FIELD EXPEDITION

ORANGUTAN SURVEY IN TABIN WILDIFE RESERVE

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Aerial picture showing the boundaries between TWR and nearby oil palm plantations where some of the RWs were carried out

Background Information

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.
- Finalizing what we know about 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 is a vehicle for relevant stakeholders' capacity building and training platform.

This report summarizes the results of the field expedition conducted under the MPOGCF project, which took place in the Tabin Wildlife Reserve between April 20th and April 29th, 2025 (seven days of fieldwork and two days of travel).

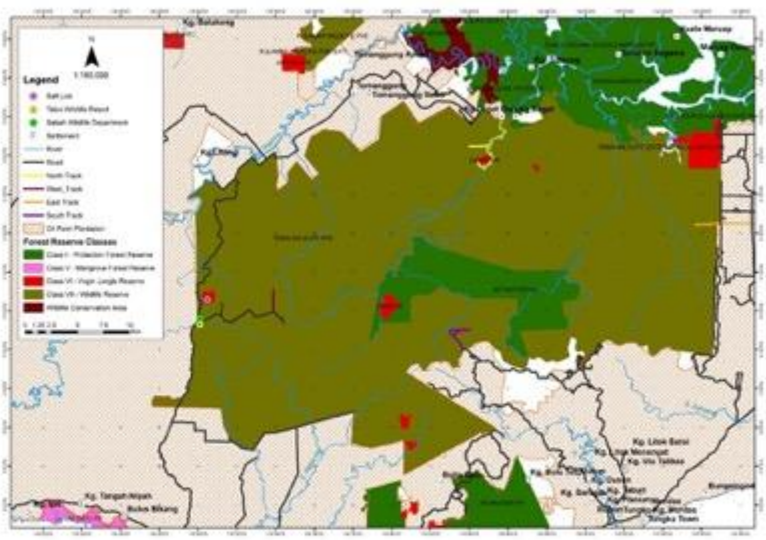
Figure 1: Picture showing the boundaries between Tabin WR and surrounding oil palm estates

Background information about Tabin Wildlife Reserve and its orangutan population

Tabin Wildlife Reserve is Sabah's largest protected wildlife area, encompassing about 122,500 hectares of diverse ecosystems. Officially gazetted in 1984, the reserve is positioned in the centre of the Dent peninsula in eastern Sabah, bounded by Lahad Datu to the south and the Segama River to the north (Figure 2).

Tabin Wildlife Reserve is in fact made up of a number of forest reserves, namely Tabin Wildlife Reserve (Class VII), Mt Hatton FR (Class I), Tabin FR (Class VI), Dagat FR (Class VI), Tabin Wildlife Reserve (Extension and Extension II, Class VII), and Sg. Kapur FR (Class VI). The Sabah Forestry Department (SFD) is legally responsible for all categories of forest reserves. However, by administrative agreement, the Sabah Wildlife Department (SWD) has been responsible for all matters concerning wildlife management in Tabin WR.

Figure 1: Map of Tabin Wildlife Reserve
Courtesy: Tabin Wildlife Holidays Sdn Bhd 2008



The landscape is characterized by complex sedimentary volcanic formations, featuring mudstone, sandstone, and rocky outcrops, with distinctive mud volcanoes. Mixed lowland dipterocarp forests dominate the reserve, though much of this habitat was selectively logged from the early 1960s through the late 1980s, except for a pristine core area of approximately 9,000 hectares. Today, Tabin remains a forest island surrounded by extensive oil palm plantations.

Historical records reveal significant fluctuations in Tabin's orangutan populations over time. In the 1960s, Haile documented that orangutans were notably scarce throughout the Tabin region and the Dent Peninsula (Haile, 1964). By 1981, data collected during the first faunal survey of Sabah revealed a more nuanced distribution pattern, with orangutans primarily concentrated in the eastern and northern sectors of the reserve (Davies & Payne, 1982). According to Payne (1988), approximately one-third of the area supported an average density of 1.2 individuals per square kilometer, while another third maintained much lower densities of 0.1 individuals per square kilometer The remaining third appeared to lack orangutan presence entirely. This distribution pattern yielded a total population estimate of 530 individuals within Tabin's boundaries.

In the mid-1980s, the systematic conversion of overlogged lowland dipterocarp forests across the "Dent Peninsula" surrounding Tabin into agricultural land displaced hundreds if not thousands, of orangutans from their traditional territories. Many individuals—particularly adult males—potentially sought refuge within Tabin's protected forests, as documented in other forests (Ancrenaz et al., 2010). Meanwhile, the Sabah Wildlife Department also initiated a large-scale orangutan translocation program. For example, between June and September 1993, wildlife teams captured 84 orangutans from areas adjacent to Tabin, including 54 adults (20 males; 34 females) and 30 younger individuals (6 males; 24 females), and released 74 individuals in three separate areas on Tabin's western boundary (Andau et al., 1994). An additional 95 orangutans were translocated in 1994 (Kilbourn et al., 1997). Over the subsequent decade, this rescue effort expanded dramatically, with an estimated 300 to 400 additional individuals relocated to Tabin (Tuuga, pers. com.). All translocated animals originated from areas surrounding the reserve, ensuring genetic continuity and maintaining the integrity of the local population.

In 2002, Hutan and the SWD carried out comprehensive helicopter-based nest surveys and estimated a total population of 1,401 (517-3,796) individuals (Ancrenaz et al., 2005). Follow-up helicopter surveys in 2010 documented population densities ranging from 0.4 to 1.5 ind/km^2, yielding a population estimate of 1,197 individuals (868-1,606). The most recent comprehensive aerial surveys, conducted between 2014 and 2017, estimated a consistent population size of 1,207 individuals (confidence interval: 814-1,794) (Simon et al., 2019): as shown in Figure 3.

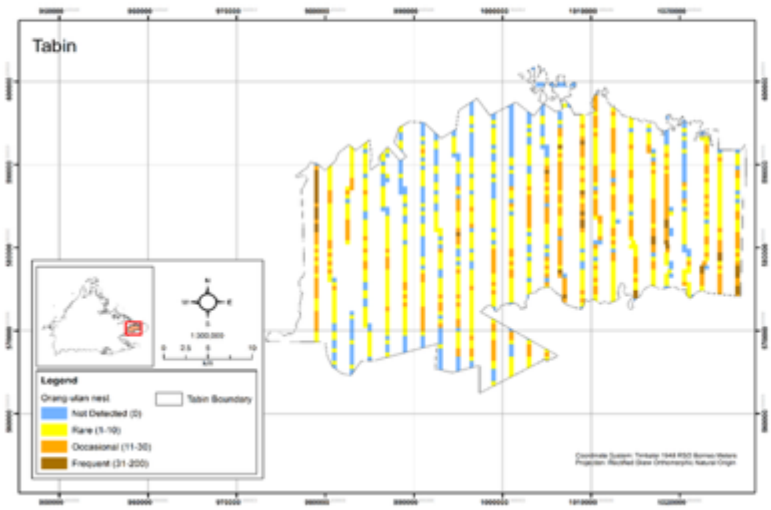


Figure 3: Encounter nest indexes during the helicopter flight carried out by WWF in 2017. Courtesy WWF Malaysia

Because orangutans are very slow breeders (one baby every 8.4 years on average), the increase of orangutan numbers observed on Tabin's western side cannot be attributed to natural demographic processes alone. Two complementary mechanisms likely account for this population expansion:

- **Habitat Displacement and Natural Migration:** The conversion of surrounding forests to oil palm plantations created a substantial refugee population of displaced orangutans. These individuals, forced from their traditional territories, sought alternative habitat within Tabin's protected boundaries. This displacement pattern mirrors similar conservation challenges documented in the Kinabatangan region to the north, where habitat fragmentation drove orangutan populations into remaining forest fragments (Ancrenaz et al. 2004; Bruford et al. 2010).
- **Translocation Program Success:** The systematic relocation of captured orangutans to Tabin's western sector appears to have boosted orangutan numbers in this part of the Reserve.

Methodology

During this field expedition, we employed standardized field methodologies designed explicitly for orangutan surveys, adhering to established protocols in Sabah (Ancrenaz, 2013).

- **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.

- **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 standardized 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 unmanned aerial vehicle (UAV) surveys:
    - *Daytime Operations*: Drones conducted nest counts along aerial line transects and during random flight patterns. All flights were recorded for subsequent video analysis at the field camp to identify and quantify orangutan nests. These aerial surveys provided critical landscape overviews that informed ground survey planning and optimization.
    - *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.
    - *Technical Specifications:* l drone operations were conducted with a DJI Mavic 3 thermal (night surveys) or a DJI Matrice 30 (day surveys) at a standardized altitude of 70 m with flight speeds maintained at 8 m/s. Data collection protocols included recording the types of findings, GPS coordinates, timestamps, and behavioral observations for all detected orangutan signs and individuals.

Analysis

We used Welch's t-test to determine if there are significant difference of nest found between highly degraded forests with non-degraded forests. Besides, we measured the correlation between nests identified from ground kilometric index compared to aerial kilometric index with Pearson's correlation coefficient (r). All these analyses were ran using JASP v. 0.19.3 (2024).

Results

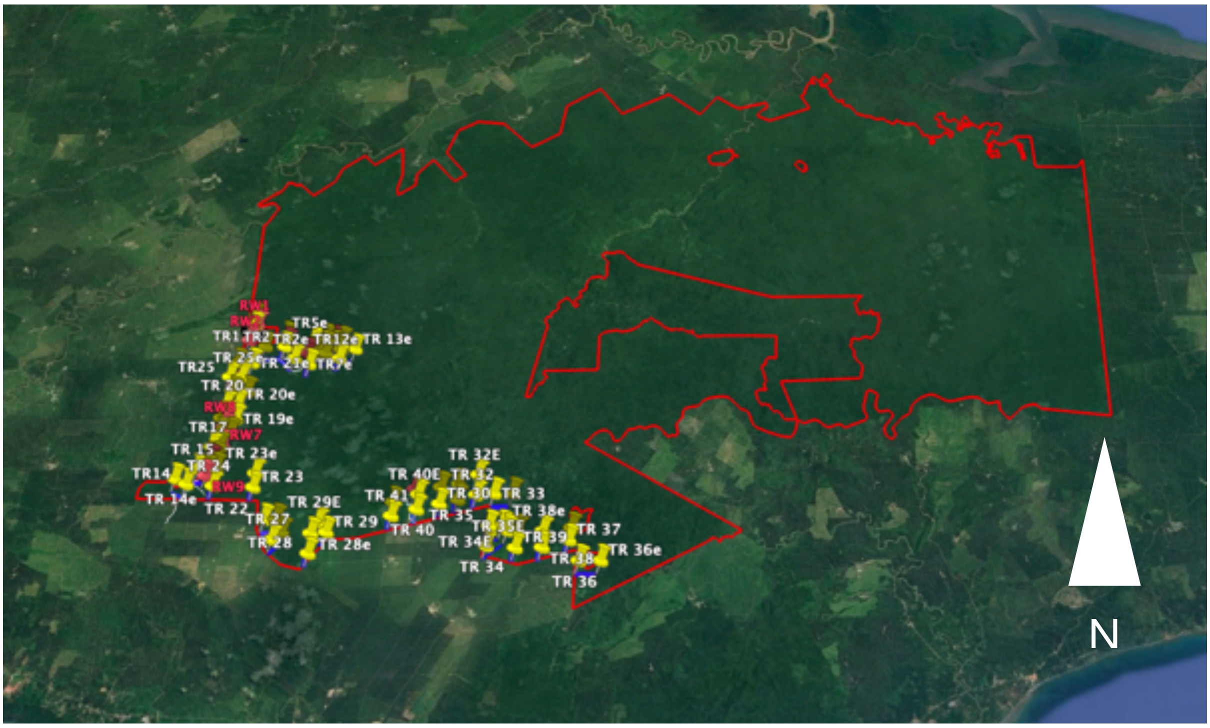


Figure : Map showing the overall location of the various surveys during fieldwork

Weather conditions and site accessibility posed significant challenges during field work operations. Heavy flooding and saturated ground conditions resulting from unusual rainfall patterns since early in the year, severely limited access to multiple survey locations. Additionally, the main access road to central Tabin is no longer passable, so all sites must be reached on foot. Given these logistical constraints, we concentrated our survey efforts on the western and southern portions of Tabin Wildlife Reserve to optimize time and resources in the field. We gave particular emphasis on the ecotone between the forest and adjacent oil palm plantations: Figure 4. Figures 5 and 6 below provided more precise locations of the various transects and RWs carried out during fieldwork.

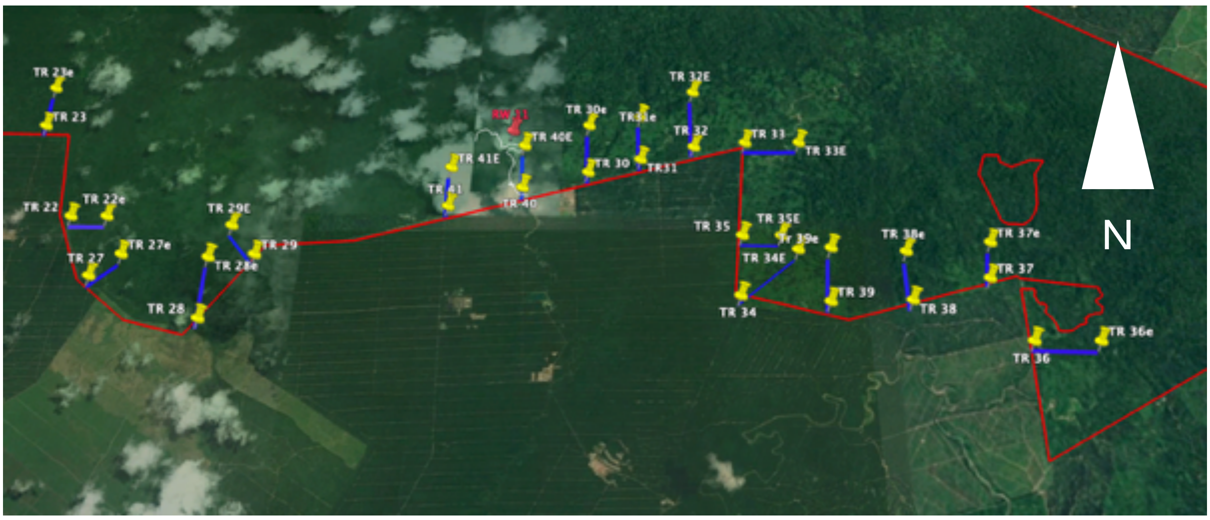


Figure 5: Location of line transects carried out with drones (Blue line); recce walks conducted on the ground (white lines and red numbers) in the southern side of Tabin WR.

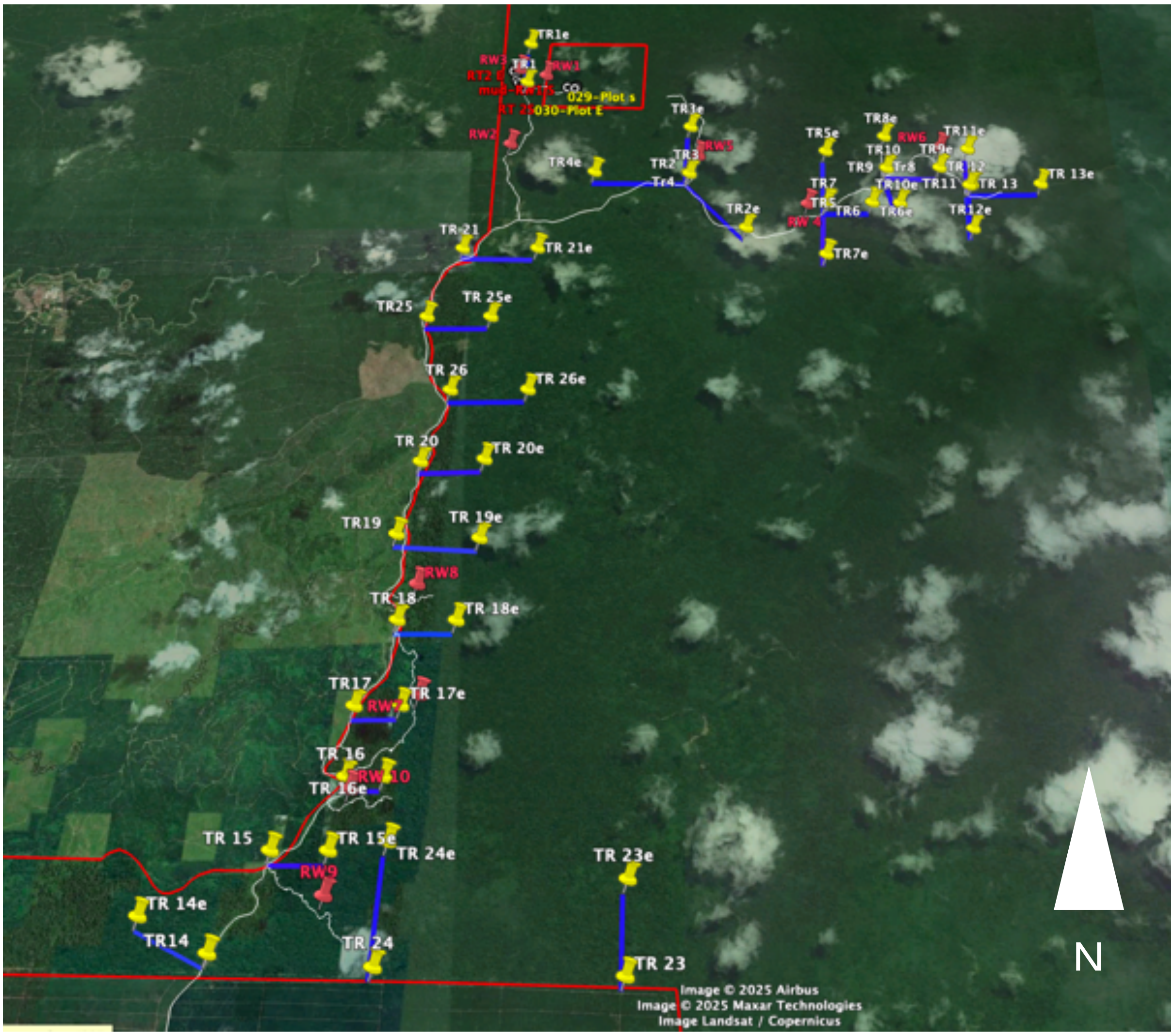


Figure 6: Location of line transects carried out with drones (Blue line); quadrat surveyed by drone (Red square); recce walks conducted on the ground (white lines and red numbers) in the western side of Tabin WR.

a. <u>*Results from Ground Recce Walks*</u>

The persistent and heavy rainfall further restricted field operations during the expedition, allowing survey teams to enter the forest for only four days. Heavy rain conditions present multiple safety hazards, including increased risk of falling branches and other forest debris. Additionally, the reduced light availability during rainy periods significantly impaired the ability to observe properly and document orangutan nests. Conducting orangutan surveys under these conditions would introduce serious observational bias into the data collection process.

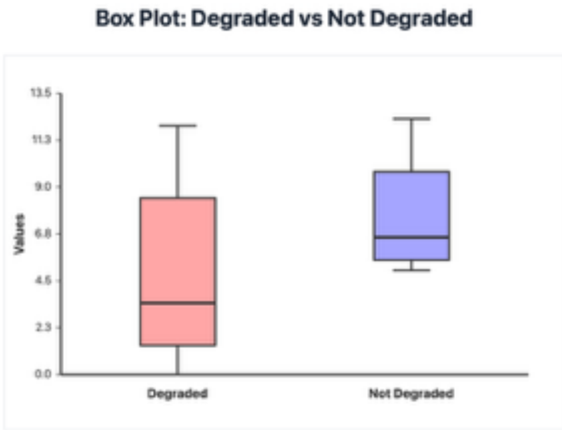
We walked a total of 13.793 km of reconnaissance walks along 11 different routes, yielding a total of 73 orangutan nests or 5.3 nests/km. We also recorded two orangutan direct sightings: Table 1. Forest condition was wet to very wet, degraded to very degraded along most of the RWs.

Nests were more commonly found in the least degraded forests, indicating the importance of forest degradation on orangutan nest distribution. Seven RWs were conducted in degraded to overdegraded forests, while four RWs were conducted in less degraded habitats: Table 2.

Date	RW Name	Length (km)	General Location	Bot. Plot	Wildlife	Forest Condition
21.04	RW1	1.000	Mud Volcano	29-30	None	Very degraded Forest – Open canopy – Some isolated tall trees – Few OU feeding resources
	RW2	1.490	Road to the mud volcano	None	1 OU DS 4 OU nests	Follow old Logging road frequently used by tourists (disturbance) – Disturbed forest
	RW3	0.251	Road to the mud volcano	None	1 OU DS 3 OU nests	Follow old Logging road – Disturbed forest
22.04	RW4	2.280	Road to Core Tabin	490-RT2 512-RT2	28 OU nests Signs: Sambar deer – Civet-Gibbon	Some tall trees – Good forest but very wet
	RW5	2.150	Goes North toward BORA	35-36 41-47	9 OU nests Signs: Sambar deer	Follow old road used by Bora (disturbance) – Disturbed forest – Tall trees – Some OU food -
	RW6	1.390	Road to Core Tabin	521-522 526-528	10 OU nests Signs: Flying lemur	Some tall trees – Good forest but very wet
23.04	RW7	1.000	Loop West Tabin from OPP to OPP	106-107	5 OU nests Signs: Sambar deer – Sunbear – Mousedeer - cat	Good forest – Wet - Little OU food
	RW8	0.652	From OPP to Tabin	337-338	1 OU nest Signs: Sambar deer - Sunbear	Very degraded Forest – Open canopy – Lot of climbers - Some isolated tall trees – Few OU feeding resources
	RW9	1.000	From OPP to SE Tabin	207-210 217-218	5 OU nests Signs: Sambar deer -	Degraded to Good Forest – Open canopy – Lot of climbers - Some isolated tall trees – Few OU feeding resources - Wet
	RW 10	1.000	From OPP to Tabin	534-536 543-547	6 OU nests Signs: Rhinoceros hornbill – Sunbear – Banteng - Sambar deer -	Good forest – OU food OK – Small river
27.04	RW 11	1.580	From Opp – South Tabin	123-126 127-131	2 OU nests Signs: Banteng – Cat - Sambar deer	Degraded Forest – Open canopy – OU food OK – Rivers ++
TOTAL		**13,793 km**		**15**	**73 OU nests**	

Table 1: List of recce walks carried out during the Tabin Orangutan Surveys

The average nest kilometric index in degraded forests was 3.8 nest/km (n=7, SD=3.98) while it was 7.62 nest/km (n=4, SD=3.23) in more intact forests. However, the difference was not statistically significant (Welch's t-test: t=1.726, df=7.6, p>0.05), from a significant effect of the small sample size (Cohen's d=1.017): Figure 7.



Only one RW was conducted in the southern side of Tabin Wildlife Reserve (TWR), at RW 11, yielding a kilometric index of 1.27 nest/km of walk. When pooled together the RW carried out on the western side of TWR (RW 1 to 10) yielded a kilometric index of 5.81 nests/km, showing a striking difference in abundance between the two sides of TWR.

RW Nb	Length	More Degraded Habitat	Less Degraded Habitat	Nest Nb	Kilometric Index
RW1	1	X		0	0.00
RW2	1.49	X		4	2.68
RW3	0.25	X		3	11.95
RW4	2.28		X	28	12.28
RW5	2.15	X		9	4.19
RW6	1.39		X	10	7.19
RW7	1		X	5	5.00
RW8	0.65	X		1	1.5
RW9	1	X		5	5.00
RW 10	1		X	6	6.00
RW 11	1.58	X		2	1.27

Table 2: Number of nests, length of RWs and kilometric indexes of nests per RW according to forest degradation.

Orangutan nests were identified in 11 known tree taxa belonging to nine tree families: Table 3. Nests were preferentially found in pioneer trees belonging to the Rubiaceae and Sterculiaceae families, since pioneer trees are more commonly found along the edges of road and in disturbed forests.

Pictures of overdegraded forests (open areas, no canopy, sparse trees, abundance of creepers) in the buffer area of Tabin WR at the edge between the forest and the oil palm plantations

Family	Genus/Species	Vernacular name	Nb of nests
Burseraceae	-	Kedondong	1
Dilleniaceae	*Dillenia sp.*	Simpor	1
Dipterocarpaceae	*Shorea sp.*	Seraya	7
	Parashorea sp.	Urat mata	4
	Dipterocarpus sp.	Keruing	3
Fagaceae	*Lithocarpus sp.*	Mempening	4
Leguminosae	*Koompassia excelsa*	Mengaris	3
Moraceae	*Artocarpus sp.*	Timbagan	3
Rubiaceae	*Neolamarckia cadamba*	Laran	15
	Nauclea sp.	Bangkal	2
Sapindaceae	*Pommetia pinnata*	Kasai	1
Sterculiaceae	*Pterospermum sp.*	Bayur	18
Unknown	-	-	11
TOTAL	**73**		

Table 3: Tree taxa and families of orangutan nests recorded from RWs.

Nest Class	Nest Number
I	1
II	4
III	22
IV	36
V	13

Nests were mostly old to very old, and only one fresh nest was recorded during our survey. These results indicate a relative scarcity of resident individuals (females) in the areas surveyed. However, the presence of old nests also indicates seasonal use of the area by orangutans, most likely during periods of increased fruit and other food resource production.

A total of 15 botanical plots were analysed along the RWs: see Annex II for the data. We recorded 369 trees with a DBH>20 cm.

The DBH distribution showed that medium-sized trees were the most abundant in our sample, with the 20-30 cm and 30-40 cm diameter classes together comprising 60% of all recorded individuals. Large trees with DBH>60 cm, while present, represented only 5% of the total sample (Figure 8).

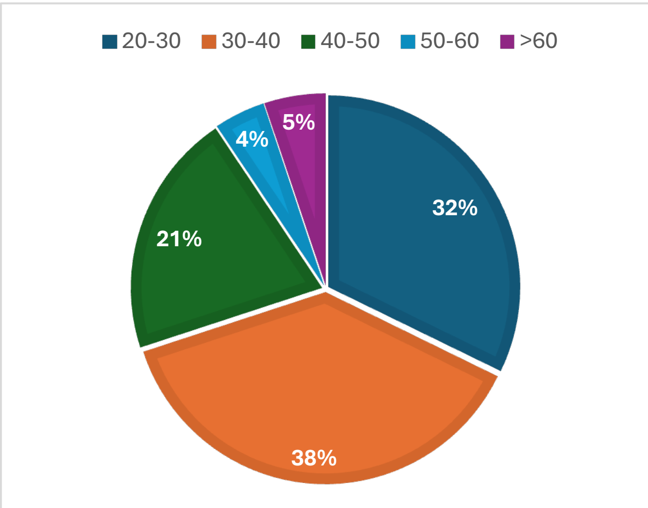


Figure 8: Percentage of the DBH Classes of trees recorded in the 15 botanical plots (n=369 trees with DBH>20 cm)

Dipterocarpaceae emerged as the dominant family, accounting for 32.8% of all recorded trees. This family was primarily represented by Seraya (*Shorea* spp.) at 23.8%, Urat Mata (*Parashorea* spp.) at 7.3%, and Keruing (*Dipterocarpus* spp.) at 1.6%. While Dipterocarpaceae typically dominate undisturbed lowland dipterocarp forests, their relatively modest majority in our sample reflects the historical logging impact and resulting forest disturbance.

Pioneer, light-demanding species characteristic of forest edges and disturbed areas represented more than half of the trees in our sample, further supporting this interpretation. Rubiaceae represented 19.5% of the sample, dominated by *Neolamarckia cadamba* (19.0%) with minor contributions from *Nauclea* spp. (0.5%); Tetramelaceae (*Octomeles sumatrana* - 12.7%-), Sterculiaceae (*Pterospermum* spp. - 12.5% -), and Lythraceae (*Duabanga moluccana* – 9.8%-).
We identified only a few species that are included in the preferred orangutan diet, such as *Dracontomelon sp.* or *Ficus* sp. (1.1% each).

The overall forest composition is characteristic of heavily logged lowland dipterocarp forest, where most large trees have been extracted and pioneer taxa have replaced many climax species. Pioneer trees are the most common species in this forest.

We conducted a rapid assessment of forest structure in our study plots using a standardized scoring system (see Methods). Results revealed that the canopy was predominantly open to semi-open across the survey area, with an average score of 1.38 ± 0.52 (range: 0.66-2.0), confirming the degraded status of most investigated areas.

Small trees and shrubs with DBH <20 cm were common throughout the study area (another sign of disturbance) but exhibited considerable variability between plots (average: 1.81 ± 1.15; range: 0-3). Climbers showed a distinct pattern, being relatively abundant in the most degraded plots while absent from better-preserved forest patches (average: 1.69 ± 1.15; range: 0-3).

Forest structure and composition documented during our rapid botanical assessment indicate that most areas located at the interface between Tabin Wildlife Reserve and adjacent oil palm plantations are degraded to severely degraded. Forest conditions improve progressively with increasing distance from plantation boundaries. Many locations were characterized by largely open habitats invaded by creepers and climbers, with only scattered emergent trees remaining.

b. Results from drone surveys above the forest during the day

During daytime, we deployed a DJI Matrice 30 drone to survey orangutan nests along predetermined line transects above the forest canopy. However, adverse weather conditions significantly hindered our data collection efforts, forcing us to cancel numerous flights due to persistent rainfall. Additionally, poor connectivity limited the drone's operational range to just 0.8-1.0 kilometers from the launch point, further constraining our survey coverage. The survey area was thus in the buffer area of TWR, covering about 1 km inside Tabin from nearby oil palm estates. However, we were able to carry out 41 flights, totalling a distance of 32.12 km, for 80 orangutan nests (Table 4).

Date	Transec No.t	Distance transect (km)	Starting Line	Bearing	Nb Nests	Forest Condition
21.04.25	1	0.626	5.209524 -118.501445	360	3	Mud volcano area – Nice canopy forest
22.04.25	2	1.000	5.196684-118.519280	140	4	Along the road used by tourists – Nice canopy forest but disturbance area
	3	0.7000	5.196712-118.519297	360	0	Along the road used by tourists – Nice canopy forest but disturbance area
	4	1.000	5.196808-118.519143	270	1	Road area – Disturbed canopy forest – Isolated trees
	5	0.730	5.19268-118.533501	360	1	Road area – Disturbed canopy forest – Isolated trees
	6	0.502	5.192885-118.533581	90	2	Road area – Disturbed canopy forest – Isolated trees

	7	0.750	5.192866-118.533508	180	5	Road area – Disturbed canopy forest
	8	0.467	5.197434-118.539828	360	2	Road area – Nice canopy forest
	9	0.600	5.197418-118.539876	90	8	Road area – Nice canopy forest
	10	0.527	5.197320-118.539897	180	4	Road area – Nice canopy forest
	11	0.529	5.195177-118.548505	360	1	Road area – Nice canopy forest
	12	0.619	5.194991-118.548402	180	3	Nice canopy forest
	13	0.815	5.195135-118.548668	90	1	Road area – Nice canopy forest
23.04.25	14	0.600	5.117702-118.482573	294	11	Road area – Disturbed forest between two oil palm plantations – Close to OPP
	15	0.500	5.125847-118.486303	90	5	Road area – Nice canopy forest - Close to OPP
	16	0.343	5.132014-118.491526	90	2	Road area – Nice canopy forest - Close to OPP
	17	0.430	5.138253-118.491604	90	0	Road area – Nice canopy forest - Close to OPP
	18	0.430	5.146203-118.494406	90	2	Road area – Nice canopy forest - Close to OPP
	19	1.000	5.154665-118.493399	90	4	Road area – Disturbed canopy forest – Close to OPP
	20	0.600	5.162221-118.494793	90	7	Road area – Nice canopy forest – Close to OPP
	21	0.820	5.187010-118.496508	90	7	Road area – Disturbed canopy forest – Isolated trees – Close to OPP
24.04.25	22	0.644	5.098475-118.523736	90	0	Disturbed canopy forest – Close to OPP – Isolated trees – Climbers ++
	23	0.840	5.115860-118.515637	360	0	Disturbed canopy forest – Close to OPP – Isolated trees – Climbers ++
	24	1.100	5.116618-118.495756	360	1	Nice canopy forest – Close to OPP
	25	0.696	5.178607-118.493743	90	3	Disturbed canopy forest – Close to OPP – Isolated trees – Close to mud volcano
	26	0.825	5.170088-118.496831	90	3	Nice canopy forest – Close to OPP
	27	0.648	5.087815-118.528968	150	0	Nice canopy forest – Close to OPP – OU food +
	28	1.200	5.080481-118.447462	360	0	Disturbed canopy forest – Close to OPP
	29	0.771	5.091496-118.554636	319	0	Disturbed canopy forest – Close to OPP
25.04.25	30	1.000	5.106386-118.607558	360	0	Disturbed canopy forest – Close to OPP
	31	0.924	5.108806-118.616254	360	0	Disturbed canopy forest – Some tall trees - Close to OPP
	32	1.220	5.111224-118.625150	360	0	Disturbed canopy forest – Some tall trees - Close to OPP
	33	1.000	5.111999-118.633737	90	0	Disturbed canopy forest – Some tall trees - Close to OPP - River
26.04.25	34	1.300	5.084034-118.631945	60	0	Disturbed canopy forest – Isolated trees - Close to OPP
	35	0.695	5.094596-118.632600	90	0	Disturbed canopy forest – Semi-inundated - Close to OPP
27.04.25	36	1.100	5.076284-118.676705	90	0	Disturbed canopy forest - Close to OPP
	37	0.700	5.086926-118.671408	360	0	Disturbed canopy forest - Close to OPP
	38	1.100	5.083506-118.658576	360	0	Nice canopy forest – Close to OPP
	39	1.100	5.082976-118.645955	360	0	Disturbed canopy forest – Isolated trees - Close to OPP
	40	0.872	5.103526-118.596815	360	0	Disturbed canopy forest - Close to OPP
	41	0.8000	5.100099-118.584877	360	0	Disturbed canopy forest - Close to OPP

Table 4: Date, location, length and number of orangutan nests recorded during random flights during the day. Keynote: OPP = Oil palm plantation.

The exact location of all these flights is given in Figures 5 and 6.

A total of 17.01 km of flights was conducted in the southern parts of Tabin, yielding only one orangutan nest. This striking result confirms the quasi-absence of orangutans in the southern part of Tabin, confirming results from past helicopter surveys (see more in the discussion). A total of 15.11 km was flown on the eastern side of TWR, yielding a total of 79 nests and resulting in a kilometric aerial index of 5.23 nests/km of flight.

We then looked at a possible correlation between kilometric indexes from RW and aerial indexes derived from drone line transect flights that were flown in the same area where ground recces were conducted: Table 5.

RW nb	Ground kilometric index	Drone transect nb	Aerial kilometric index
RW 1	0	LT 1	4.79
RW 2-3	4.02	LT 21	8.54
RW 4	12.28	LT 2-4-5-6-7	3.26
RW 5	4.19	LT 3	0
RW 6	7.19	LT 8 to 13	5.34
RW 7	5.00	LT 17-18	2.3
RW 8	1.53	LT 19	4.00
RW 9	5.00	LT 15	10.00
RW 10	6.00	LT 16	5.83
Average	5.023	Average	4.896
SD	3.49	SD	3.05

Table 5: Ground and aerial kilometric indexes of RW and drone transects carried out in similar areas

A t-test shows no statistical difference between the samples (t=0.08; df=8, p=0.938): Figure 9.

However, there is no correlation between the two data sets: Pearson's r = -0.070, p=0.858: Figure 10. In other words, we cannot draw a correlation between the number of nests detected from the drone and the ground (and vice-versa).

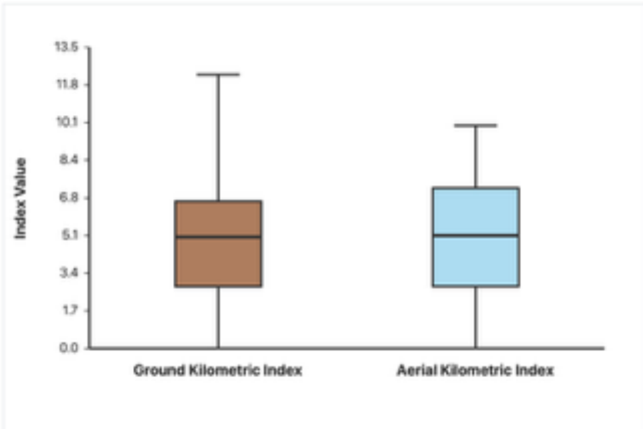


Figure 9: Box plot of ground and aerail kilometric indexes.

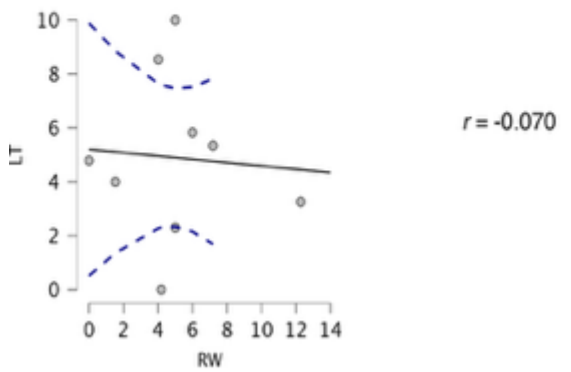


Figure 10: Scatter Plots RW vs LT with 95% Confidence intervals

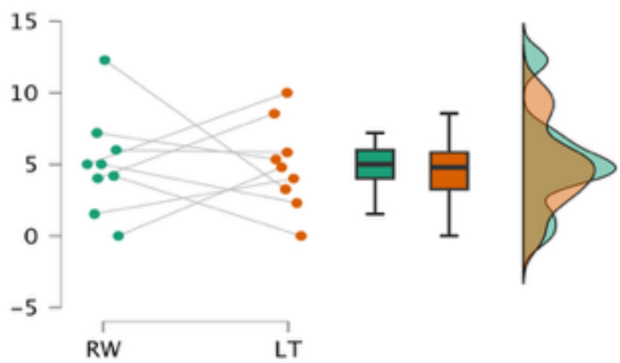


Figure 11: Raincloud plots of kilometric indexes RW vs drone transects

The absence of correlation can be explained by the high coefficient of variation of both data sets: 0.695 for RW and 0.624 for drone transects. The variation originates from the different forest types and structures thatgreatly influence nest detectability from the ground and from the air. More data will be needed to build a model that could derive a ground nest density from aerial drone surveys.

Results from reconnaissance walks (RWs) and drone transects do not provide direct estimates of orangutan abundance. Table 6 summarizes the results obtained during recent past orangutan surveys. If we compare our findings from Tabin Wildlife Reserve with the data from previous field expeditions from other sites, we can assume that the current orangutan density in the surveyed areas is roughly about 1 individual/km².

Location	Nest Kilometric Index (nest/km)		Orangutan Density (ind./km²)
	Ground RW	Drone	
Deramakot	20.0	9.13	2.26
Lot 8 LKWS	-	3.32	0.5
Lot 9 LKWS	-	3.11	0.96
Tabin WR (west)	5.81	5.23	-

Table 6: Nest kilometric indexes obtained during ground RWs and drone transects during previous field expeditions and resulting orangutan densities

c. *Results from drone surveys at night*

Nocturnal thermal camera surveys hold considerable promise for advancing our knowledge of orangutan abundance and distribution patterns. Nevertheless, establishing detection probability remains a critical prerequisite for validating this novel methodology. We conducted repeated surveys of identical quadrats over two consecutive nights (detailed in the methodology section), yet recorded no orangutan detections throughout our sampling effort, as documented in Table 7.

Date	Flight Nb	Flight Time	Species	Observation Time	Observation
22.04.25	I	19:18 – 19:44	Pig-tailed Macaque	19:24	Resting in a tree – 1 ind.
	II	20:03 - 20:56	Pig-ailed Macaque	20:29	Resting in a tree- 1 ind.
			Long-tailed Macaque	20:37	Resting in a tree- 6 ind.
			Banteng	20:37	Feeding – 1 Ad. Male
23.04.2025	I	18:37-19:14	Silvered langurs	18:51	Resting in a tree -2 ind.
	II	19:43-20.20	Pig-tailed Macaque	19:49	Resting in a tree – 14 ind.
			Pig-tailed Macaque	20:08	Resting in a tree- 2 ind.
			Banteng	20:18	Feeding – 1 ind.

Table 7: Findings obtained from the flights above the quadrat used to determine orangutan detectability

However, we detected several groups of primates (macaques and silver langurs) and a banteng, twice: Table 7.

Discussion and Conclusion

Given the extensive area of Tabin Wildlife Reserve, accurate population density estimates require comprehensive helicopter-based aerial surveys. Past aerial surveys conducted by Hutan with SWD in 2001 and WWF in 2017 indicated relative population stability over approximately two decades (Simon et al., 2019). Rather than attempting to assess the entire Tabin orangutan population, our recent survey specifically targeted the documentation and analysis of orangutan distribution and abundance patterns along the reserve's periphery, providing focused insights into edge habitat utilization within this protected area.

Weather conditions posed the primary challenge throughout our fieldwork, with persistent rainfall and flooding severely compromising data collection quality and operational safety. Conducting orangutan surveys during wet weather presents significant risks to personnel safety while simultaneously reducing data reliability due to impaired visibility within the forest understory. Extensive flooding rendered most study areas inaccessible, effectively preventing field teams from reaching designated survey locations. Furthermore, precipitation precluded drone operations entirely, substantially limiting our aerial survey capabilities throughout the expedition period.

Helicopter surveys conducted by Hutan and SWD in 2001 revealed that orangutans were more abundant in less degraded and more intact forest areas, with significantly lower densities observed in edge habitats and buffer zones compared to the reserve's interior. Our current field expedition in the southwestern edge of Tabin yielded similarly sparse orangutan encounters, corroborating these historical patterns. During that earlier period, orangutan populations were predominantly distributed in the eastern lowland and seasonally inundated forests of eastern Tabin, as illustrated in Figure 12. Subsequent aerial surveys conducted by WWF in 2017 documented comparable distribution patterns, reinforcing these findings (Figure 3).

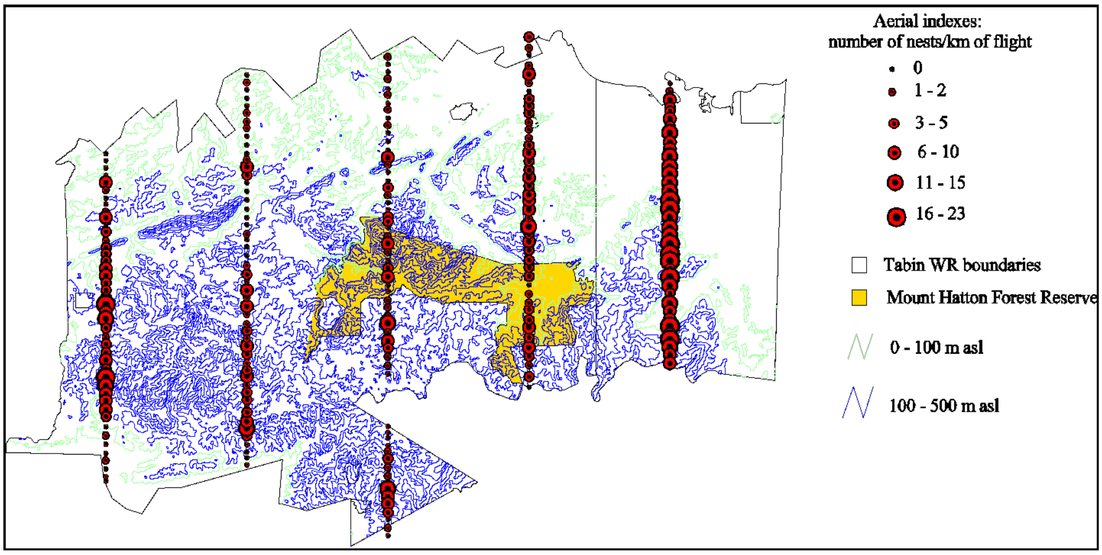


Figure 12: Map showing the nest aerial index from a helicopter in the early 2000s (@Hutan - unpublished data)

Our recent surveys corroborate findings from previous studies in Tabin, revealing a consistent pattern of orangutan distribution. We documented extremely sparse orangutan presence in the degraded buffer forests of southwestern Tabin, and a rather low abundance in the heavily degraded eastern buffer zones, while orangutan abundance appeared comparatively higher in the less disturbed interior forest areas.

The virtual absence of orangutans in buffer zones between forest and adjacent oil palm plantations presents a stark contrast to patterns observed in Kinabatangan, where orangutans frequently use forest-plantation edges and even venture into plantation areas. Throughout our Tabin surveys, we recorded no evidence of orangutan activity within the oil palm estates bordering the wildlife reserve, highlighting a fundamental difference in habitat use patterns between these two populations.

Concluding remarks

Prolonged heavy rainfall significantly impacted our field operations, constraining data collection opportunities and limiting survey effectiveness throughout the expedition period. Despite these challenges, our findings offer valuable insights into orangutan distribution patterns within the Tabin Wildlife Reserve.

Drone technology demonstrates considerable potential for orangutan population monitoring, offering efficient methods for nest detection during daylight hours and individual identification through nocturnal thermal imaging. However, operational limitations, including restricted signal range and limited battery life, currently constrain field applications of this technology. Equipment upgrades planned for the coming months will address these technical constraints and enhance the utility of drone-based survey methods.

Our survey results confirm the sparse orangutan presence in edge and buffer zones between Tabin's forests and adjacent oil palm plantations. This pattern contrasts markedly with the Kinabatangan population, where orangutans regularly utilize forest-plantation interfaces. The observed difference may reflect the substantially larger size of Tabin Wildlife Reserve compared to the fragmented forest lots comprising the Lower Kinabatangan Wildlife Sanctuary.

The survey results corroborate extremely low orangutan densities in southwestern Tabin and relatively sparse populations in western areas. However, orangutan abundance increases progressively with habitat quality as distance from degraded edge habitats increases toward the reserve's interior forests.

A comprehensive population assessment for Tabin Wildlife Reserve will require helicopter-based aerial surveys to adequately cover the reserve's extensive area. The allocation of MPOGCF funding for such surveys warrants discussion at the upcoming steering committee meeting to determine the most appropriate approach for population monitoring in this critical habitat.

Additional data about other wildlife taxa

1. Gibbon rapid surveys

We employed a triangulation methodology to estimate gibbon population abundances. This approach involves systematic acoustic monitoring of gibbon vocalizations (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 bearing direction. Two survey teams positioned at separate listening posts (at least 50 to 100 m apart) collected data simultaneously, enabling spatial mapping of gibbon groups through acoustic triangulation. We conducted surveys over three consecutive mornings at each location to ensure adequate sampling coverage. We reported a group of gibbons only when the call was heard by the two teams. From our experience in Kinabatangan (similar habitat), we estimate that a gibbon long call can be heard at a distance of about 800 m in the forest. This means that the surface area covered during our acoustic surveys is 2 km^2 (0.8 x 2 x 3.14).

Gibbon surveys were conducted near the Enforcement Post Mukim Hutan Simpan (Sungai Ireton), located adjacent to a Kuala Lumpur Kepong (KLK) oil palm plantation. The survey area exhibited extensive habitat degradation and disturbance from previous logging activities. Large-diameter trees had been systematically removed, creating a landscape dominated by dense secondary shrub growth interspersed with areas lacking canopy cover entirely. The degraded habitat structure resulted in most gibbon calls being detected at considerable distances from observation points, likely due to the open nature of the disturbed forest landscape.

Results are given in the Table below:

Date	Total number of groups heard by any of the two teams	Number of groups heard by the two teams and considered for analysis	Estimated Density (km^2)
22/4/2025	6	3	1.5
23/4/2025	3	2	1
24/4/2025	3	2	1

The average gibbon density recorded at our survey location was 1.2 group/km^2, with SD=0.3 group/km^2.

This relatively low density is characteristic of heavily logged and disturbed forests, as previously documented in Sabah. Unlike some other primate species like macaques or orangutans, gibbons don't do well in disturbed forests.

2. Frog surveys

Frog surveys are conducted along a 400–meter transect line along the river found within the Tabin Forest Reserve. We only managed to perform this on one night during the expedition. The survey, conducted from 1900 hours to 2015 hours, involved detecting frog species by direct sighting or by their calls along the transect. The 400-meter distance was divided into 10 sections of 40 meters each (0 – 40 m, 40 – 80 m, 80 – 120 m, 120 – 160 m, 160 – 200 m, 200 – 240 m, 240 – 280 m, 280 – 320 m, 320 – 360 m, 360 – 400 m). The species encountered were recorded for each section.

The survey was only conducted for one night, at Sungai Ireton. This small river had a steady current flow with rocks and boulders along the banks. The river flows from the forest area of Tabin FR to the plantation. Our single effort managed to record six species of frogs. The findings were as follow:

No	Frog name	Scientific Name	Notes
1	Cricket frog	*Indosylvirana nicobariensis*	Forest
2	Green Paddy frog	*Hylarana erythraea*	Plantation
3	White-lipped stream frog	*Chalcorana megalonesa*	Forest
4	Rough guardian frog	*Limnonectes finchii*	Forest, Plantation
5	Grass frog	*Fejevarya limnocharis*	Plantation
6	Four-line tree frog	*Polypedates leucomystax*	Plantation

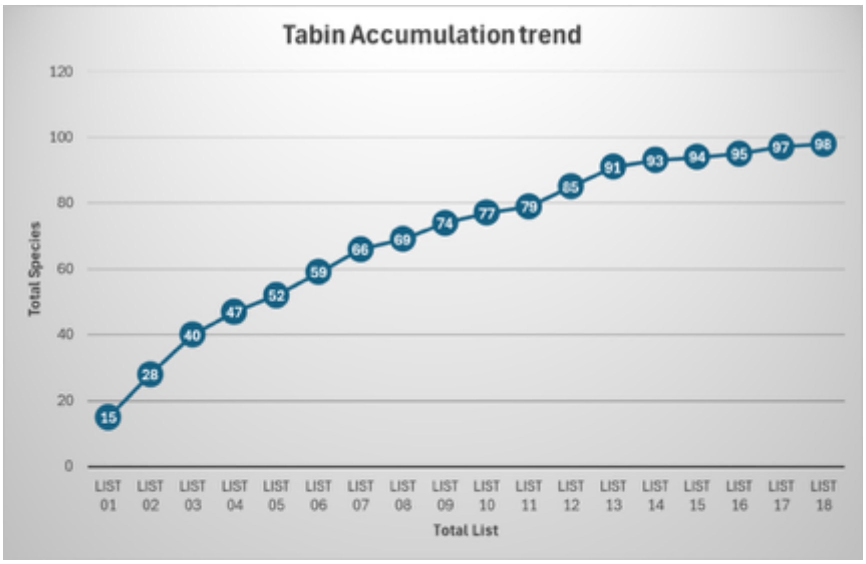
These species are generalists and characteristic of forest edges and disturbed habitats. More survey are needed to explore the Amphibian community in Tabin.

3. Road surveys at night

Following the frog survey, on our way back to camp, we recorded several direct sightings of Leopard cat (2), Moonrat (1), red giant flying squirrel (2) and an unidentifiable flying squirrel. The length of this single effort is short, with a 3.91km journey back to basecamp. The road used for this survey was adjacent to a plantation, and it is a designated buffer zone of Tabin FR to the riparian area.

4. Bird Survey

Using the Mac Kinnon List method, our bird survey in Tabin Forest Reserve throughout the expedition compiled a total of 18 lists and 98 different bird species. The accumulation curve generated from our 18 MacKinnon Lists is presented below. The curve increases as additional species were added that were not listed in previous lists to the total number of species. The graph shows that the curve did not reach a plateau and shows that more bird species could be recorded at the site with increased sampling efforts



Overall, our efforts recorded one endemic bird (Black-crowned pitta, *Erythropitta ussheri*), 2 species that are listed in the IUCN Red List as Endangered (Storm's stork and White-crowned hornbill), and three Vulnerable (Rhinoceros hornbill, Black hornbill, and Wreathed hornbill).

The table below shows the frequency count of bird species during monitoring (ie the number of times a given species appears in one of the 18 lists), with scientific names, their IUCN status, endemism and their protection status in the Sabah Wildlife Enactment 1997.

Frequencies of species between 1 and 3 were rarely recorded birds, 4 to 7 moderately recorded birds, and 8 to 12 commonly recorded birds.

About 70% of the birds recorded were from direct sightings and 30% from calls.

Frequency	Scientific name	Common name	IUCN Redlist	Endemism	SWE 1997
1	*Aplonis panayensis*	Asian Glossy Starling	LC	NE	S2
1	*Erythropitta ussheri*	Black-crowned Pitta	NT	E	S2
1	*Psilopogon duvaucelii*	Black-eared Barbet	LC	NE	S2
1	*Erythropitta venusta*	Blue-crowned Pitta	LC	NE	S2
1	*Meiglyptes tristis*	Buff-rumped Woodpecker	LC	NE	S2
1	*Phaenicophaeus curvirostris*	Chestnut-breasted Malkoha	LC	NE	S2
1	*Stachyris maculata*	Chestnut-rumped Babbler	LC	NE	S2
1	*Gracula religiosa*	Common Hill Myna	LC	NE	S2
1	*Aegithina tiphia*	Common Iora	LC	NE	S2
1	*Prionochilus percussus*	Crimson-breasted Flowerpecker	LC	NE	S2
1	*Hemicircus concretus*	Gray-and-buff Woodpecker	LC	NE	S2
1	*Cyanoderma bicolor*	Gray-hooded Babbler	LC	NE	S2
1	*Aegithina viridissima*	Green Iora	LC	NE	S2
1	*Acridotheres javanicus*	Javan Myna	LC	NE	S2
1	*Malacopteron magnirostre*	Moustached Babbler	LC	NE	S2
1	*Anhinga melanogaster*	Oriental Darter	LC	NE	S2
1	*Cinnyris ornatus*	Ornate Sunbird	LC	NE	S2
1	*Ardea purpurea*	Purple Heron	LC	NE	S2
1	*Lophotriorchis kienerii*	Rufous-bellied Eagle	LC	NE	S2
1	*Malacopteron magnum*	Rufous-crowned Babbler	LC	NE	S2
1	*Philentoma pyrhoptera*	Rufous-winged Philentoma	LC	NE	S2
1	*Surniculus lugubris*	Square-tailed Drongo-Cuckoo	LC	NE	S2
1	*Megalurus palustris*	Striated Grassbird	LC	NE	S2
1	*Butorides striata*	Striated Heron	LC	NE	S2
1	*Artamus leucorynchus*	White-breasted Woodswallow	LC	NE	S2
1	*Pellorneum rostratum*	White-chested Babbler	LC	NE	S2
1	*Pycnonotus goiavier*	Yellow-vented Bulbul	LC	NE	S2
2	*Irena puella*	Asian Fairy-Bluebird	LC	NE	S2
2	*Cypsiurus balasiensis*	Asian Palm Swift	LC	NE	S2
2	*Bubo sumatranus*	Barred Eagle-Owl	LC	NE	S2
2	*Brachypodius atriceps*	Black-headed Bulbul	LC	NE	S2

2	*Hemipus hirundinaceus*	Black-winged Flycather-shrike	LC	NE	S2
2	*Alcedo meninting*	Blue-eared Kingfisher	LC	NE	S2
2	*Mixornis bornensis*	Bold-striped Tit-Babbler	LC	NE	S2
2	*Anthreptes malacensis*	Brown-throated Sunbird	LC	NE	S2
2	*Ketupa ketupu*	Buffy Fish-Owl	LC	NE	S2
2	*Lonchura atricapilla*	Chestnut Munia	LC	NE	S2
2	*Aethopyga siparaja*	Crimson Sunbird	LC	NE	S2
2	*Lonchura fuscans*	Dusky Munia	LC	NE	S2
2	*Gallinula chloropus*	Eurasian Moorhen	LC	NE	S2
2	*Passer montanus*	Eurasian Tree Sparrow	LC	NE	S2
2	*Macronus ptilosus*	Fluffy-backed Tit-Babbler	LC	NE	S2
2	*Muscicapa griseisticta*	Gray-streaked Flycather	LC	NE	S2
2	*Argusianus argus*	Great Argus	LC	NE	S2
2	*Ducula aenea*	Green Imperial-Pigeon	LC	NE	S2
2	*Cuculus micropterus*	Indian Cuckoo	LC	NE	S2
2	*Chloropsis cyanopogon*	Lesser Green Leafbird	LC	NE	S2
2	*Egretta garzetta*	Little Egret	LC	NE	S2
2	*Arachnothera longirostra*	Little Spiderhunter	LC	NE	S2
2	*Psittacula longicauda*	Long-tailed Parakeet	LC	NE	S2
2	*Ardea intermedia*	Medium Egret	LC	NE	S2
2	*Pycnonotus plumosus*	Olive-winged Bulbul	LC	NE	S2
2	*Hirundo tahitica*	Pacific Swallow	LC	NE	S2
2	*Rhinortha chlorophaea*	Raffles's Malkoha	LC	NE	S2
2	*Gallus gallus*	Red Junglefowl	LC	NE	S2
2	*Pericrocotus speciosus*	Scarlet Minivet	LC	NE	S2
2	*Pellorneum malaccense*	Short-tailed Babbler	LC	NE	S2
2	*Rhaphidura leucopygialis*	Silver-rumped Spinetail	LC	NE	S2
2	*Malacopteron affine*	Sooty-capped Babbler	LC	NE	S2
2	*Pelargopsis capensis*	Stork-billed Kingfisher	LC	NE	S2
2	*Lonchura leucogastra*	White-bellied Munia	LC	NE	S2
2	*Amaurornis phoenicurus*	White-breasted Waterhern	LC	NE	S2
2	*Prinia flaviventris*	Yellow-bellied Prinia	LC	NE	S2
3	*Loriculus galgulus*	Blue-crowned Hanging Parrot	LC	NE	S2
3	*Anorrhinus galeritus*	Bushy-crested Hornbill	NT	NE	S2
3	*Tachybaptus ruficollis*	Little Grebe	LC	NE	S2
3	*Copsychus saularis*	Oriental Magpie-Robin	LC	NE	S2
3	*Cacomantis merulinus*	Plaintive Cuckoo	LC	NE	S2
3	*Chalcoparia singalensis*	Ruby-cheeked Sunbird	LC	NE	S2
3	*Halcyon coromanda*	Ruddy Kingfisher	LC	NE	S2
3	*Orthotomus sericeus*	Rufous-tailed Tailorbird	LC	NE	S2
3	*Ciconia stormi*	Storm's Stork	EN	NE	S2
3	*Hemiprocne comata*	Whiskered Treeswift	LC	NE	S2
3	*Berenicornis comatus*	White-crowned Hornbill	EN	NE	S2
4	*Chalcophaps indica*	Asian Emerald Dove	LC	NE	S2
4	*Pycnonotus simplex*	Cream-vented Bulbul	LC	NE	S2
4	*Treron olax*	Little Green-Pigeon	LC	NE	S2

4	*Ceyx rufidorsa*	Rufous-backed Dwarf-Kingfisher	LC	NE	S2
4	*Arborophila graydoni*	Sabah Partridge	LC	NE	S2
4	*Harpactes duvaucelii*	Scarlet-rumped Trogon	LC	NE	S2
4	*Rubigula erythropthalmos*	Spectacled Bulbul	LC	NE	S2
4	*Nisaetus nanus*	Wallace's Hawk-Eagle	LC	NE	S2
4	*Copsychus stricklandii*	White-crowned Shama	LC	NE	S2
4	*Rhyticeros undulatus*	Wreathed Hornbill	VU	NE	S2
5	*Ictinaetus malaiensis*	Black Eagle	LC	NE	S2
5	*Anthracoceros malayanus*	Black Hornbill	VU	NE	S2
5	*Eurylaimus ochromalus*	Black-and-yellow Broadbill	NT	NE	S2
5	*Todiramphus chloris*	Collared Kingfisher	LC	NE	S2
5	*Anthracoceros albirostris*	Oriental Pied Hornbill	LC	NE	S2
5	*Corvus enca*	Sunda Crow	LC	NE	S2
6	*Terpsiphone affinis*	Blyth's Paradise-Flycather	LC	NE	S2
6	*Centropus sinensis*	Greater Coucal	LC	NE	S2
6	*Dicrurus paradiseus*	Greater Racket-tailed Drongo	LC	NE	S2
7	*Rhipidura javanica*	Malaysian Pied Fantail	LC	NE	S2
7	*Buceros rhinoceros*	Rhinoceros Hornbill	VU	NE	S2
8	*Pitta sordida*	Hooded Pitta	LC	NE	S2
9	*Orthotomus ruficeps*	Ashy Tailorbird	LC	NE	S2
12	*Spilornis cheela*	Crested Serpent Eagle	LC	NE	S2

Aerial view showing the edge between a replanting area and the degraded forests of Tabin WR (presence of a riparian HCV)

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Annex I: Brief Specifics of the Field Expedition carried out in Tabin Wildlife Reserve

Location: Tabin Wildlife Reserve (West and South West border)
Date: 20.04.2025 to 29.04.2025 (2 travel days, 2 working days)

Staff/freelance personnel involved:

- Hartiman Bin Abdul Rahman, OURS, Hutan
- Suhaimi Bin Bahrani, OURS, Hutan
- Azli Bin Etin, OURS, Hutan
- Herman Bin Suali, OURS, Hutan
- Mohd Daisah Bin Kapar, 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
- Shahri bin Jamrin, OURS, Hutan
- Hardiman bin Abdul Rahman, OURS, Hutan
- Mohd Faisal bin Asmara, OURS, Hutan
- Eddie bin Ahmad, WSP, Hutan
- Hasbollah bin Sinyor, WSP, Hutan
- Mahathir bin Ratag, WSP, Hutan
- Ahmad Sapie bin Kapar, 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

Adjacent area type: Oil palm plantations

Types of activities conducted:

- Aerila drone transects & surveys
- Ground Reconnaissance Walks (Recces or RW)
- Botanical plots monitoring
- Audiomoth (bioacoustics)

Work Timeline

20.04.2025 - OURS and WSP teams departed from Kampung Sukau at 8:00 am and arrived in Tabin Wildlife Reserve at about 2:00 pm. Some team members immediately checked the accommodation, while other staff unloaded equipment and organized the provided lodging. Around 8:00 pm, everyone gathered to discuss group divisions and target points for the next morning's orangutan study work.

21.04.2025 - At 7:30 am, the teams began moving to the survey location points. The journey to the location took 1 hour and 45 minutes. Teams were divided into 4 groups. Data collected included Reconnaissance Walk data, Drone data, Botanical data, and Audiomoth installation.

22.04.2025 – One vehicle was damaged during the day before and was driven to Lahad datu for repair. The field work was carried out with the two remaining vehicles.

23.04.2025 - Field data collection work.

24.04.2025 - Field work had to be postponed due to very heavy rain from morning until noon. Meanwhile, we reviewed the data we had collected on previous days.

25.04.2025 – The WSP team returned to Sukau. The rain was a hindrance to our field activities. After the rain stopped (around 2.00 pm), the drone team went out to fly and used a plantation road to access the flying location. Unfortunately, the car got stocked in a mud pool and could not be extracted despite the assistance of plantation machinery (Porson). The car was left on site overnight and the team came back to camp..

26.04.2025 - At 8:00 am, a team of four researchers visited the KLK plantation office to request an excavator machinery assistance to rescue the vehicle. This task work was completed around 2:00 pm and then the team went to several locations for drone surveys.

27.04.2025 - 2 teams were split where 1 team went to fly drones while the other team conducted reconnaissance in the buffer zone area along the river for 2 kilometers.

28.04.2025 - The team could fly several transects with their drones, but the ground teams could not conduct the RW in the forest due to flood and impenetrable edges..

29.04.2025 – Data review - Accommodation cleaning and journey back to Sukau.

Annex II: Description of Botanical Plots: Number and size of Trees

Table A: Number, size, tree species and botanical scores within each botanical plot.

Plot	Tree species	DBH (cm)					Score (from 0 to 3)		
		20-30	30-40	40-50	50-60	>60	Canopy	Small trees (<20 cm)	Climbers
RW 1 Plot 029-030	Ficus	1	1	1	1				
	Seraya	2	2		1	1			
	Bayur		1	2	1				
	Keruing	1				1			
	Kapur		1	1					
TOTAL		**4**	**5**	**4**	**3**	**2**	**2**	**1.33**	**0.66**
RW 4 Plot 490 RT2	Binuang	7	10	3					
	Seraya		5	7					
	Urat mata				5				
TOTAL		**7**	**15**	**10**	**5**		**0.66**	**2**	**3**
RW 4 Plot 512 RT2	Laran	3	4						
	Binuang		5						
	Urat mata		4						
	Magas	7	4						
	Seraya		7						
	Mengaris					3			
	Bayur	12							
TOTAL		**22**	**24**			**3**	**2**	**3**	**2.66**
RW 5 Plot 035-036	Seraya		6						
	Binuang	2							
	Laran		11						
	Bayur		4						
	Magas	5							
	Urat mata	5							
TOTAL		**12**	**21**				**2**	**0.66**	**0**
RW 5 Plot 041-047	Mangaris					1			
	Keruing		3						
	Laran	5							
	Magas	4							
	Seraya		2						
	Binuang		2						
	Bangkal	1							
TOTAL		**10**	**7**			**1**	**2**	**0.66**	**0**
RW 6 Plot 521-522	Bayur	1	2						
	Magas		7						
	Laran	1	3						
	Seraya		4						
	Trapikal	1	1						
TOTAL		**3**	**17**				**1**	**0**	**0**
RW 6 Plot 526-528	Seraya	2	5						
	Laran	3	6						
	Magas	7	2						
TOTAL		**12**	**13**				**1**	**1**	**0.66**
RW 7 Plot 106-107	Bayur		10						
	Seraya			15					
	Binuang			8					
	Laran			13					
	Kayu malam	12							
TOTAL		**12**	**10**	**36**			**1**	**3**	**3**
RW 8 Plot	Belian	2				1			
	Bayur		1	2		1			

337-338	Laran	1							
	Seraya			1					
	Togop	1							
	Sindaman		1	1					
TOTAL		**4**	**2**	**4**		**2**	**2**	**2**	**2.66**
RW 9 Plot 207-210	Laran	6	2						
	Urat mata	1							
	Bangkal	1							
	Bayur	3							
	Mangaris					2			
	Seraya			1	2				
TOTAL		**11**	**2**	**1**	**2**	**2**	**1**	**2**	**1.66**
RW 9 Plot 217-218	Seraya	2	6	1	1	2			
	Sengkuang	1				1			
	Laran	4	2			4			
	Kapur		1		1				
	Unknown	1				1			
TOTAL		**8**	**9**	**1**	**2**	**8**	**1.66**	**3**	**2**
RW 10 Plot 534-536	Seraya	1	1	1	1	1			
	Urat mata	1	1	1	1	1			
	Binuang		1	1		1			
	Bayur	1	1		1	1			
	Belian	1	1		1	1			
TOTAL		**4**	**5**	**3**	**4**	**5**	**2**	**3**	**3**
RW 10 Plot 543-547	Seraya			6					
	Urat mata			5					
	Binuang			3					
TOTAL				**14**			**1**	**3**	**3**
RW 11 Plot 127-131	Binuang	1	1						
	Ranggu		1						
	Sengkuang		1	1					
	Macaranga		1						
	Seraya	1							
	Urat mata		1	1					
	Obah	1							
TOTAL		**3**	**5**	**2**			**1**	**0**	**0**
RW 11 Plot 123-126	Binuang		2						
	Bayur	1		1					
	Laran		1						
	Keruing	1							
	Seraya		1						
TOTAL		**2**	**4**	**1**			**1**	**2**	**2**

Table B: DBH and total of tree species across all botanical plots.

Species	**DBH (cm)**					**Total**	**Percentage**
	20-30	**30-40**	**40-50**	**50-60**	**>60**		
Ficus	1	1	1	1		4	1.1%
Bangkal	2					2	0.5%
Bayur	18	19	5	2	2	46	12.5%
Belian	3	1		1	2	7	1.9%
Binuang	10	21	15		1	47	12.7%
Kapur		2	1	1		4	1.1%

Kayu malam	12					**12**	3.3%
Keruing	2	3			1	**6**	1.6%
Laran	28	29	13			**70**	19.0%
Macaranga		1				**1**	0.3%
Magas	23	13				**36**	9.8%
Mangaris					6	**6**	1.6%
Obah	1					**1**	0.3%
Ranggu		1				**1**	0.3%
Sengkuang	1	1	1		1	**4**	1.1%
Seraya	8	39	32	5	4	**88**	23.8%
Sandaman		1	1			**2**	0.5%
Togop	1					**1**	0.3%
Trapikal	1	1				**2**	0.5%
Unknown	1				1	**2**	0.5%
Urat mata	7	6	7	6	1	**27**	7.3%
TOTAL	**119**	**139**	**76**	**16**	**19**		