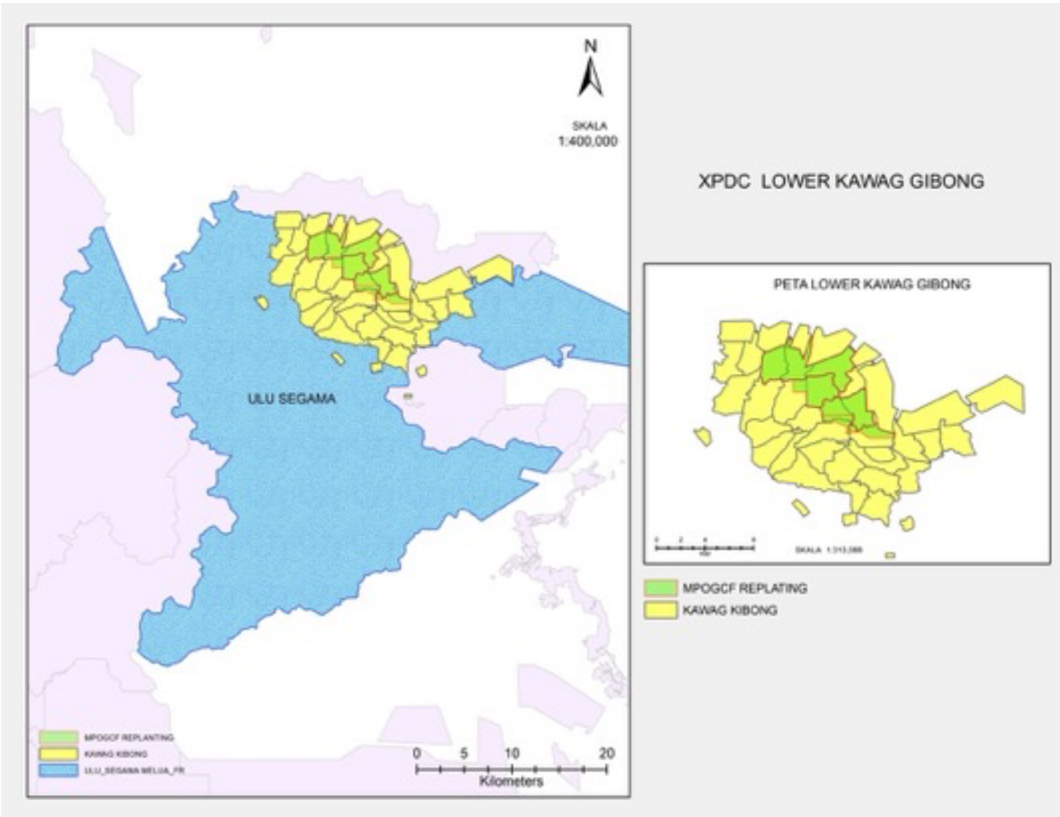
This report summarises the results of the field expedition conducted under the MPOGCF project in Lower Kawag between August 6th and August 15th, 2025. In addition to the team of orangutan researchers, Hutan also sent a team specifically tasked with identifying other biodiversity taxa.

Background information about Lower Kawag and its orangutan population

Lower Kawag Gibong FR (Map 1) is part of the larger complex of Ulu Segama Malua, totaling 242,888 ha: Table 1.

No	FR Name	FR Class	Function	Area (Ha)
1	Sapagaya	I	Protection	698.00
2	Ulu Segama	I	Protection	126,846.00
3	Mount Louisa	I	Protection	54,760.00
4	Sungai Taliwas	I	Protection	9,546.00
5	Extension Danum Valley	I	Protection	92.00
6	Bukit Piton	I	Protection	11,612.00
7	Malua	I	Protection	33,969.00
8	Kawag Gibong	VI	Protection	707.00
9	Sepagaya	VI	Protection	2,316.00
10	Merisuli	VI	Protection	552.00
11	Extension Mt Louisa	I	Protection	1,786.00
	Total			**242,884.00**

Table 1: List, status and surface area of the various FRs that are part of the Ulu Segama Malua complex (source: SFD Annual Report).



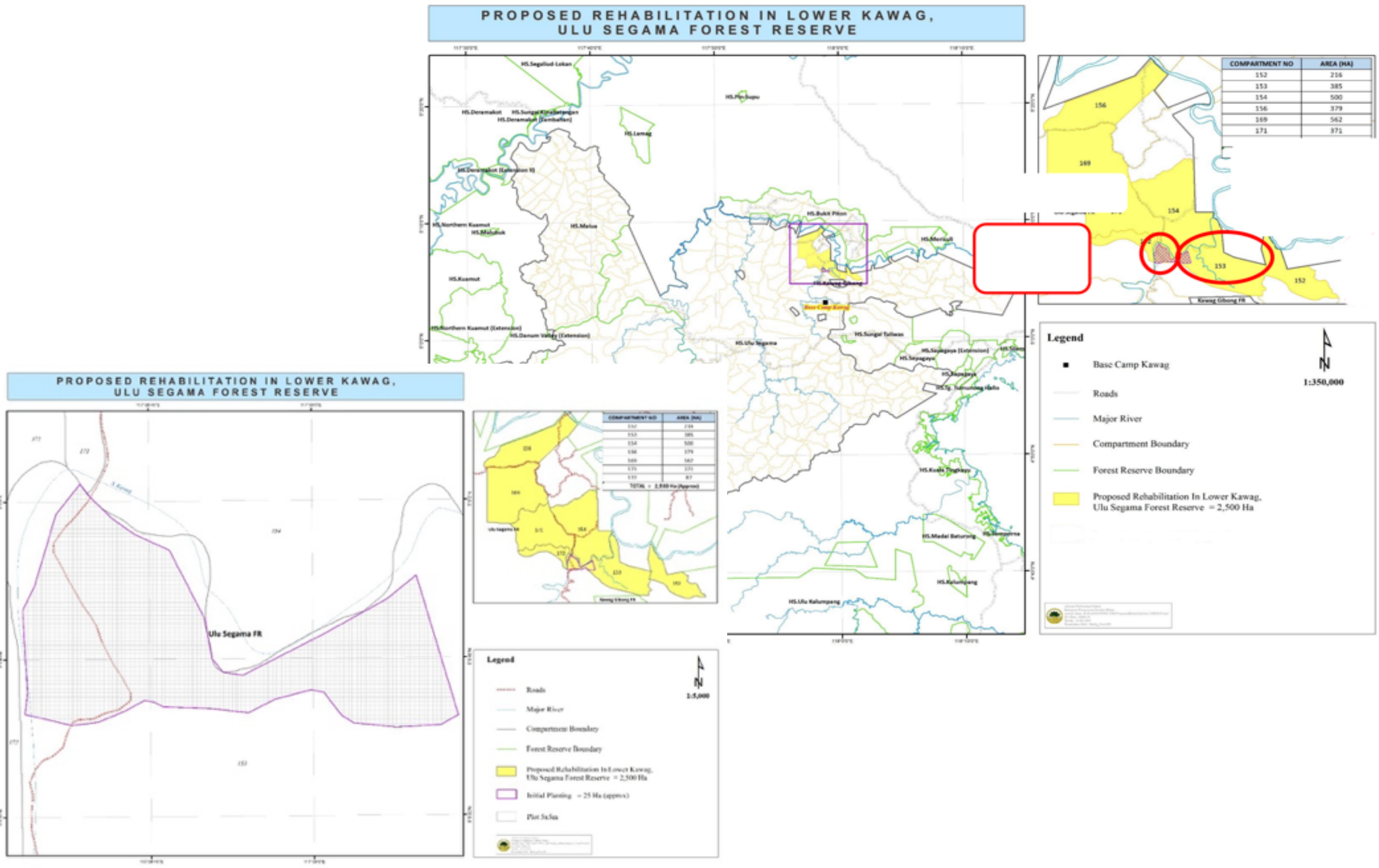
Map 1: Map showing the location of Lower Kawag Gibong (LKG)

With about 2,500 orangutans, the Ulu-Segama Malua FR complex harbors the largest unfragmented orangutan population in Malaysia[1]. However, due to past logging activities, most of these areas are degraded and fragmented. Intense sylviculture and restoration treatments are underway to restore parts of this complex. The Forest Rehabilitation Programme is vital for implementing Sustainable Forest Management (SFM), mitigating depleted forest cover, restoring wildlife habitats and corridors, and promoting ecosystem recovery to its natural state.

Restoration in Lower Kawag (a small part of the complex) was initiated in 2019 with funding from MPOGCF (Table 2 and Map 2). In early 2024, about 1,200 ha of land had been replanted and were still maintained.

Phase	Target Year	Target of Planting (ha)	Total of Seedlings	Achievement (ha)	Remarks
1	2019 - 2022	25	10,000	25	• MCO: Year 2020 & 2021; • Planting completed by Kontraktor DY Mekar; • 8th Maintenance Round (up to 18 rounds)
2	2021 - 2022	200	80,000	200	• Planting completed by Kontraktor Fajar • 8th Maintenance Round (up to 20 rounds)
3	2023 - 2024	750	300,000	129	On-going by appointed contractors (51,444 seedlings successfully planted)
4	2025	750	300,000	-	Rescheduling
5	2026	775	310,000	-	Rescheduling
Total		**2500**	**1,000,000**	**354**	

Table 2: Proposed plan for restoration in Lower Kawag (Source: SFD Annual Report).



Map 2: Compartments to be restored in LKG under the MPOGCF project.

[1] Ancrenaz M., Ambu L., Sunjoto I., Ahmad E., Manokaran K., *et al.* 2010 Recent Surveys in the Forests of Ulu Segama Malua, Sabah, Malaysia, Show That Orang-utans (*P. p. morio*) Can Be Maintained in Slightly Logged Forests. *PLoS ONE*, 5(7): e11510. doi:10.1371/journal.pone.0011510

Previous orangutan surveys by Hutan and SWD[2], WWF[3], and SFD[4] in the area resulted in orangutan densities from 0.9 to 1.4 ind./km^2. Overall, orangutan nests were detected in higher abundance on medium-sized trees and lower crowns of pioneer tree species (*Neolamarckia cadamba* and *Pterospermum* spp.) that are fast growing trees.

Lower Kawag Gibon was selected as a survey site because of the on-going restoration exercises funded by MPOGCF. However, given its rather small size, we combined several orangutan and biodiversity survey methodologies within LKG and surrounding areas to obtain a more precise picture of the orangutan population status living and around LKG.

Methodology

The Hutan members and SFD staff were divided into several teams. Each team used a combination of standardised field methodologies designed explicitly for orangutan surveys (and other taxa), adhering to established protocols in Sabah (Ancrenaz, 2013). Data were collected over eight full days (excluding travel days). Daily excursions were planned in accordance with site accessibility and weather suitability.

During this field expedition, we employed the following methods:

- **Reconnaissance Walks (RWs) :** Reconnaissance walks follow terrain-adapted routes rather than predetermined transects. This flexible approach enables the teams to navigate challenging terrain features, allowing for coverage of greater distances and more extensive areas within limited timeframes. While density estimation is not possible from RW observations, we can calculate linear encounter rates expressed as the number of nests detected per kilometer walked. Each team organised seven points to recce around the vicinity of Tawau Hills Park. The location of all reconnaissance walks is presented in Appendix 1.

- **Botanical Monitoring:** We established botanical monitoring plots (100m × 20m) at each RW location to assess forest condition and composition. Within each plot, we counted and identified all trees with a diameter at breast height (DBH) exceeding 20cm. Forest structure parameters, including canopy openness, small tree presence, and climber abundance, were evaluated using a standardised scoring system ranging from 0 (minimum/absent) to 3 (maximum).

- **Ancillary Data Collection:** Comprehensive environmental data collection included weather conditions, human presence indicators, forest disturbance signs, and topographical features that might influence wildlife observations and distribution patterns.

- **Drone Surveys:** We conducted two distinct types of un-manned aerial vehicle (UAV) surveys:
    - *Daytime Operations*: Drones conducted nest counts along aerial line transects and during random flight patterns. All flights were recorded at the field camp for subsequent video analysis to identify and quantify the number of orangutan nests. These aerial surveys provided critical landscape overviews that informed ground survey planning and optimisation.

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[2] Ancrenaz, M., Gimenez, O., Ambu, L., Ancrenaz, K., Andau, P., Goossens, B., Payne, J., Tuuga, A., and Lackman-Ancrenaz, I. 2005. Aerial surveys give new estimates for orang-utans in Sabah, Malaysia. *Plos Biology*, 3 (1): 30-37: e3. doi:10.1371/journal.pbio.0030003

[3] Simon, D., Davies, G., Ancrenaz, M. 2019. Changes to Sabah's orangutan population in recent times: 2002-2017. *Plos One*, 14(7): e0218819. https://doi.org/10.1371/journal.pone.0218819

[4] SFD, Annual Report – 2023; 2024.

- *Nocturnal Thermal Surveys:* Thermal imaging technology enabled direct detection of orangutans in their nests during nighttime flights. These surveys followed systematic linear transects within 800 m × 800 m quadrats (64 ha or 0.64 km^2). Each quadrat was surveyed for two nights and twice each night by two different teams, to estimate the detection probability of sleeping orangutans.

- Whenever possible, the same quadrats were surveyed once during the day with a drone to estimate the nest encounter rate per km; ground surveys from line transects and orangutan detection at night for two different nights.

- *Technical Specifications:* Drone operations were conducted with a DJI Mavic 3 thermal and DJI Macic 4 (for night surveys) or a DJI Matrice 30 (for day surveys) at a standardised altitude of 70 m, with flight speeds maintained at 8 m/s, whenever possible. Data collection protocols included recording the types of findings, GPS coordinates, timestamps, and behavioural observations for all detected orangutan signs and individuals.

- **Camera traps:** We deployed ten camera traps (Model Reconyx Hypefire Professional 2). All cameras were mounted on trees at an average height of 30–60 cm above ground level. Camera location and placement were determined based on the presence of wallows, forest ridges, and observed wildlife tracks. Each camera was configured to take five photos per trigger, with a three-minute quiet period. The cameras were deployed in August 2025 and retrieved by the end of October 2025.

- **Small mammal trapping:** We established five 200 m transects and placed ten wire-mesh live traps at 20 m intervals. We baited each trap with either banana or palm mesocarp fruit. The traps were checked at 0730 hrs and 1530 hrs for five consecutive mornings and evenings. We identified the trapped individuals at the species level before releasing them on the spot.

- **Bio-acoustic sampling:** We deployed Audiomoth devices at six locations, including forest edges, near the main road and close to human activities. The audiomoths were installed on August 7^{th} and retrieved on August 12^{th}. We configured the Audiomoth devices to actively record their surroundings in four different periods: 0500–0800 hours, 1100–1400 hours, 1700–2000 hours, and 2300–0200 hours. We used a frequency of no more than 48 kHz, and the devices were active for 60 seconds every 5 minutes (300 seconds).

- **Gibbon survey:** We employed the modified triangulation methodology to estimate gibbon abundance. This approach involves systematic acoustic monitoring of gibbon vocalisations (both long and short calls) during the peak calling period between 06:00 and 08:00. For each detected call, observers recorded the precise time, estimated distance from the listening post, and the bearing of the call. Two survey teams, positioned at separate listening posts (at least 50 to 100 m apart), collected data simultaneously, enabling the spatial mapping of gibbon groups through acoustic triangulation. We conducted surveys over three consecutive mornings to ensure adequate coverage of the sample. We reported a group of gibbons only when the two teams heard the call. Based on our experience in Kinabatangan (a similar habitat), we estimate that a gibbon's long call can be heard at approximately 800 m in the forest. This means that the surface area covered during our acoustic surveys is 2 km² (0.8 × 2 × 3.14).

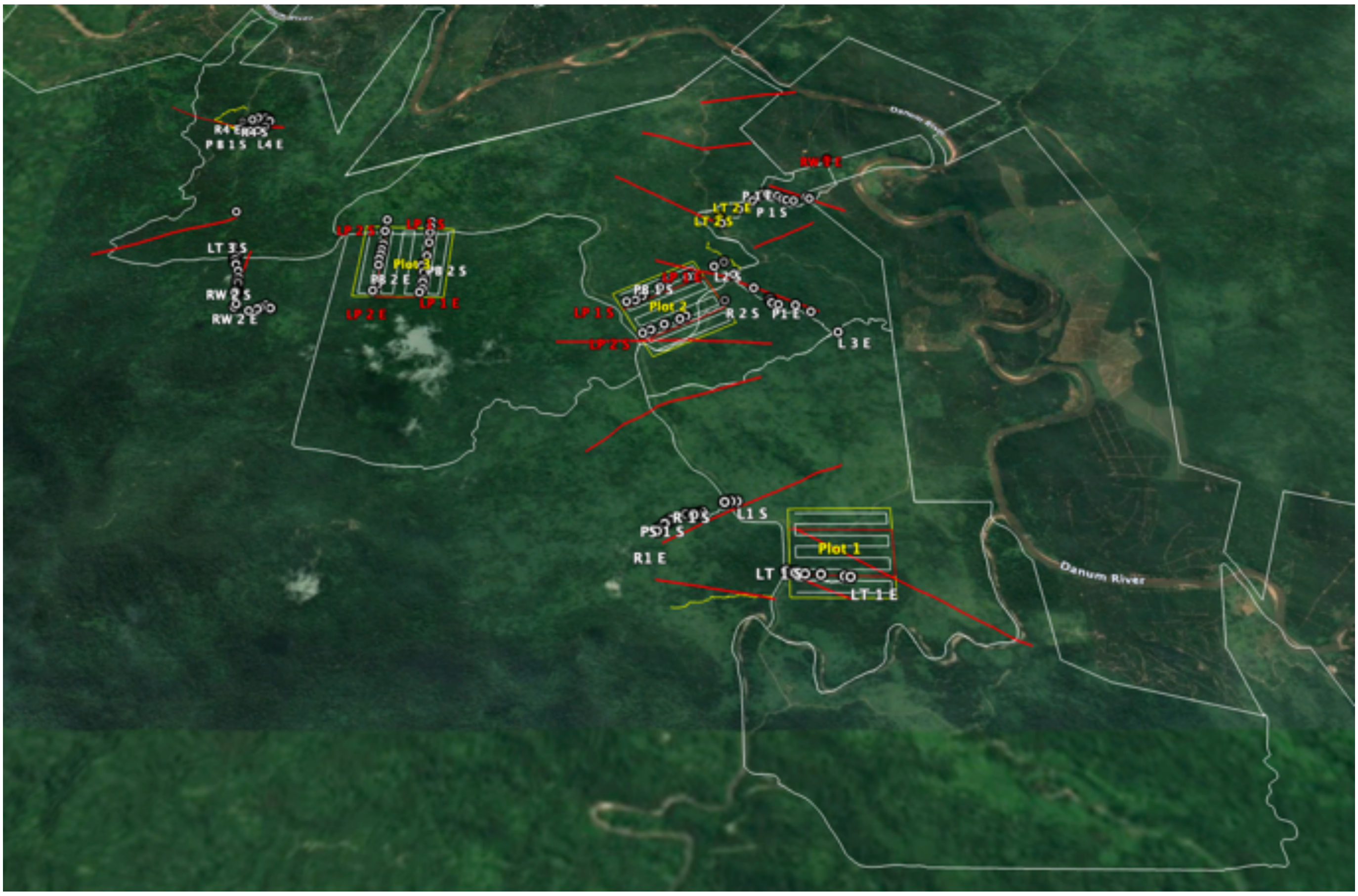
- **Bird Survey**: Avian surveys were carried out concurrently during reconnaissance walks and from each camp substation to maximise field efficiency. Each bird identified by the observers (direct sighting, voice) was listed in the 15 species MacKinnon List (i.e. a new species list was started as soon as the total number of species recorded b the observer reached 15). This approach gives a rough species abundance index between species. This rapid assessment is suggested as a cost-effective method for conducting rapid bird surveys in the tropics.
- **Night Survey**: One team conducted night spotting from a vehicle while driving to frog survey locations. Animals were searched for using a spotlight from the car.

RESULTS OF ORANGUTAN SURVEYS

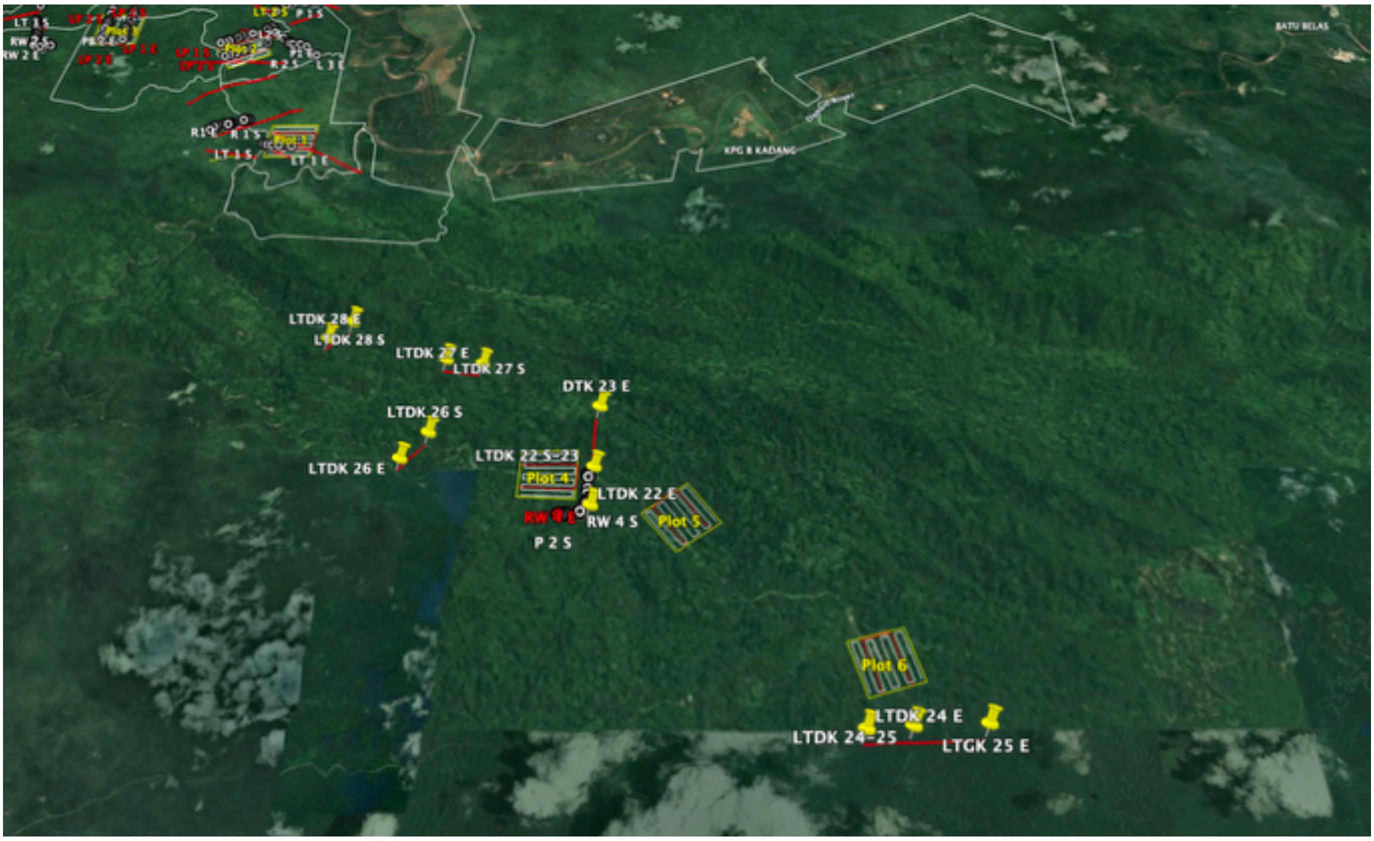
Following the fieldwork, we stratified the survey area into three strata: Maps 3 and 4.

- Medium Part: Compartments included and surrounding restoration activities supported by MPOGCF: Map 3.
- South of LKG: Map 4
- Extreme South of LKG: Map 4

1. Ground line transects and recce walks



Map 3: Compartments of LKG that are part of the MPOGCF-funded project



Map 4: South (Plot 4 and 5) and Extreme South (Plot 6) strata during surveys

Table 3 presents the overall results of nest-kilometric indexes recorded along line transects from the ground and from the drones, and recce walks outside the quadrats for the three strata.

	Ground LT				Drone LT				RW			
	Nb lines	Tot km	Nb nests	Index	Nb Lines	Tot km	Nb nests	Index	Nb Recces	Tot km	Nb nests	Index
Medium	10	6.591	75	11.38	21	17.89	227	12.68	9	5.314	37	6.96
South	1	0.504	8	15.87	5	2.93	48	16.40	2	1.713	3	1.75
Ex South	2	1.143	3	2.62	2	1.845	6	3.25	2	1.794	7	3.90

Table 3: Kilometric indexes obtained in three different strata of LKG with three different approaches.

Although the results for extreme south are well below the two other starta, a one-way ANOVA comparison between the three strata fails to show a significant difference between the three strata:

- LT drones: $F = 32.205$, $df = 2, 25$; $p>0.05$ (ns)
- LT ground: $F = 0.634$; $df = 2, 11$; $p>0.05$ (ns)
- RW ground: $F = 1.049$, $df = 2, 10$; ; $p>0.05$ (ns)

This lack of significance is explained by the very small number of samples for the extreme south; the high variability of the index in the Medium stratum (variation between 0 and 38.2 nests/km); a wide range overlap

(Fig. 1) and the lack of statistical power due to the low number of samples in South and Extreme South. As such, we decided not to pool the data together and to keep them separated for the following calculations.

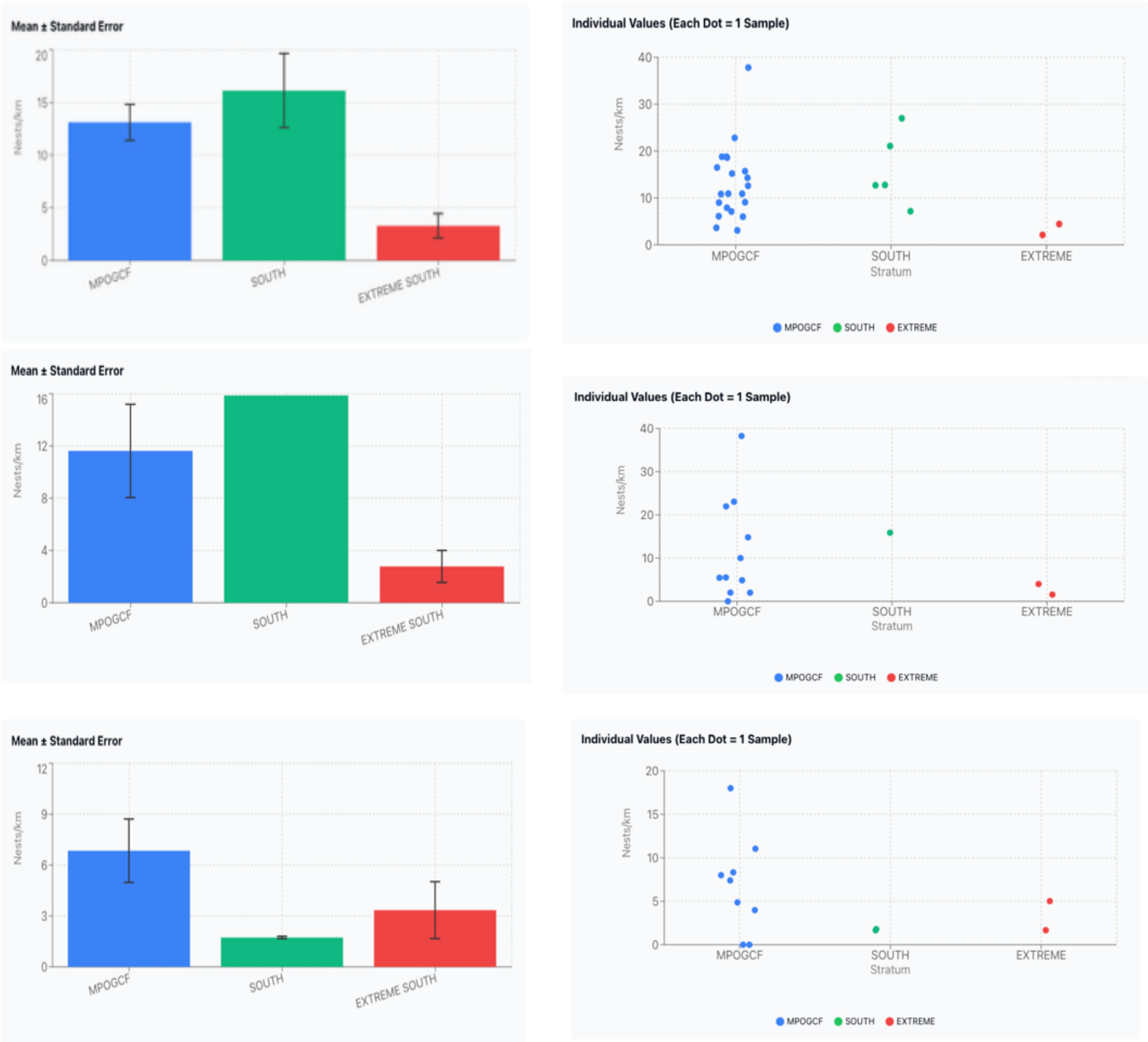


Figure 1: Graph showing the Mean and SE of nest kilometric indexes (left) and individual values (right) in the three strata for Drone Transects (top); Ground line transects (middle) and recce walks (Bottom)

We then examine possible correlations between the kilometric indices obtained with the three methods. Since transect locations were independent within each stratum, we used the mean-based correlation approach. Of course, we have only three strata to test with this data set, and the resulting statistical power is very low: Table 4. However, we observe a positive correlation between the kilometric indices obtained with drones and those obtained from the ground for the three strata. Additional data collected during other field expeditions carried out under this MPOGCF project will improve the statistical power of this type of analysis.

Method Pair	Pearson r	R^2	Strength	Significance
LT Drones vs LT Ground	0.995	99.0%	Strong	p > 0.05 (ns)
LT Drones vs RW Ground	-0.016	0.0%	Weak	p > 0.05 (ns)
LT Ground vs RW Ground	-0.113	1.3%	Weak	p > 0.05 (ns)

Table 4: Results of correlation analysis between methods

On average, LT Drones is 0.76 nests/km higher than LT ground, which is a relatively small bias (indeed, 95% of the difference falls between -0.53 and 2.05 nests/km), so the methods could potentially be used interchangeably. However the Blant-Altman analysis shows that RW ground is in very poor agreement with LT drones or LT ground with our current data set.

Our data also show that nest distribution in the forest is clumped, a common pattern among orangutans. For all three methods, Encounter Rates (or kilometric indexes) vary widely across transects, suggesting a patchy distribution of nests across the landscape. Indeed, significant heterogeneity is evident in the high CV values for LT ground (101.8%) and RW ground (81.9%) in the Medium stratum, for example. This finding is confirmed by the uneven location of the nests along the RWs or the LTs (Table 5 for RW or Annex III for LTs). One major determining factor for nest location is the availability of a suitable nesting site. This patchy distribution is correlated with the landscape itself. Indeed, we find orangutan nests where trees are large enough to support the sleeping structures. However, the habitat in LKG and surrounding forests is highly fragmented. Small patches of forest are surrounded by empty areas invaded with grasses and bushes: this type of habitat is not suitable for orangutan nesting. This strong habitat fragmentation and mosaic contributes to the very uneven distribution of potential sleeping nesting sites. **Availability of trees that are large enough to support orangutan nests is far from being even in LKG, explaining the uneven and clumped nest distribution. This will be a very important factor to consider when estimating the entire population size in LKG** (see below).

Date	RW Nb	Distance (km)	Starting	Ending	Objects	Description	Forest conditions
07.08	L2	0.503	RW2S	RW2E	OU nest	1, 73 m, III, Pterospermum	Disturbed forest +
						1, 122 m, V, Pterospermum	
						1, 181 m, IV, Neolamarckia	
					Wildlife	Footprints of Rusa Deer	
	R1	0.500	R1S	R1E	OU nest	1, 67 m, IV, unknown	MPOGCF plot: heavily disturbed forest with isolated patches of trees surrounded by open areas.
						1, 88 m, V, unknown	
						1, 187 m, IV, Seraya	
						1, 520 m, IV, Pterospermum	
					Wildlife	Signs: Rusa deer and elephants	
08.08	RW1	0.500	R2S	R2E	Wildlife	Signs wild boars and rusa, one wallow	Nice flat and dry forest, canopy closed (60%), some large trees
	RW1	0.676	RW1S	RW1E	OU nest	1, 32 m, III, Kasai	Nice dry and semi-inundated forest; claosed canopy; many pioneer trees OU food: +++
						1, 211 m, IV, Neolamarckia	
						1,252 m, III, Neolamarckia	
						1, 508 m, III, Malotus	
						1, 514 m, III, Dracontomelon	
					Wildlife	Signs: rusa deer	
09.08	L3K	1.004	RWS	RWE	OU nest	1, 510 m, III, Pterospermum	Disturbed forest, dry and steep, open canopy, cimbers ++ OU food: +
						1, 693 m, III, Pterospermum	
						2, 806, III and IV, Laran	
					Wildife	FP tembadau	

						Rhinoceros hornbill	
	L4	0.500	R4S	R4E	OU nest	1, 339 m, IV, Pterospermum	Disturbed forest, few large trees, climbers ++ Ou food: +
						1, 797 m, V, Laran	
						1, 872 m, IV, Laran	
						1, 892 m, III, Laran	
						2, 915 m, IV and V, Laran	
						2, 915 m, V and V, Magas	
						1, 974 m, I, pterospermum	
					Wildife	Signs: bear, rusa deer	
					Human	Signs	
	1	0.634	RW2S	RW2E	OU nest	1, 212 m, III, Laran	First 400 m: Disturbed forest, waddens ++ Then better forest with OU food ++
						1, 405 m, III, unknown	
						1, 490 m, III, Laran	
						1, 584 m, III, Sireh2	
						1, 590 m, III, Sepatir	
						2, 593 m, I and IV, Seraya	
					Wildlife	Rusa and wild boar	
						Tembadau: frsh signs (2 days)	
10.08	LP1	0.283	RWLP1S	RWLP1E	Wildife	Signs of rusa deer	Degrded forest
12.08	RW5	1.112	RW5	RWE	OU nest	1, 628 m, Teralis	Highly degraded forest, no large tree, little OU food, open canopy, wadden ++
						1, 628 m, Seraya	
	LT4	0.601	RW4KS	RW4KE	OU nest	1, 162 m, IV, unknown	Forest slightly degraded and dry, steep slope (up and down) OU food: +
						1, 180 m, III, Pterospermum	
						1, 182 m, IV, Tandiran	
						1, 421 m, III, Ampas tebu	
						1, 478 m, III, unknown	
					Human	Signs broken branches	
13.08	RW	1.194	RWS	RWE	OU nest	1, 655, IV, Seraya	Follow old logging road. Disturbed forest. Dry and slopes. OU food: + After 1000m: very disturbed
						1, 655, III, Kasai	
						1, 819, IV, Nauclea	
						1, 1038, II, Neolamarckia	
						1, 1089, III, Kapur	
						1, 1089, III, Neolamarckia	
					Wildlife	Signs: Rusa deer and elephants	
						Voice: gibbons	
	RW5K	0.600	RW5KS	RW5KE	OU nest	1, 246 m, IV, unknown	Nice forest; dry and flat OU food: ++
					Wildlife	OU feeding signs	
						Signs rusa deer	
						DS: barking deer; mouse deer	

Table 5: Details of location, distance, and sightings for each ground RW walked at the survey locations.

On the 14th of August, the teams conducted a nest survey from the road using two cars. We mostly covered the South and Extreme South strata (toward Taliwas):

South stratum:

- Car 1: 11.0 km 50 nests
- Car 2: 8.93 km 83 nests

Extreme South (toward Taliwas):

- Car 2: 5.66 km 11 nests

Figure 2: Map showing the road transect on the Southern and Extreme South strata

A total of 133 nests were recorded along 19.93 km of road within the South stratum, generating a kilometric index of 6.62 nest/km. In the Extreme Southern part of the survey area, the team drove 5.66 km and identified 11 nests, yielding a kilometric index of 1.94 nests/km.

These results confirm that orangutan nests become less abundant as we approach Taliwas, despite a forest being in better condition (see results of botanical plots). A lower density could be explained by:

- The proximity of Sepagaya and other kampung and possible past hunting pressure on orangutans;
- The scarcity of food resources;
- Topography: orangutans naturally prefer extreme lowland alluvial forests (which used to cover LKG before timber exploitation), while undulating dry forests are a less preferred habitat (South and Extreme South of the survey region).

However, what this result confirms is that once extirpated from a given landscape (either by killing, forest exploitation and conversion, or fires), it will take decades for orangutans to move in and establish a new self-sustaining population.

1. Nest classes and tree selection for nesting

A total of 217 nests from ground RWs, car recces and ground line transects are included for the analysis of orangutan nesting behavior and age classes.

We identified at least 38 genera of trees used by orangutans for nesting. Most nests were identified in pioneer and fast-growing species:

• Neolamarckia cadamba	Laran	Rubiaceae	47 nesting trees	21.6 %
• Pterospermum sp.	Bayur	Sterculiaceae	42 nesting trees	19.35%
• Nauclea sp.	Bangkal	Rubiaceae	14 nesting trees	6.45%

The selection of nesting trees by orangutans reflects the availability of trees in the overdegraded forests of LKG. Indeed, in this overdegraded forest, the tallest and strongest trees that can support the weight of an orangutan while sleeping at night are mostly pioneer fast-growing tree species, since this type of trees is preferentially used in restoration exercises in areas devoid of trees, contributing to their dominance in restored areas (see the section on botanical analysis). Many climax tree species are still too small for orangutans to use as nesting sites.

However, Dipterocarpaceae and other climax tree species are used by orangutans in better quality forest compartments (especially some areas in South and Extreme south strata):

• Shorea sp.	Seraya	Dipterocarpaceae	19 nesting trees	8.75%
• Parashorea sp.	Urat mata	Dipterocarpaceae	9 nesting trees	4.14%
• Pommetia pinnata:	Kasai	Sapindaceae	7 nesting trees	3.2%

The class ages of the nests are distributed as follows:

- Class I (Fresh): 9 nests (4.1%)
- Class II (Recent): 12 nests (5.5%)
- Class III (Mature): 75 nests (34.6%)
- Class IV (old): 73 nests (33.6%)
- Class V (very old): 48 nests (22.1%)

Fresh and recent nests are relatively scarce in our data set. This could indicate that orangutans are constrained by the choice of potential nesting sites.

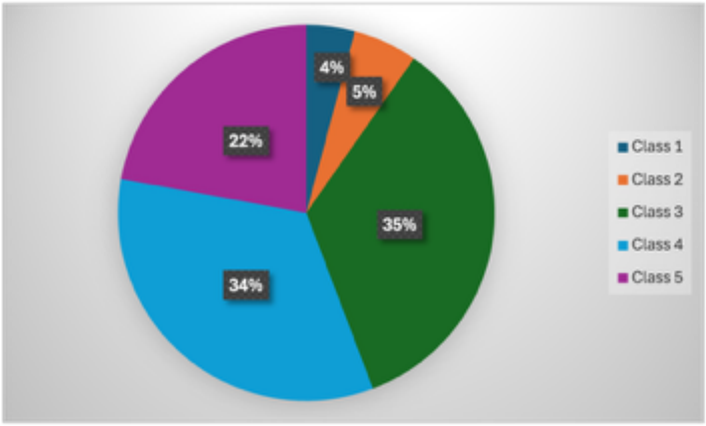


Figure 3: Age-classes for nests identified during the field surveys

2. Ground Line transects

We can pool the line transects carried out in the two strata Medium (MPOGCF) and South, while keeping Extreme South on its own, since there is no significant difference in the kilometric indexes between the two first strata. For the first area (Medium and South strata) we performed a Distance analysis to obtain a nest density for the survey area. We tested three different models and selected the Hazard-rate based on AIC results:

- Number of transects: 12
- Otal length of transects: 7.095 km
- Number of nests: 73
- Mean perpendicular distance: 9.90 m
- Truncation distance (95th percentile): 22.62 m
- Number of nests after truncation (95%): 69
- Detection function: Hazard-rate
  - AIC = 4.00
  - Delta AIC with Half-Normal is 414.75
  - Bootstrap stable (1000 iterations)
  - Good detection with truncation distance
- Effective Strip Width: 22.62 m

Based on this analysis, we estimated the orangutan nest density to be 215 nests/km^2 (95% CI: 109 - 326 nests/km^2: CV=26.3%). Our results show a moderate precision and a very high Coefficient of Variation across transects (CV=100%), indicating a highly clustered nest distribution in the forest, as noted above.

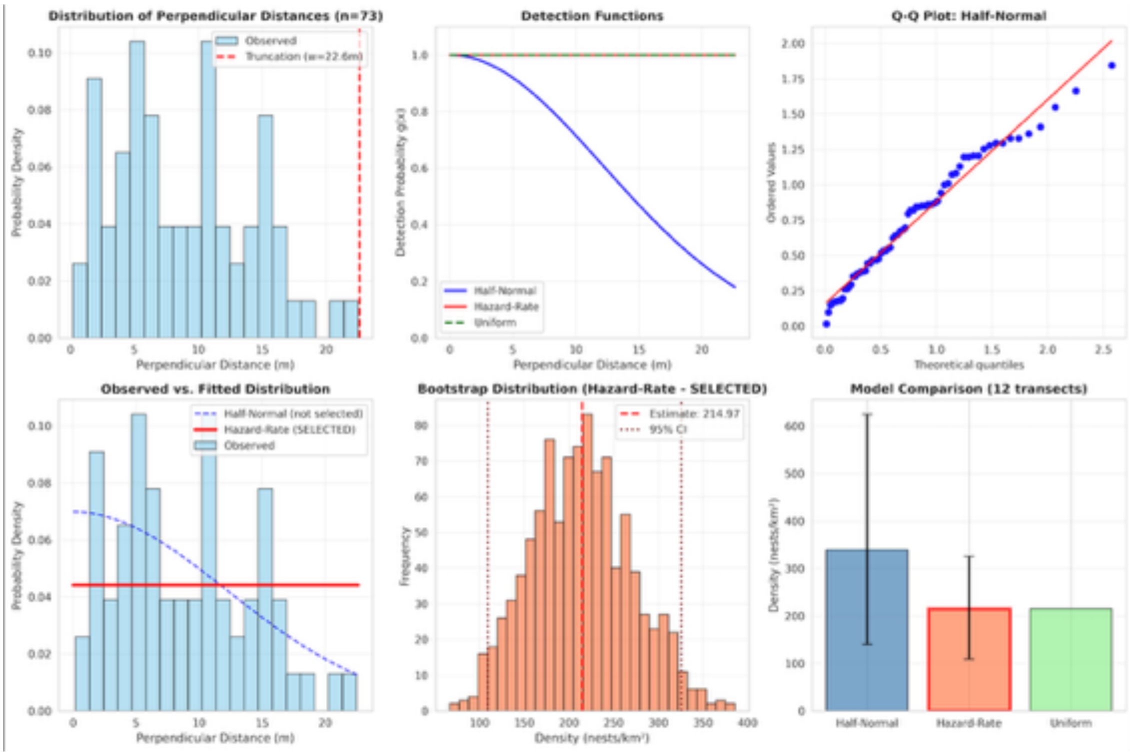


Figure 4: Graphs showing the results of the Distance analysis with our data set.

Orangutan densiy is then estimated with the formula:

$$D_{OU} = D_{nest} / p\ r\ t$$

With p the proportion of nest builders, r the rate of daily construction and t the nest decay rate. For this calculation, we use the values defined for Kinabatangan[5], since the two habitat types are similar (same type of extremely lowland disturbed forests):

$$p=0.9$$
$$r=1.084\ (CV=6.3\%)$$

The nest decay rate is the most variable parameter for orangutan density calculations. From our previous work, we showed that the decay rate differs significantly between two different groups of trees[5]:

- Hardwood (*Eusideroxylon* or *Dimocarpus*): t_1 = 431 days, SD=170
- OT and pioneer trees: t_2 = 153 days, SD= 93

In order to obtain a more precise orangutan density estimate, we used a weighted nest decay rate. A total of seven nests were built in trees belonging to Group 1, while the other nests were built in trees belonging to Group 2 (n=62), providing a final t estimate for the survey area of t = 181.2 days (SE=84.85; CV=46.5%).

The final estimate is

D_{OU} = 1.22 orangutan / km² (95% CI: 0.42 – 3.51 OU/km²; CV = 54.1%)

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[5] *Ancrenaz, M., Calaque, R., and I. Lackman-Ancrenaz. 2004. Orang-utan (Pongo pygmaeus) nesting behavior in disturbed forest (Sabah, Malaysia): implications for nest census. International Journal of Primatology, 25 (5): 983-1000*

As usual for this type of estimate, the high CV for decay time (46.8%) is the dominant source of uncertainty in the orangutan density estimate, contributing to 75.1% of the variance of the final orangutan density. The 95% CI of the final estimate is obtained with a log-normal approximation:

$$CI = \exp[\ln(D) \pm z \times CV(D)], \text{ with } z=1.96 \text{ for 95\% CI}$$

$$95\% \text{ CI} = 0.42 – 3.51 \text{ orangutan/km}^2.$$

We cannot conduct a Distance analysis for the ExtremeSouth startum due to the paucity of data collected in this area (3 line transects totaling 1.143 km; 3 nests). However, we can approximate the nest density using a Kelker-modified methodology, yielding a nest density estimate of about 26.3 nests/km^2, resulting in a final orangutan density estimate of 0.18 ind./km^2.

- **Nest surveys with drones during the day**

During the day, the team flew the drone above straight lines and looked for orangutan nests. Overall results are presented in Table 3 above and detailed results in Table 6 below.

Stratum	Tr. Name	Distance (km)	Number of nests	Index (nest/km)
Medium	LTDK1	0.55	2	3.64
	LTDK2	1.000	9	9.00
	LTDK3	0.667	11	16.49
	LTDK4	0.975	3	3.08
	LTDK5	0.715	9	12.59
	LTDK6	0.958	18	18.79
	LTDK7	1.128	21	18.62
	LTDK8	0.723	11	15.21
	LTDK9	0.700	10	14.29
	LTDK10	0.833	19	22.81
	LTDK11	0.642	7	10.90
	LTDK12	1.100	10	9.09
	LTDK13	2.000	12	6.00
	LTDK14	0.369	4	10.84
	LTDK15	0.844	6	7.11
	LTDK16	1.400	22	15.71
	LTDK17	0.635	24	37.80
	LTDK18	0.632	5	7.91
	LTDK19	0.458	5	10.92
	LTDK20	0.820	5	6.10
	LTDK21	0.745	14	18.79
South	LTDK 22	0.712	15	21.07
	LTDK 23	0.63	8	12.70
	LTDK 26	0.556	15	26.98
	LTDK 27	0.558	4	7.17
	LTDK 28	0.470	6	12.77
Extreme South	LTDK 24	0.900	4	4.44
	LTDK 25	0.945	2	2.12

Table 6: Number of line transects flown with a drone, distance and number of nests in three different strata.

All these-line transects were carried out at a mean flight altitude of 100-500 m, depending on the topography. Since the width of the strip surveyed by the drone is fluctuating, we cannot directly derive any density estimate, but we can analyse the nest kilometric indexes. When we compare the means across the three strata, we find no significant difference (Kruskal-Wallis, p=0.064). However, this analysis is severely limited by an extremely small sample size in the third stratum (only 2 transects).

We now focus our analysis on the two strata Medium and South. Both datasets exhibit high variability due to uneven nest distribution in the forest and small sample size in South stratum (n=5). However there is no difference between the two strata, as already observed above and in Table 7.

Stratum	Nb transects	Mean ± SE (nb nest/km)	Median	Range	95% CI
Medium	21	13.13 ± 1.71	10.92	3.08 - 37.80	9.57 - 16.69
South	5	16.14 ± 3.50	12.77	7.17 - 26.98	6.41 - 25.86

Table 7: Mean and SE of nest kilometric indexes from drone line transects in two strata.

We don't find any significant difference between the two strata (Mann-Whitney U test: p=0.329), although South is 3.01 nest/km higher than Medium: figure 5.

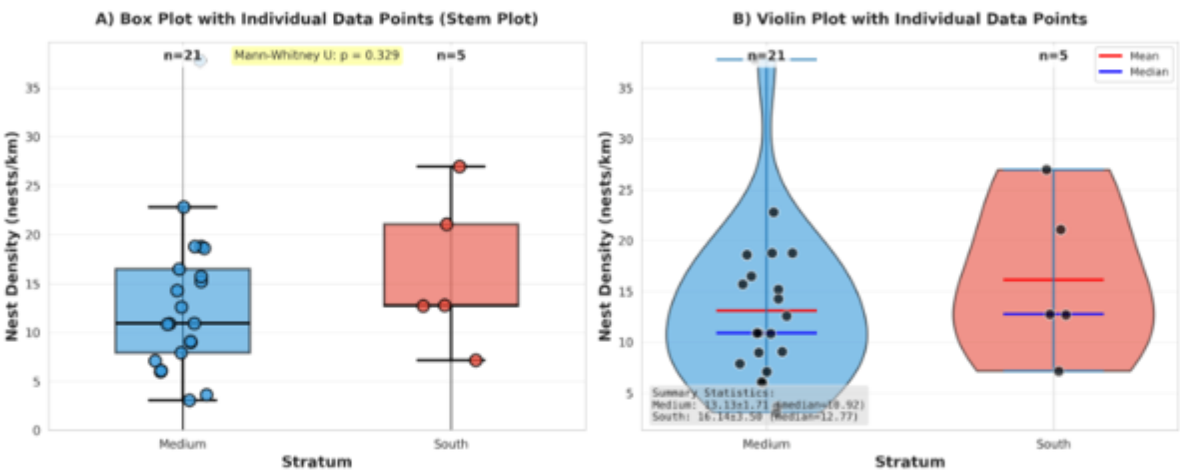

Figure 5: Box plot and Violin Plots for the two data sets in Mediaum and South strata (red line=mean; blue line=median; black dots=transects).

- **Results of thermal drone surveys**

The team completed five plots for thermal imagery during field survey. Eact plot was surveyed for two consecutive nights and by two teams each night (so, total of four flights for each plot). Plot information is shown in Table 8 and plot location is given in Annex IV.

Plot Number	Plot Size	Date	Flight number	Number of orangutans	
				Inside Plot	Outside Plot
1	0.64 km²	07.08.2025	1	0	1
		07.08.2025	2	0	1
		08.08.2025	3	0	0
		08.08.2025	4	0	0
2	0.64 km²	07.08.2025	1	0	0

		07.08.2025	2	0	0
		08.08.2025	3	2	0
		08.08.2025	4	2	0
3	0.64 km^2	09.08.2025	1	0	0
		09.08.2025	2	0	3
		10.08.2025	3	0	4
		10.08.2025	4	0	0
4	0.64 km^2	10.08.2025	1	3	0
		10.08.2025	2	3	0
		11.08.2025	3	4	0
		11.08.2025	4	4	0
5	0.64 km^2	10.08.2025	1	3	0
		10.08.2025	2	0	0
		11.08.2025	3	3	0
		11.08.2025	4	2	0
TOTAL	**12.8 km^2**			**26 ind.**	**9 ind.**
6 (Extreme South)	0.64 ha	12.08.2025	1	0	0

Table 8: Number of orangutans detected with the thermal drone at night

We detected a total of 26 individuals in the plots during our night surveys (this number encompasses all orangutans detected during all flights, so the same individual might have been recorded twice or more), while an additional nine individual sightings were obtained from the areas just outside of the plots.

A rough orangutan density estimate from the drone surveys would be the total number of individuals detected across successive nights divided by the total surface covered during those nights (or 26/0.64*20=2.03 ind./km^2). However, this is still impossible to estimate the orangutan density from thermal night surveys since we still don't know what is the detection probability for this new methodology.

One of the proposed outcomes of the entire MPOGCF project is to determine this detection probability and develop a suitable methodology for orangutan surveys using thermal drones. This will be achieved by pooling all results from the three years of field expeditions.

3. Results of ground line transect surveys within the plots

During fieldwork, the team conducted ground-line transects within three thermal plots. Given the small sample size, we cannot use the Distance analysis to estimate nest density; thus, we employ the Kelker-modified approach to provide a rough estimate of orangutan density derived from ground-line transects. Results are presented in Table 9.

Plot	Line	Dist. (km)	Perp. Dist. nest	Trees	Calcul
Plot 3	LP2	0.894	30>	laran	Outliers = Red Strip width = 12.47 m Nb nests within w = 5 D_{nests} = 112.6 nests/km^2 D_{OU} = 0.74 ind./km^2
			20.8	bayur	
			8.7	keruing	
			4.2	bayur	
			3.1	laran	
			7.9	durian	
			27.9	laran	
			30>	laran	
	P2	0.882	>50	laran	
			>50	laran	
			15.7	laran	

			>50	laran	
			>50	laran	
			>50	laran	
			12.5	laran	
			18.2	bangkal	
			5.7	laran	

Plot 2	LP2	0.859	8.2	karpus	Outliers = Red Strip width = 11.87 m Nb nests within w = 5 D_{nests} = 128.7 nests/km² D_{OU} = 0.84 ind./km²
			8.2	karpus	
			5.6	laran	
			11.2	laran	
			50>	laran	
	LP1	1.1	8.5	mamboakat	
			6.8	kutang-kutang	
			14.7	urat mata	
			15.8	urat mata	
			27.8	sedaman	
			30>	laran	

Plot 1	L1	0.5	2.1	unknown	Strip width = 11.87 m Nb nests within w = 5 D_{nests} = 645.1 nests/km² D_{OU} = 4.22 ind./km²
			14.7	kasai	
			3.6	bangkal	
			4.7	unknown	
			5.7	unknown	

Table 8: Number and length of ground line transects carried out within the thermal drone plots and estimate of orangutan densities (Kelker-modified approach) – In red color are outliers not used in the analysis

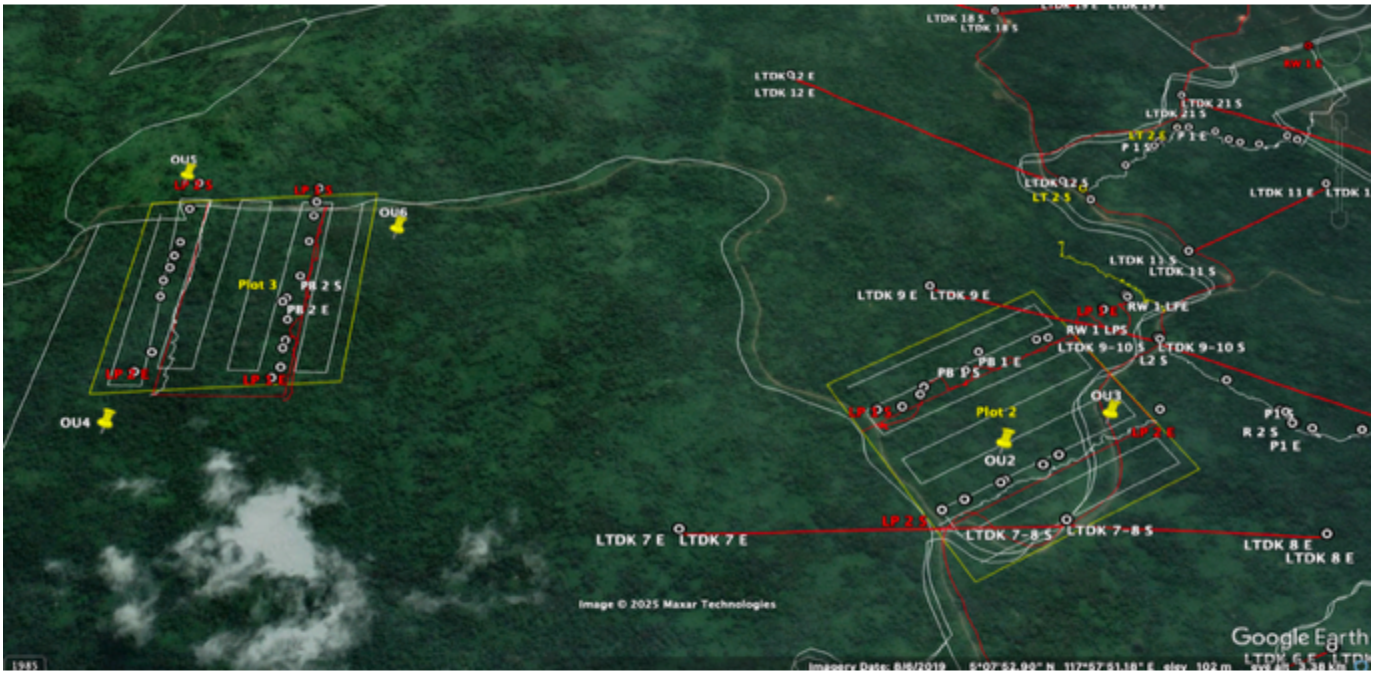

Figure 6: Map showing the location of two thermal plots and the location of orangutans detected during the night with the respective ground line transects and location of nests identified during the day.

- **Results of rapid Forest assessments**

4.1. Forest structure

The team completed a total of 18 plots and recorded 264 trees with a dbh >20 cm within these plots (Table 10).

Stratum	Nb plots	Nb trees	Dbh				
			20-30	30-40	40-50	50-60	>60
Medium	13	179	67.6	22.9	8.9	0	0.6
South	2	30	26.7	53.3	20	0	0
Ex South	3	55	54.6	21.8	20	3.6	0

Table 10: Percentages of tree dbh classes for each stratum

Results show very distinct forest structure between the three strata (Figure 7):

- Medium (n=179 trees)**:** Heavily skewed toward young trees with 67.6% in the smallest diameter class (20-30cm). This finding is in accordance with the highly degraded stage of the forest and the restoration efforts, with young (and as such, smaller-sized) trees commonly found. Only 9.5% of trees are ≥40cm DBH, and virtually no mature trees exist (0.6% >60cm).
- South (n=30 trees)**:** Shows a more mature population with 53.3% in the 30-40cm class - a notable shift toward larger diameters. However, this area has only 30 trees, making it the least statistically reliable of the three datasets.

- Extreme South (n=55 trees): Displays the most diverse age structure with a broader distribution across size classes. It's the only area with meaningful representation in the 50-60cm class (3.6%) and has the highest proportion of large trees overall (23.6% ≥40cm).

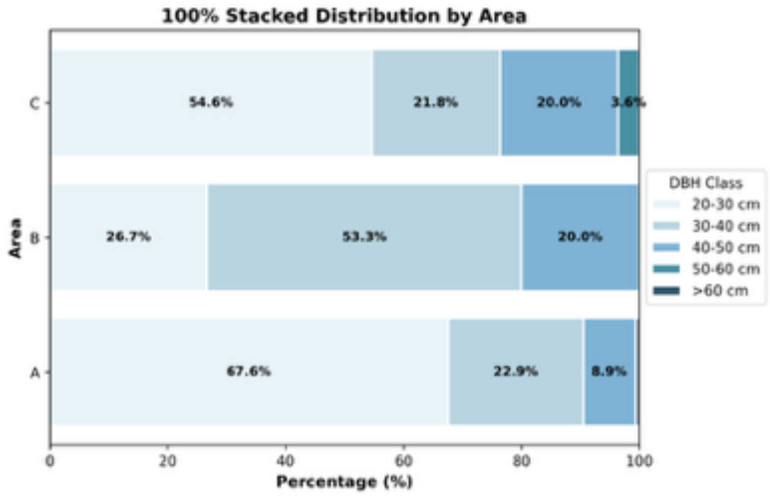

Figure 7: Stacked distribution of dbh classes in the three different strata.

The scores estimated from three different locations within each botanical plot show that the canopy was more open in the Medium stratum compared to the other two strata (Table 11). Small trees also tend to be less common in this stratum. Climbers, however, have a very similar abundance for all strata, indicating a certain level of disturbance.

		Score (0 to 3)		
Area	Nb plots	Canopy	Small trees	Climbers
Medium	13	0.85	2.21	2.62
South	2	2	3	2
Ex South	3	1.67	3	2.6

Table 11: Scores (ranging from 0 to 3) for canopy, presence of small trees and climbers for the three strata.

Overall, the forest structure is the most disturbed in the Medium stratum, compared to South and Extreme South.

4.2. Forest composition

Table 12 presents the contributions of the five most common tree families across the three strata. Rubiaceae and Sterculiaceae (pioneer tree species) are the most common families in Medium, reflecting the restoration efforts underway in this area. Indeed, many trees selected for restoration in LKG are pioneer species such as Laran (Rubiaceae) or Bayur (Sterculiaceae). Dipterocarpaceae, however, is the commonest family for South and Extreme South, with relatively few pioneer trees in these two strata. The tree family composition reflects the forest structure documented above. Pioneer trees tend to be of smaller size than climax species, such as members of the Dipterocarpaceae family. The forests in the South and Extreme South, also degraded, appear to be in a better and more mature regeneration stage than the forests of the Medium stratum of LKG.

	MEDIUM		SOUTH		Extreme SOUTH	
Nb plots	13		2		3	
TOTAL	179		30		55	
Dipterocarpaceae	28	15.6%	16	53.3%	17	30.9%
Rubiaceae	50	27.9%	0	0.0%	3	5.5%
Sterculiaceae	33	18.4%	4	13.3%	1	1.8%
Sonneratiaceae	9	5.0%	0	0.0%	0	0.0%
Unknown	17	9.5%	3	10.0%	5	9.1%

Table 11: Five commonest tree families identified in our plots for the tree survey strata.

Tree densities in the botanical plots show a wide variation between strata:

> Medium: av.= 13.7 trees/km^2 (SD=5.0 trees/km^2)
> South: av. = 16.0 trees/km^2 (SD=1.4 trees/km^2)
> Extreme South: av. = 18.3 trees/km^2 (SD=2.5 trees/km^2)

Conclusions about orangutan surveys

Our preliminary conclusions indicate that:

- **Density estimates suggest orangutan persistence in the landscape**: Our current density estimate (1.22 ind/km^2) falls within the range previously documented by Hutan, WWF, and SFD, suggesting the population is surviving despite intensive degradation of their natural habitat.
- **Thermal drone methodology**: Nocturnal thermal surveys show promising results. Subsequent surveys under the MPOGCF-funded project will provide critical data for refining this novel approach to orangutan monitoring.
- **Nest tree selection reflects degradation**: In heavily degraded LKG forests, orangutans predominantly nest in pioneer, fast-growing tree species—the tallest and strongest trees capable of supporting their weight. These pioneer species dominate the landscape due to their use in restoration efforts in areas previously devoid of trees. Many climax tree species remain too small to serve as viable nesting sites.
- **Need to continue restoration activities in the area**: Many open areas are infested with creeper plants and climbing bamboos, which suppress natural forest regeneration. Restoring these over-degraded forests, especially with pioneer tree species, is a way to improve the quality of the habitat for orangutans and other fruit eater animals and to sustain their populations.
- **Use of climax species in better-quality habitat**: In higher-quality forest compartments (particularly in the South and Extreme South strata), orangutans do utilize Dipterocarpaceae and other climax tree species for nesting.
- **Eastern paradox—lower density despite better forest condition**: Despite forests being in significantly better condition on the eastern side of the survey area (Taliwas and surrounding areas), orangutan density is markedly lower. This counterintuitive pattern likely results from multiple factors:
  - *Historical hunting pressure:* Proximity to Sepagaya and other settlements (kampung) may have resulted in past hunting pressure that locally extirpated orangutans.
  - *Food resource scarcity:* Potential limitations in food availability in these areas.
  - *Habitat preference*: Orangutans naturally prefer extreme lowland alluvial forests (which historically covered LKG before timber exploitation), whereas the undulating dry forests characteristic of the eastern region may represent suboptimal habitat.

This finding underscores a critical conservation principle for orangutans: once orangutans are extirpated from a landscape—whether through hunting, forest exploitation and conversion, or fire—recolonization and establishment of a self-sustaining population requires decades.

RESULTS OF BIODIVERSITY SURVEYS

1. Camera Trap

One of the ten deployed cameras was faulty (it triggered via a time-lapse mode, resulting in 35,640 photos taken at regular time intervals, and not when wildlife was passing by). Hence, we discarded the results from this camera from the analysis

Over two months, the nine camera traps yielded a sampling effort of 789.93 days and collected 3,630 wildlife photos. These photos derived 452 independent detections belonging to 25 species and an additional three groups that we were unable to identify down to species level (mousedeers, rodents, treeshrews). The list of species and their detection frequency is given in Figure 8.

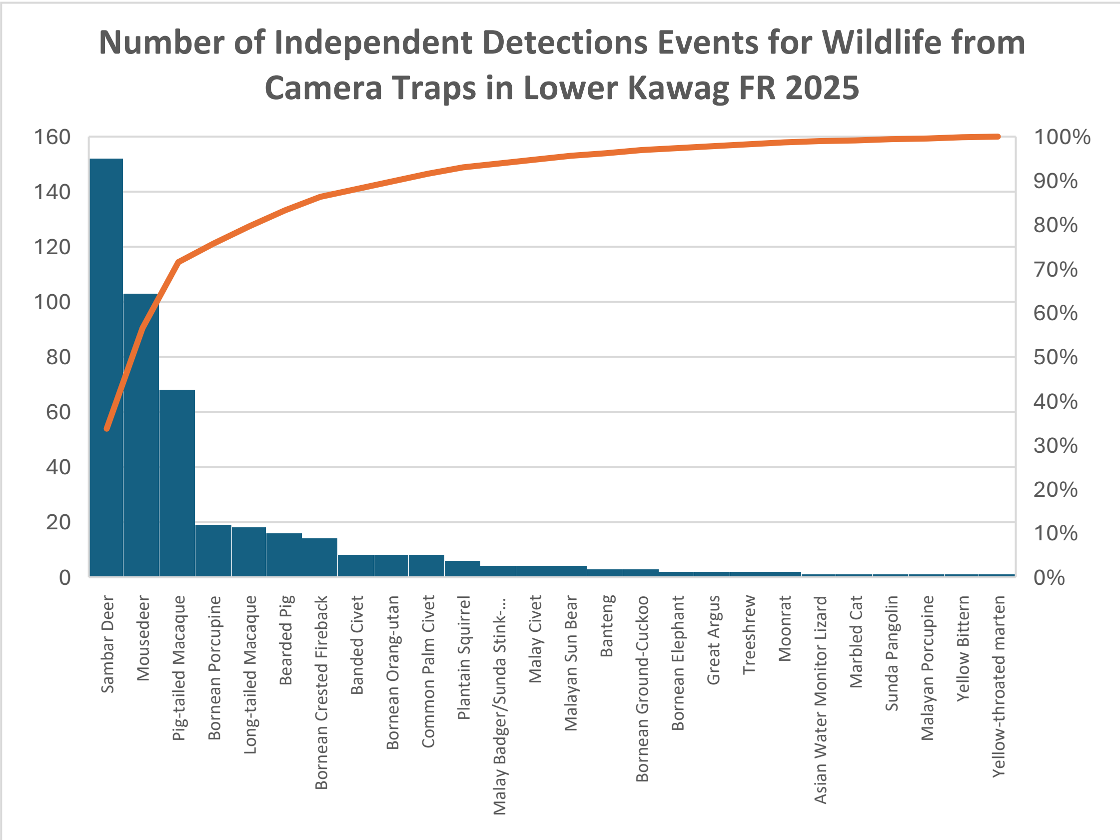

Figure 8: Histogram showing the number of independent detections per species

Out of these 25 species, a total of 12 species are listed in the IUCN Red List as Critically Endangered (Bornean orangutan, Sunda pangolin, Banteng), Endangered (Bornean elephant, Long-tailed macaque, Pig-tailed macaque), and Vulnerable (Bornean bearded pig, Bornean crested fireback, Bornean ground cuckoo, Great argus, Malayan sun bear, Sambar deer). Seven of the species are endemic to Borneo.

Three species accounted for 78.4% of all independent detections:

- Sambar deer (*Cervus unicolor*) were the most commonly captured species. They were found at all locations, and accounted for 33.63% (152 of 452) of the total of independent detection events
- Mousedeer (*Tragulus sp.*) accounted for 22.79% (103 independent detections).
- Pig-tailed macaques (*Macaca nemestrina*) yielded 15.04% (68) of the independent detections.

All other species accounted for fewer than 20 independent events each.

Cervids' abundance can be related to the degraded status of the landscape (thereby offering numerous foraging opportunities for these browser species), and also indicates relatively low hunting pressure. The presence of wild boars (*Sus barbatus*) indicates that the local population is undergoing a slow recovery from the outbreak of African swine flu that swept across the forests of Ulu Segama in the early 2020s. All pictures showed single individuals or pairs, and not large family groups.

A very interesting sighting was three independent detections of the CE banteng (*Bos javanicus*). This species is undergoing an overall decline across its range in Sabah due to poaching and habitat fragmentation. It is of the utmost importance to protect the small herd of tembadaus living in Ulu Segama Malua complex (see the Sabah Banteng Action Plan 2020-2030).

Not surprisingly, we also detected elephant's presence during our trapping session.

All ungulate images captured with our cameras indicated that the animals were in good physical condition, with no signs of malnutrition.

Other species of interest detected via the deployment of camera traps included:

- The CE Sunda pangolin (*Manis javanica*), showing a female and her baby riding on the back of his mother.
- Several individuals of the CE Bornean orangutans, seen walking on the ground, including adult males and adult females with babies.
- Seven carnivore species, including a single detection of a marbled cat (*Pardofelis marmorata*) mother and her cub, and a yellow-throated marten (*Martes flavigula*). Other species include sunbear (*Helarctos malayanus*), Malay civet (*Viverra tangalunga*), Malay badger (*Mydaus javanensis*), Common palm civet, and the elusive and rare Banded civet (*Hemigalus derbyanus*).

Last, but not least, we detected the presence of the endemic Bornean ground-cuckoo (*Carpococcys radiatus*). This species is often seen in association with ungulates or sunbears while foraging on the forest floor. We captured an image of this bird with a sambar deer.

2. **Small mammals**

In total, we captured and released 19 small mammals belonging to 8 species across the five capture lines: Table 12.

Most species and individuals were captured at SM01 (7 species and 9 individuals), a transect under a low canopy with abundant vines of medium size, bushes, and climbers, characterized by many small trees 5-10 m high. This type of ecosystem provides ample food resources, and locomotion substrate and opportunities for predation avoidance, factors that could account for the higher capture rate at this line compared to other lines. Other transects were located on flat ground and characterized by the presence of larger trees (up to 20 m high) with a closer canopy (60-70% closeness), less vines, and more shrubs.

Treshrews were the most common taxa captured in our traps (3 species; 9 captures), followed by rats (3 species; 4 captures) and squirrels (2 species; 3 captures). With six captures, plain treeshrews presented the highest capture rate. Overall, the species captured are commonly associated with the environmental conditions characterising degraded forest and forest edges.

Additional bycatches included:

- Common palm civet
- Masked palm civet (*Paguma larvata*)
- Moonrat (two captures) (*Echinosorex gymnurus*)
- Short-tailed babbler (*Trichastoma malaccense*)

Local name	Scientific name	Transects				
		SM01	SM02	SM03	SM04	SM05
Large Treeshrew	*Tupaia tana*	2				
Lesser Treeshrew	*Tupaia minor*	1				
Low's Squirrel	*Sundasciurus lowi*	1		1		
Plain Treeshrew	*Tupaia longipes*	2			3	1
Plaintain Squirrel	*Callosciurus notatus*	1				
Red Spiny Maxomys	*Maxomys surifer*				3	
Tioman Rat	*Rattus tiomanicus*	1				1
Whitehead's Maxomys	*Maxomys whiteheadi*	1				1
	Total captures	**9**	**0**	**1**	**6**	**3**

Table 12: Species and number of individuals caught and released along five transects.

3. Night spotting

Along 29 km of road surveyed across three consecutive nights, we recorded 17 wildlife sightings: Table 13. By far, sambar deer and Malay civet are the commonest sightings along the road of Kawag at night (with both species scoring a kilometric index of 0.21 ind./km). These species are edge specialists and common along logging roads.

The sighting of a banded linsang was of special interest. This nocturnal, arboreal species is rarely observed.

No	**Species**	**Recce 1 (15 km)**	**Recce 2 (8 km)**	**Recce 3 (6 km)**	**Total**	**Encounter Index (29 km)**
1	Sambar deer	2	2	2	6	0.21
2	Common palm civet	1		1	2	0.07
3	Muntjac	1			1	0.03
4	Malay civet	2	2	2	6	0.21
5	Buffy-fish owl		1		1	0.03
6	Banded linsang (*Pronodon linsang*)			1	1	0.03
	Total	**6**	**5**	6	17	

Table 13: Species, number of individuals and resulting kilometric index (nb of sighting/ km) for three consecutive nights

4. Opportunistic sightings

We also recorded opportunistic sightings during fieldwork, as indicated in Table 14.

No.	Common Name	Scientific Name	Group
1	Long-tailed Macaque	*Macaca fascicularis*	Mammal
2	Pig-tailed Macaque	*Macaca nemestrina*	Mammal
3	Orangutan	*Pongo pygmaeus morio*	Mammal
4	Slow Loris	*Nycticebus coucang*	Mammal
5	Prevost's Squirrel	*Callosciurus prevostii*	Mammal
6	Bornean Pygmy Squirrel	*Exilisciurus exilis*	Mammal
7	Plain Treeshrew	*Tupaia longipes*	Mammal
8	Yellow-throated Marten	*Martes flavigula*	Mammal
9	Samba Deer	*Cervus unicolor*	Mammal
10	Greater Mousedeer	*Tragulus napu*	Mammal
11	Red Muntjac	*Muntiacus muntjak*	Mammal
12	Muntjac sp.	*Muntiacus sp.*	Mammal
13	Giant Tortoise		Reptile
14	Angle-head Lizard	*Gonocephalus sp.*	Reptile
15	Spitting Cobra	*Naja sp.*	Reptile
16	Mock Viper	*Psammodynastes pulverulentus*	Reptile

Table 14: Species observed during fieldwork (opportunistic sightings)

By combining all survey methodologies for terrestrial mammals, we confirmed the presence of:

- Nine carnivore species during field activities: seven detected from camera traps, one from a night survey, and one from opportunistic sightings.
- Five primate species
- Ten small mammal species: 4 squirrels, 3 tresshrews, and 3 rats.

5. Gibbon surveys

Table 15 below shows the results of the three-day gibbon surveys for vocalising groups. Based on terrain assessment, we estimated the average radial area of the listening area to be approximately 2 km^2.

Date	Group Heard by at least one team	Groups heard by the two teams	Area, a (km^2)	Density group (n/km^2)
9/8/2025	3	1	2	0.5
10/8/2025	4	3	2	1.5
11/8/2025	3	2	2	1
			Average (SD)	1 (0.5)

Table 15: Species observed during fieldwork (opportunistic sightings)

Daily density estimates of gibbon groups fluctuated between 0.5 and 1.5 groups/km², resulting in a mean density of approximately 1.0 group/km² (SD = 0.5 groups/km²) over the three-day survey period at Lower Kawag. This density is substantially lower than estimates from the same area in the 1980s, prior to large-scale logging operations and forest conversion[6]..However, the current density is comparable to values documented more recently in these forests following the drastic land-use changes that have characterized Lower Kawag and surrounding forests[7,8]. The extreme degradation of these lowland forests and the fragmented nature of current restoration blocks explain this low gibbon abundance. Unlike orangutans, which are frequently observed traveling on the ground, gibbons almost never do so.

Nevertheless, the relictual gibbon population may benefit from ongoing restoration efforts, and densities could increase as restored forests mature and become less patchy. Forest reconnection thus appears essential to sustain this population and secure its long-term viability.

6. Bird Surveys

Figure 9 below shows the species accumulation curve for bird species observed in Lower Kawag FR. Collectively, the team completed 29 '15-MacKinnon Lists', totalling 133 species.

The curve in the graph rises steadily, indicating that we have not fully captured the avian diversity present in Lower Kawag FR.

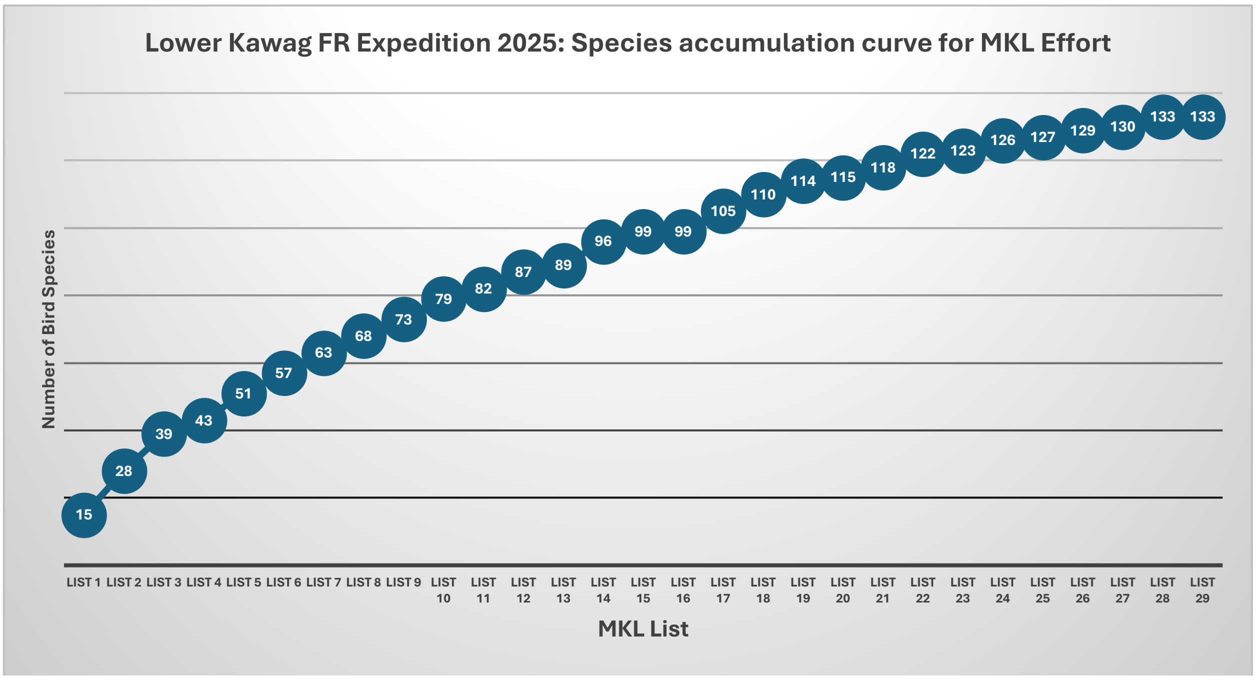

Figure 9: Species accumulation curve for bird species in Lower Kawag

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[7] Ancrenaz, M., Ahmad, E., and I. Lackman-Ancrenaz. 2006. Rapid surveys of Bornean gibbons (*Hylobates muelleri*) in Sabah, Malaysia. In *All Apes: Great and Small. Second volume: Asian Apes*, BMF Galdikas, N. Briggs, L. Sheeran, G. Shapiro, J. Goodall Eds. Kluwer Academic Press.
[8] Davies, G. and Payne, J. 1982. A faunal survey of Sabah.

A rapid analysis of the 29 "15 species MK Lists" available show that five species are very commonly seen or heard in the area. They are:

1. Black and yellow broadbill (13) – 44.8% representation in the total number of lists
2. Blyth's Paradise flycatcher (12) – 41.4% representation
3. Sunda Pied fantail (12) - 41.4% representation
4. Raffles's malkoha (12) – 41.4% representation
5. Ashy tailorbird (12) – 41.4% representation

Bioacoustics analysis detected 100 species, including 37 species not recorded during MKL surveys. Combined, the surveys documented 170 species, with four families accounting for approximately one-quarter of this total: Pycnonotidae (bulbuls, 14 species), Cuculidae (cuckoos, 13), Pellorneidae (babblers, 11), and Nectariniidae (sunbirds, 12).

The dominance of these families reflects the disturbed nature of the survey areas, as all four families are typical of degraded lowland mixed dipterocarp forests.

The full list of birds (gathering all survey methodologies used during the expedition) is given in Annexe III.

In total, we recorded 181 bird species across 50 families.

About 14 out of 181 species are listed in the IUCN Redlist as:

- **Critically Endangered: Helmeted Hornbill**
- **Endangered: Storm's stork, White-crowned hornbill, Wrinkled Hornbill**
- **Vulnerable: Black Hornbill, Blue-headed Pitta, Bornean Ground-Cuckoo, Crested Fireback, Grey-cheeked Bulbul, Great Argus, Great Slaty Woodpecker, Javan Myna, Rhinoceros Hornbill, Wallace's Hawk-Eagle.**

Ten species recorded in Lower Kawag are Endemic to Borneo (See Annexe).

Annex I: Brief Specifics of the Field Expedition carried out in Lower Kawag

Location: Lower Kawag

Date: 06.08.2025 to 15.08.2025 (2 travel days, 8 working days)

Staff involved:

- Hartiman Bin Abdul Rahman, OURS, Hutan
- Suhaimi Bin Bahrani, OURS, Hutan
- Azli Bin Etin, OURS, Hutan
- Herman Bin Suali, OURS, Hutan
- Waslee Bin Maharan, OURS, Hutan
- Bahrani Bin Elahan, OURS, Hutan
- Muhd Azizi Sulaiman Bin Bahrani, OURS, Hutan
- Muhammad Asim Addin Bin Zainal Abidin, OURS, Hutan
- Khairul Mizan Bin Johry, OURS, Hutan
- Vhielcey Villey, OURS, Hutan
- Hardiman bin Abdul Rahman, OURS, Hutan
- Mohd Faisal bin Asmara, OURS, Hutan
- Hamisah bin Elahan, OURS, Hutan
- Rusiman bin Rukimin, OURS, Hutan
- Eddie bin Ahmad, WSP, Hutan
- Hasbollah bin Sinyor, WSP, Hutan
- Mahathir bin Ratag, WSP, Hutan
- Azman bin Abdullah, WSP, Hutan
- Selamat bin Suali, WSP, Hutan
- Mohammad Fazdhil bin Ormat, WSP, Hutan
- Muhammad Hasraf bin Hasbollah, WSP, Hutan
- Mohd Fazlee bin Sarathy, WSP, Hutan
- Abdul Malek bin Pastor, WSP, Hutan
- Aziman bin Azrul, PANGI, Hutan
- Mohamad Hazlie bin Mohd Nazrie, PANGI, Hutan
- SFD: Marli bin Suali (Jabatan Perhutanan); Ramlan bin Sakong (Jaabatan Perhutanan)

Adjacent area type: Oil palm plantations

Work timeline

06.08.2025 - At 8:00 am, the OURS and WSP teams gathered at the OURS office and began loading all equipment into the cars and departed for Lower Kawag. The team arrived mid-day. At 8:00 pm, we gathered together with all our teams, including WSP, and were joined by several staff members from SFD to discuss the activities we would conduct and team composition.

07.08.2025 to 14.08.2025 - Teams were divided and started their respective tasks. On 14.08.2025, all teams gathered and double-checked all the data we had collected and equipment to ensure nothing was left behind.

15.08.2025 - We packed all work equipment and personal belongings into the cars. After ensuring no equipment/items were left behind, we all departed from Lower Kawag back to Kampung Sukau, Kinabatangan.

Annex II: Line transects and nest perpendicular distances for all transects

Date	Tr. Name	Dist. (km)	Nest Nb	Dist. Nest along Tr.	Nest height	Nest Class	Perp. Dist.	Bearing	Tree height	Tree species
7.08	L2KW	0.508	1	138.99	0/10	5	10.3	360	10/20	bangkal sp
			2	216.4	20/30	2	10	180	20/30	bangkal merah
			3	216.4	20/30	5	15.3	180	20/30	bayur
			4	226.77	10/20	3	13.2	360	10/20	bangkal
			5	273.1	20/30	5	16.2	180	20/30	laran
			6	309.07	20/30	5	20.3	180	20/30	bayur
			7	349.3	20/30	5	16.6	180	20/30	kandis
			8	349.3	20/30	4	16.2	180	20/30	bayur
			9	586.13	0/10	3	10.5	180	10/20	bayur
			10	586.13	10/20	3	2.4	180	20/30	sengkuang
			11	416.67	10/20	3	10.5	180	20/30	mempening
	L1	0.5	1	44	0/5	4	2.1	320	0/10	unknown
			2	46	0/10	2	14.7	320	0/10	kasai
			3	55	0/10	4	3.6	320	0/10	bangkal
			4	71	0/5	5	4.7	320	0/10	unknown
			5	71	0/10	5	5.7	320	0/10	unknown
	LP	0.544	1	127	0/5	4	14.6	180	10/20	bayur
			2	289	10/20	3	10.6	360	10/20	selangan
			3	485	10/20	3	22.8	360	10/20	laran
8.08	L7	0.503	1	9.75	10/20	4	50>	90	20/30	magas
			2	67.97	20/30	4	7.6	90	20/30	bayur
			3	152.4	20/30	2	2	90	20/30	tandiran
			4	152.4	20/30	3	11.5	270	20/30	laran
			5	166.12	10/20	1	4.5	270	10/20	mata kucing
			6	166.12	20/30	4	50>	90	20/30	seraya
			7	187.76	10/20	1	3.2	90	10/20	mata kucing
			8	187.76	10/20	2	5.4	90	10/20	dara-dara
			9	188.37	10/20	4	7.8	90	10/20	bayur
			10	188.37	20/30	3	2.1	90	20/30	laran
			11	188.67	20/30	2	6.5	90	20/30	laran
			12	188.67	10/20	3	4.3	270	10/20	bayur
			13	188.67	20/30	3	6.3	270	20/30	bayur
			14	188.67	10/20	2	10.3	270	10/20	pulai
			15	217.63	10/20	3	50>	270	20/30	mata kucing
			16	217.63	10/20	3	6.5	270	20/30	mata kucing
			17	243.84	10/20	1	10	270	10/20	mempening
			18	329.49	20/30	3	50>	270	20/30	seraya
			19	329.49	20/30	3	50>	90	20/30	laran
			20	395.94	20/30	4	27.3	90	20/30	kubin
	L2	0.5	1	305	0/10	5	4.3	270	0/10	unknown

9.08	L3	0.505	1	170	10/20	4	14.6	210	20/30	pokok magas
	L4	0.5	1	50	9.5	5	10.1	360	0/10	kandis
			2	96	0/10	1	0.1	360	0/10	laran (renew sarang)
			3	192	0/10	5	11.7	180	0/10	laran
			4	245	0/10	3	12.3	180	0/10	laran
			5	390	0/10	5	12.3	180	0/10	bayur
	LT3	0.694	1	16.74	0/10	2	4..6	260	0/10	kasai
			2	81.69	10/20	3	2.2	260	10/20	laran
			3	116.43	20/30	3	30>	80	20/30	laran
			4	135.33	20/30	4	1.2	80	20/30	laran
			5	139.9	20/30	3	1.8	80	20/30	laran
			6	139.9	10/20	3	5.8	260	10/20	unknown
			7	141.43	20/30	4	4.7	260	20/30	laran
			8	186.23	20/30	3	8.3	260	20/30	laran
			9	192.33	20/30	4	30>	80	20/30	laran
			10	242.93	10/20	3	30>	80	10/20	seraya
			11	251.76	20/30	3	3.2	80	20/30	laran
			12	274.32	20/30	3	4.8	80	20/30	laran
			13	380.09	20/30	5	2.2	80	20/30	laran
			14	445.92	10/20	3	15.8	260	10/20	unknown
			15	497.13	10/20	3	10.4	260	10/20	unknown
			16	633.07	0/10	3	6.7	80	0/10	langsat-langsat
10.08	LP2	0.859	1	65.53	10/20	2	8.2	150	20/30	karpus
			2	65.53	10/20	2	8.2	150	20/30	karpus
			3	188.36	20/30	5	5.6	150	20/30	laran
			4	205.43	20/30	2	11.2	330	20/30	laran
			5	347.16	20/30	3	50>	330	20/30	laran
	LP1	1.1	1	81	10/20	3	8.5	160	10/20	mamboakat
			2	157	0/10	4	6.8	340	10/20	kutang-kutang
			3	193	0/10	4	14.7	160	20/30	urat mata
			4	193	10/20	5	15.8	160	20/30	urat mata
			5	739	10/20	3	27.8	340	20/30	sedaman
			6	775	20/30	4	30>	160	20/30	laran
11.08	P2	0.8824	1	118.26	20/30	4	>50	271	20/30	laran
			2	118.26	20/30	4	>50	271	20/30	laran
			3	269.74	20/30	5	15.7	271	20/30	laran
			4	335.28	20/30	2	>50	271	20/30	laran
			5	335.28	20/30	2	>50	271	20/30	laran
			6	335.28	20/30	3	>50	271	20/30	laran
			7	456.89	20/30	5	12.5	271	20/30	laran
			8	584.91	20/30	4	18.2	271	20/30	bangkal
			9	847.34	10/20	4	5.7	271	10/20	laran
	LP2	0.894	1	54	10/20	5	30>	90	20/30	laran

			2	74	10/20	1	20.8	90	10/20	bayur
			3	137	10/20	3	8.7	90	10/20	keruing
			4	279	0/10	3	4.2	90	10/20	bayur
			5	550	20/30	5	3.1	90	20/30	laran
			6	647	20/30	4	7.9	90	20/30	durian
			7	740	20/30	5	27.9	90	20/30	laran
			8	758	20/30	5	30>	270	20/30	laran
12.08	TR	0.5038	1	145.38	20/30	4	5.7	330	20/30	bayur
			2	145.38	20/30	4	5.7	330	20/30	kayu malma
			3	182.88	20/30	3	3.3	120	20/30	bayur
			4	214.27	20/30	5	12.3	120	20/30	bayur
			5	214.27	20/30	2	13.1	120	20/30	magas
			6	243.53	20/30	4	17.2	330	20/30	magas
			7	243.53	20/30	5	0.2	120	20/30	seraya
			8	316.68	10/20	5	10.4	330	20/30	bayur
	LT4	0.608	1	39	20/30	3	22.5	90	20/30	keruing
			2	73	0/10	1	13.8	90	10/20	geronggang
			3	283	10/20	5	30>	90	20/30	laran
			4	372	10/20	3	18.9	270	10/20	kasai
			5	521	10/20	3	12.2	90	10/20	belian
			6	604	10/20	4	8.2	90	10/20	belian
			7	604	10/20	3	9.7	90	10/20	belian
			8	604	10/20	5	7.9	90	10/20	belian
			9	607	0/10	3	10.8	270	10/20	unknown
13.08	TR	0.5	1	260.29	20/30	5	4.7	201	20/30	binuang
			2	488.59	20/30	3	27.2	30	20/30	mempening
	LT5	0.643	1	517	0/10	4	17.9	160	Oct-20	sengkuang

Annex III: Composition of Botanical Plots during recce walks and orangutan surveys

Medium Stratum

Plot	Tree species	Dbh					Score			Comments
		20-30	30-40	40-50	50-60	>60	Canopy	Small trees	Climbers	
L2K	Kleinhovia hospita	1					0	3	3	
	Lansium sp.		1							
	Diospyros sp.	1								Semi-inundated - Swamp
L1K	Dipterocarpus sp.	1	2							
	Pterospermum sp.		1							
	Aquillaria malaccensis	1	1							
	Shorea sp.	1					1	2	2	
	Parashorea sp.	1								
	Shorea sp.	1	1							
	Unknown	1								
	Pometia pinnata	2	1							
	Baccaurea sp.	1								Dry - Flat
L7	Hydnocarpus sp	1								
	Neolamarckia cadamba		1							
	Kompasia excelsa	1								
	Dimocarpus longan	1								
	Intsia sp.		1							
	Vitex pinnata		2				1	3	3	
	Kutang-kutang	1								
	Vitex pinnata	1	1							Dry
P1D	Unknown		1	1						
	Octomeles sumatrana	1	1							
	Shorea sp.	1	1							
	Neolamarckia cadamba		1	1			1.6	2	2	
	Nauclea sp	1								
	Pterospermum sp.	2								
	Duabangga moluccana	2								
	Neolamarckia cadamba	2	1	2						
	Microcos sp.	1								Dry - Flat - Degraded Old logging road
LT2	Dryobalanops sp.			1						
	Shorea sp.		1	1						
	Cananga odarata	1								
	Octomeles sumatrana		1							
	Unknown			1						
	Kompasia excelsa					1	1	1.6	2.6	

L3	Pterospermum sp.	4								Dry - Slope - Disturbed
	Neolamarckia cadamba	3								
	Macaranga sp.	3								
	Duabangga moluccana	4								
	Nauclea sp	2								
	Diospyros sp.	1					0	1	3	
LT3	Unknown	2								Dry - Deg and ok
	Neolamarckia cadamba	3	2							
	Shorea sp.		1	2						
	Dryobalanops sp.		1	2						
	Unknown	4								
	Hydnocarpus sp	1					1	1.6	2.6	
LT3 (2)	Neolamarckia cadamba	3	2							Dry - Nice
	Hydnocarpus sp	1								
	Pternandra sp.	2	1							
	Unknown	1	1	1						
	Palaqium sp.	1								
	Shorea sp.		2	2			2	2	2	
LP2	Neolamarckia cadamba	4								Open - Degraded
	Pterospermum sp.	3								
	Kubin	2								
	Nauclea sp	2					0.6	3	3	
LP1	Pterospermum sp.	3	2							Disturbed
	Neolamarckia cadamba	3	3	1						
	Unknown	1								
	Nephelium sp.	1								
	Nauclea sp	1					1	1.6	2.6	
LP/2	Neolamarckia cadamba	3								Slope - Dry - Disturbed
	Parkia sp.		1							
	Duabangga moluccana	3								
	Pterospermum sp.	5								
	Kompasia excelsa		1				0	3	2.3	
LP2	Pterospermum sp.	9	1							Slope - Dry - Nice
	Neolamarckia cadamba	1	2							
	Octomeles sumatrana	1								
	Shorea sp.	1								
	Unknown		1	1						
	Nauclea sp	1	**1**				1.6	2	3	
PB1	Artocarpus sp.	1								Flat - Dry - Open
	Neolamarckia cadamba	4								
	Pterospermum sp.	3								
	Duabangga moluccana	2								
	Shorea sp.	3								

	Shorea sp.	2					0.3	3	3	
	TOTAL	**121**	**41**	**16**	**0**	**1**	**0.85**	**2.21**	**2.62**	

SOUTH stratum

LT4	Octomeles sumatrana			1						Slope - Dry - Nice
	Dipterocarpus sp.		1							
	Pterospermum sp.	3								
	Shorea sp.		1							
	Unknown	1	1							
	Shorea sp.		3	1						
	Parashorea sp.	1								
	Eusideroxylon zwagerii	1	**1**	1						
	Dryobalanops sp.		**1**				2	3	2	
RW4	Shorea sp.	1	1							Slope - Dry - Nice
	Parashorea sp.	1	2							
	Dryobalanops sp.		1	1						
	Ficus sp.			1						
	Carralia brachiata		1							
	Pterospermum sp.		2	1			2	3	2	
	Unknown		**1**							
TOTAL:										

Extreme SOUTH stratum

PB1	Neolamarckia cadamba	4								Dry - Flat - Open
	Octomeles sumatrana	4								
	Lithocarpus sp	3								
	Dryobalanops sp.	2								
	Pometia pinnata	2								
	Canarium sp.	1								
	Shorea sp.	2								
	Dipterocarpus	3					1	3	3	
LT5	Octomeles sumatrana		1	1	1					Dry - Flat - Nice
	Shorea sp.	1	1	2						
	Dryobalanops sp.		1	1						
	Carralia brachiata	1								

	Shorea sp.			1						
	Maranthes sp.			1						
	Unknown	1	**2**	2	1		2	3	2.6	
RW5	Parinari sp.	1								Dry - Nice
	Neolamarckia cadamba	2	2							
	Cananga odarata	1	1							
	Octomeles sumatrana		1	2						
	Shorea sp.		1							
	Unknown		1							
	Dipterocarpus	1		1						
	Pterospermum sp.		1							
	Intsia sp.	1					2	3	2.3	
TOTAL:										

ANNEX IV: Location of plots surveyed with thermal drones at night

Plot 3

5° 8'8.87"N 117°56'52.88"E	5° 8'8.47"N 117°57'18.46"E
5° 7'42.86"N 117°56'52.19"E	5° 7'42.34"N 117°57'18.20"E

Plot 2

5° 7'43.79"N 117°58'6.13"E	5° 7'56.09"N 117°58'28.94"E
5° 7'21.10"N 117°58'18.10"E	5° 7'33.19"N 117°58'41.22"E

Plot 1

5° 6'31.57"N 117°58'53.80"E	5° 6'31.60"N 117°59'19.96"E
5° 6'6.06"N 117°58'53.59"E	5° 6'5.56"N 117°59'19.62"E

Plot 4

5° 3'6.92"N 117°59'51.21"E	5° 2'58.09"N 118° 0'15.63"E
5° 2'42.24"N 117°59'42.65"E	5° 2'33.76"N 118° 0'6.62"E

Plot 4/5

5° 2'43.57"N 118° 1'34.62"E	5° 2'42.96"N 118° 2'0.37"E
5° 2'17.37"N 118° 1'33.94"E	5° 2'16.75"N 118° 1'59.91"E

Plot 6

5° 1'3.62"N 118° 3'58.06"E	5° 1'11.32"N 118° 4'23.10"E
5° 0'38.70"N 118° 4'5.72"E	5° 0'45.88"N 118° 4'30.12"E

ANNEX VI: Total List of birds recorded during field activities: Bio-acoustic (BA), Direct Sighting (DS), and MacKinnon List (MKL)

Family	Common Name	Scientific Name	IUCN	Endemism	BA	DS	MKL
ACANTHIZIDAE	Golden-bellied Gerygone	*Gerygone sulphurea*	LC		Yes		
ACCIPITRIDAE	Bat Hawk	*Macheiramphus alcinus*	LC		Yes		
ACCIPITRIDAE	Black Eagle	*Ictinaetus malaiensis*	LC				Yes
ACCIPITRIDAE	Black Kite	*Milvus migrans*	LC				Yes
ACCIPITRIDAE	Changeable Hawk-Eagle	*Nisaetus cirrhatus*	LC		Yes		Yes
ACCIPITRIDAE	Crested Goshawk	*Lophospiza trivirgata*	LC				Yes
ACCIPITRIDAE	Crested Serpent Eagle	*Spilornis cheela*	LC		Yes		Yes
ACCIPITRIDAE	Oriental Honey-Buzzard	*Pernis ptilorhynchus*	LC				Yes
ACCIPITRIDAE	Wallace's Hawk-Eagle	*Nisaetus nanus*	VU				Yes
AEGITHINIDAE	Common Iora	*Aegithina tiphia*	LC				Yes
AEGITHINIDAE	Green Iora	*Aegithina viridissima*	NT		Yes		Yes
ALCEDINI	Blue-eared Kingfisher	*Alcedo meninting*	LC				Yes
ALCEDINIDAE	Bornean Banded Kingfisher	*Lacedo melanops*	LC	Endemic			Yes
ALCEDINIDAE	Collared Kingfisher	*Todiramphus chloris*	LC				Yes
ALCEDINIDAE	Malaysian Blue-banded Kingfisher	*Alcedo peninsulae*	NT				Yes
ALCEDINIDAE	Ruddy Kingfisher	*Halcyon coromanda*	LC		Yes		
ALCEDINIDAE	Rufous-backed Dwarf-kingfisher	*Ceyx rufidorsa*	LC				Yes
ALCEDINIDAE	Rufous-collared Kingfisher	*Actenoides concretus*	NT		Yes		Yes
ALCEDINIDAE	Stork-billed Kingfisher	*Pelargopsis capensis*	LC		Yes		Yes
APODIDAE	Asian Palm Swift	*Cypsiurus balasiensis*	LC				Yes
APODIDAE	Silver-rumped Spinetail	*Rhaphidura leucopygialis*	LC		Yes		Yes
ARDEIDAE	Black-crowned Night-Heron	*Nycticorax nycticorax*	LC		Yes		
BUCEROTIDAE	Black Hornbill	*Anthracoceros malayanus*	VU		Yes		Yes
BUCEROTIDAE	Bushy-crested Hornbill	*Anorrhinus galeritus*	NT				Yes
BUCEROTIDAE	Helmeted Hornbill	*Rhinoplax vigil*	CR				Yes
BUCEROTIDAE	Oriental Pied-Hornbill	*Anthracoceros albirostris*	LC		Yes		Yes
BUCEROTIDAE	Rhinoceros Hornbill	*Buceros rhinoceros*	VU		Yes		Yes
BUCEROTIDAE	White-crowned Hornbill	*Berenicornis comatus*	EN				Yes
BUCEROTIDAE	Wrinkled Hornbill	*Rhabdotorrhinus corrugatus*	EN				Yes
CALYPTOMENIDAE	Green Broadbill	*Calyptomena viridis*	NT		Yes		
CAMPEPHAGIDAE	Bar-bellied Cuckooshrike	*Coracina striata*	LC			Yes	
CAMPEPHAGIDAE	Black-winged Flycatcher-shrike	*Hemipus hirundinaceus*	LC				Yes
CAMPEPHAGIDAE	Lesser Cuckooshrike	*Lalage fimbriata*	LC		Yes		
CICONIIDAE	Storm's Stork	*Ciconia stormi*	EN				Yes
CISTICOLIDAE	Ashy Tailorbird	*Orthotomus ruficeps*	LC		Yes		Yes
CISTICOLIDAE	Dark-necked Tailorbird	*Orthotomus atrogularis*	LC				Yes
CISTICOLIDAE	Rufous-tailed Tailorbird	*Orthotomus sericeus*	LC		Yes		
CISTICOLIDAE	Yellow-bellied Prinia	*Prinia flaviventris*	LC		Yes		Yes
COLUMBIDAE	Asian Emerald Dove	*Chalcophaps indica*	LC		Yes		Yes
COLUMBIDAE	Little Green-Pigeon	*Treron olax*	LC		Yes		Yes
CORVIDAE	Bornean Black Magpie	*Platysmurus aterrimus*	NE	Endemic	Yes		
CORVIDAE	Large-billed Crow	*Corvus macrorhynchos*	LC		Yes		
CORVIDAE	Slender-billed Crow	*Corvus enca*	LC		Yes		
CORVIDAE	Sunda Crow	*Corvus enca*	LC				Yes
CUCULIDAE	Banded Bay Cuckoo	*Cacomantis sonneratii*	LC		Yes		
CUCULIDAE	Black-bellied Malkoha	*Phaenicophaeus diardi*	NT				Yes
CUCULIDAE	Bornean Ground-Cuckoo	*Carpococcyx radiceus*	VU	Endemic			Yes
CUCULIDAE	Chestnut-bellied Malkoha	*Phaenicophaeus sumatranus*	NT				Yes
CUCULIDAE	Chestnut-breasted Malkoha	*Phaenicophaeus curvirostris*	LC				Yes
CUCULIDAE	Greater Coucal	*Centropus sinensis*	LC		Yes		Yes
CUCULIDAE	Green Imperial Pigeon	*Ducula aenea*	NT		Yes		Yes
CUCULIDAE	Indian Cuckoo	*Cuculus micropterus*	LC		Yes		
CUCULIDAE	Moustached Hawk-Cuckoo	*Hierococcyx vagans*	NT			Yes	
CUCULIDAE	Plaintive Cuckoo	*Cacomantis merulinus*	LC		Yes		Yes
CUCULIDAE	Raffles's Malkoha	*Rhinortha chlorophaea*	LC		Yes		Yes
CUCULIDAE	Short-toed Coucal	*Centropus rectunguis*	LC				Yes
CUCULIDAE	Square-tailed Drongo-Cuckoo	*Surniculus lugubris*	LC		Yes	Yes	
DICAEIDAE	Crimson-breasted Flowerpecker	*Prionochilus percussus*	LC				Yes
DICAEIDAE	Orange-bellied Flowerpecker	*Dicaeum trigonostigma*	LC		Yes		Yes

DICAEIDAE	Yellow-rumped Flowerpecker	*Prionochilus xanthopygius*	LC	Endemic	Yes		
DICRURIDAE	Greater Racket-tailed Drongo	*Dicrurus paradiseus*	LC				Yes
ESTRILDIDAE	Chestnut Munia	*Lonchura atricapilla*	LC			Yes	
ESTRILDIDAE	Dusky Munia	*Lonchura fuscans*	LC				Yes
EURYLAIMIDAE	Banded Broadbill	*Eurylaimus javanicus*	NT			Yes	
EURYLAIMIDAE	Black-and-red Broadbill	*Cymbirhynchus macrorhynchos*	LC		Yes		Yes
EURYLAIMIDAE	Black-and-yellow Broadbill	*Eurylaimus ochromalus*	NT		Yes		Yes
HEMIPROCNIDAE	Grey-rumped Treeswift	*Hemiprocne longipennis*	LC				Yes
HEMIPROCNIDAE	Whiskered Treeswift	*Hemiprocne comata*	LC				Yes
HIRUNDINIDAE	Pacific Swallow	*Hirundo javanica*	LC				Yes
IRENIDAE	Greater Green Leafbird	*Chloropsis sonnerati*	LC				Yes
IRENIDAE	Lesser Green Leafbird	*Chloropsis cyanopogon*	NT		Yes		Yes
LEIOTHRICHIDARE	Brown Fulvetta	*Alcippe brunneicauda*	NT				Yes
MEROPIDAE	Blue-eared Barbet	*Psilopogon duvaucelii*	LC		Yes		
MEROPIDAE	Blue-throated Bee-eater	*Merops viridis*	LC		Yes		Yes
MEROPIDAE	Red-bearded Bee-eater	*Nyctyornis amictus*	LC		Yes		Yes
MONARCHIDAE	Black-naped Monarch	*Hypothymis azurea*	LC		Yes		Yes
MONARCHIDAE	Blyth's Paradise-Flycatcher	*Terpsiphone affinis*	LC				Yes
MOTACILLIDAE	Grey Wagtail	*Motacilla cinerea*	LC			Yes	
MUSCICAPIDAE	Asian Brown Flycatcher	*Muscicapa dauurica*	LC			Yes	
MUSCICAPIDAE	Blue-and-white Flycatcher	*Cyanoptila cyanomelana*	LC			Yes	
MUSCICAPIDAE	Chestnut-naped Forktail	*Enicurus ruficapillus*	NT				Yes
MUSCICAPIDAE	Malaysian Blue Flycatcher	*Cyornis turcosus*	NT		Yes		Yes
MUSCICAPIDAE	Oriental Magpie Robin	*Copsychus saularis*	LC				Yes
MUSCICAPIDAE	Rufous-tailed Shama	*Copsychus pyrropygus*	NT		Yes		
MUSCICAPIDAE	Verditer Flycatcher	*Eumyias thalassinus*	LC				Yes
MUSCICAPIDAE	White-crowned Forktail	*Enicurus leschenaulti*	LC				Yes
MUSCICAPIDAE	White-crowned Shama	*Copsychus stricklandii*	LC	Endemic	Yes		Yes
NECTARINIIDAE	Bornean Spiderhunter	*Arachnothera everetti*	NE	Endemic			Yes
NECTARINIIDAE	Brown-throated Sunbird	*Anthreptes malacensis*	LC		Yes		Yes
NECTARINIIDAE	Crimson Sunbird	*Aethopyga siparaja*	LC		Yes		Yes
NECTARINIIDAE	Little Spiderhunter	*Arachnothera longirostra*	LC		Yes		Yes
NECTARINIIDAE	Ornate Sunbird	*Cinnyris ornatus*	NE			Yes	
NECTARINIIDAE	Purple-naped Spiderhunter	*Kurochkinegramma hypogrammicum*	NE		Yes		Yes
NECTARINIIDAE	Red-throated Sunbird	*Anthreptes rhodolaemus*	NT				Yes
NECTARINIIDAE	Ruby-cheeked Sunbird	*Chalcoparia singalensis*	LC		Yes		Yes
NECTARINIIDAE	Thick-billed Spiderhunter	*Arachnothera crassirostris*	LC		Yes		
NECTARINIIDAE	Van Hasselt's Sunbird	*Leptocoma brasiliana*	LC				Yes
NECTARINIIDAE	Yellow-eared Spiderhunter	*Arachnothera chrysogenys*	LC		Yes		Yes
ORIOLIDAE	Black-and-crimson Oriole	*Oriolus consanguineus*	LC				Yes
ORIOLIDAE	Dark-throated Oriole	*Oriolus xanthonotus*	LC		Yes		
ORIOLIDAE	Ventriloquial Oriole	*Oriolus consobrinus*	LC				Yes
PASSERIDAE	Eurasian Tree Sparrow	*Gallinula chloropus*	LC				Yes
PELLORNEIDAE	Abbott's Babbler	*Malacocincla abbotti*	LC		Yes		
PELLORNEIDAE	Black-capped Babbler	*Pellorneum capistratoides*	LC		Yes		Yes
PELLORNEIDAE	Black-throated Wren-Babbler	*Turdinus atrigularis*	NT		Yes		
PELLORNEIDAE	Ferruginous Babbler	*Pellorneum bicolor*	LC		Yes		Yes
PELLORNEIDAE	Horsfield's Babbler	*Malacocincla sepiaria*	LC		Yes		
PELLORNEIDAE	Moustached Babbler	*Malacopteron magnirostre*	LC		Yes		
PELLORNEIDAE	Rufous-crowned Babbler	*Malacopteron magnum*	NT		Yes		Yes
PELLORNEIDAE	Scaly-crowned Babbler	*Malacopteron cinereum*	LC		Yes		Yes
PELLORNEIDAE	Short-tailed Babbler	*Pellorneum malaccense*	NT		Yes		Yes
PELLORNEIDAE	Sooty-capped Babbler	*Malacopteron affine*	LC		Yes		Yes
PELLORNEIDAE	Striped Wren-Babbler	*Kenopia striata*	NT				Yes
PELLORNEIDAE	White-chested Babbler	*Pellorneum rostratum*	LC		Yes		Yes
PHASIANIDAE	Crested Fireback	*Lophura ignita*	VU				Yes
PHASIANIDAE	Great Argus	*Argusianus argus*	VU		Yes		Yes
PHASIANIDAE	Red Junglefowl	*Gallus gallus*	LC		Yes		
PHASIANIDAE	Sabah Partridge	*Tropicoperdix graydoni*	NT				Yes
PHYLLOSCOPIDAE	Arctic Warbler	*Phylloscopus borealis*	LC		Yes		
PICIDAE	Crimson-winged Woodpecker	*Picus puniceus*	LC		Yes		
PICIDAE	Gray-and-buff Woodpecker	*Hemicircus concretus*	LC		Yes	Yes	

PICIDAE	Great Slaty Woodpecker	*Mulleripicus pulverulentus*	VU					Yes
PICIDAE	Maroon Woodpecker	*Blythipicus rubiginosus*	LC			Yes		
PICIDAE	Olive-backed Woodpecker	*Chloropicoides rafflesii*	NT					Yes
PICIDAE	Orange-backed Woodpecker	*Chrysocolaptes validus*	LC					Yes
PICIDAE	Rufous Piculet	*Sasia abnormis*	LC			Yes		Yes
PICIDAE	Rufous Woodpecker	*Micropternus brachyurus*	LC			Yes		Yes
PICIDAE	White-bellied Woodpecker	*Dryocopus javensis*	LC			Yes		
PICUMINAE	Buff-necked Woodpecker	*Meiglyptes tukki*	NT					Yes
PICUMINAE	Buff-rumped Woodpecker	*Meiglyptes grammithorax*	LC					Yes
PITTIDAE	Black-crowned Pitta	*Erythropitta ussheri*	LC			Yes		Yes
PITTIDAE	Blue-headed Pitta	*Hydrornis baudii*	VU					Yes
PITTIDAE	Western Hooded Pitta	*Pitta sordida*	LC					Yes
PITYRIASIDAE	Bornean Bristlehead	*Pityriasis gymnocephala*	NT	Endemic		Yes		
PLATYLOPHIDAE	Crested jayshrike	*Platylophus galericulatus*	NT			Yes		Yes
PSITTACULIDAE	Blue-crowned Hanging Parrot	*Loriculus galgulus*	LC					Yes
PYCNONOTIDAE	Black-headed Bulbul	*Microtarsus melanocephalos*	LC			Yes		Yes
PYCNONOTIDAE	Buff-vented Bulbul	*Iole crypta*	NE					Yes
PYCNONOTIDAE	Charlotte's Bulbul	*Iole charlottae*	NT					Yes
PYCNONOTIDAE	Cinereous Bulbul	*Hemixos cinereus*	LC			Yes		
PYCNONOTIDAE	Cream-vented Bulbul	*Pycnonotus simplex*	LC			Yes		Yes
PYCNONOTIDAE	Gray-cheeked Bulbul	*Alophoixus tephrogenys*	VU					Yes
PYCNONOTIDAE	Hairy-backed Bulbul	*Tricholestes criniger*	LC			Yes		Yes
PYCNONOTIDAE	Olive-winged Bulbul	*Pycnonotus plumosus*	LC			Yes		Yes
PYCNONOTIDAE	Pale-faced Bulbul	*Pycnonotus leucops*	LC					Yes
PYCNONOTIDAE	Puff-backed Bulbul	*Brachypodius eutilotus*	NE			Yes		Yes
PYCNONOTIDAE	Red-eyed Bulbul	*Pycnonotus brunneus*	LC			Yes		Yes
PYCNONOTIDAE	Spectacled Bulbul	*Rubigula erythropthalmos*	LC			Yes		Yes
PYCNONOTIDAE	Yellow-bellied Bulbul	*Alophoixus phaeocephalus*	LC					Yes
PYCNONOTIDAE	Yellow-vented Bulbul	*Pycnonotus goiavier*	LC			Yes	Yes	
RALLIDAE	Eurasian Moorhen	*Gallinula chloropus*	LC			Yes		
RALLIDAE	White-breasted Waterhen	*Amaurornis phoenicurus*	LC			Yes		
RAMPHASTIDAE	Black-eared Barbet	*Psilopogon duvaucelii*	LC					Yes
RAMPHASTIDAE	Brown Barbet	*Caloramphus fuliginosus*	LC	Endemic				Yes
RAMPHASTIDAE	Golden-naped Barbet	*Psilopogon pulcherrimus*	LC	Endemic		Yes		
RAMPHASTIDAE	Gold-whiskered Barbet	*Psilopogon chrysopogon*	LC	Endemic			Yes	
RAMPHASTIDAE	Red-throated Barbet	*Psilopogon mystacophanos*	NT			Yes		Yes
RAMPHASTIDAE	Yellow-crowned Barbet	*Psilopogon henricii*	NT			Yes		
RHIPIDURIDAE	Spotted Fantail	*Rhipidura perlata*	LC					Yes
RHIPIDURIDAE	Sunda Pied Fantail	*Rhipidura javanica*	LC			Yes		Yes
RHIPIDURIDAE	White-throated Fantail	*Rhipidura albicollis*	LC			Yes		
SCOTOCERCIDAE	Yellow-bellied Warbler	*Abroscopus superciliaris*	LC			Yes		
STENOSTIRIDAE	Gray-headed Canary-Flycatcher	*Culicicapa ceylonensis*	LC					Yes
STRIGIDAE	Buffy-fish Owl	*Ketupa ketupu*	LC					Yes
STURNIDAE	Asian Glossy Starling	*Aplonis panayensis*	LC					Yes
STURNIDAE	Common Hill Myna	*Gracula religiosa*	LC					Yes
STURNIDAE	Javan Myna	*Acridotheres javanicus*	VU					Yes
TIMALIIDAE	Black-throated Babbler	*Stachyris nigricollis*	NT			Yes		
TIMALIIDAE	Bold-striped Tit-Babbler	*Mixornis bornensis*	LC			Yes		Yes
TIMALIIDAE	Chestnut-rumped Babbler	*Stachyris maculata*	NT			Yes		Yes
TIMALIIDAE	Chestnut-winged Babbler	*Cyanoderma erythropterum*	LC			Yes		
TIMALIIDAE	Fluffy-backed Tit-Babbler	*Macronus ptilosus*	NT			Yes		Yes
TIMALIIDAE	Gray-hooded Babbler	*Cyanoderma bicolor*	LC					Yes
TIMALIIDAE	Gray-throated Babbler	*Stachyris nigriceps*	LC			Yes		
TIMALIIDAE	Sunda Schimitar-babbler	*Pomatorhinus bornensis*	LC			Yes		Yes
TROGONIDAE	Diard's Trogon	*Harpactes diardii*	NT			Yes		Yes
TROGONIDAE	Red-naped Trogon	*Harpactes kasumba*	NT			Yes		Yes
TROGONIDAE	Scarlet-rumped Trogon	*Harpactes duvaucelii*	NT					Yes
VANGIDAE	Large Woodshrike	*Tephrodornis virgatus*	LC					Yes
VANGIDAE	Maroon-breasted Philentoma	*Philentoma velata*	NT			Yes		Yes
VIREONIDAE	White-bellied Erpornis	*Erpornis zantholeuca*	LC					Yes

Keynote: In IUCN Column: Critically-Endangered-(CR), Endangered-(EN), Vulnerable-(VU), Near-Threatened-(NT), Not-Evaluated-(NE),-DD-(Data-Deficient).

ANNEX VI: List of species recorded in Lower Kawag Forest Reserve from camera trapping.

Common Name	Scientific Name	Group	IUCN	Endemism
Water Monitor Lizard	*Varanus salvator*	Reptilia	LC	
Banded Civet	*Hemigalus derbyanus*	Mammal	NT	
Banteng	*Bos javanicus*	Mammal	CR	
Bearded Pig	*Sus barbatus*	Mammal	VU	Yes
Bornean Crested Fireback	*Lophura ignita*	Bird	VU	Yes
Bornean Elephant	*Elephas maximus borneensis*	Mammal	EN	Yes
Bornean Ground-Cuckoo	*Carpococcyx radiatus*	Bird	VU	Yes
Bornean Orangutan	*Pongo pygmaeus morio*	Mammal	CR	Yes
Thick-spined Porcupine	*Hystrix crassispinis*	Mammal	LC	Yes
Common Palm Civet	*Paradoxurus philippinensis*	Mammal	LC	
Great Argus	*Argusianus argus*	Bird	VU	
Long-tailed Macaque	*Macaca fascicularis*	Mammal	EN	
Sunda Stink-badger	*Mydaus javanensis*	Mammal	LC	
Malay Civet	*Viverra tangalunga*	Mammal	LC	
Malayan Porcupine	*Hystrix brachyura*	Mammal	LC	
Malayan Sun Bear	*Helarctos malayanus euryspilus*	Mammal	VU	Yes
Marbled Cat	*Pardofelis marmorata*	Mammal	NT	
Moonrat	*Echinosorex gymnura*	Mammal	LC	
Mousedeer	*Tragulus sp*	Mammal	LC	
Pig-tailed Macaque	*Macaca nemestrina*	Mammal	EN	
Plantain Squirrel	*Callosciurus notatus*	Mammal	LC	
Sambar Deer	*Rusa unicolor*	Mammal	VU	
Sunda Pangolin	*Manis javanica*	Mammal	CR	
Yellow Bittern	*Ixobrychus sinensis*	Bird	LC	
Yellow-throated marten	*Martes flavigula*	Mammal	LC	