Biodiversity of Lesan Protection Forest

Operation Wallacea

Expedition 2019

Introduction

In June and July 2019, Operation Wallacea UK collaborated with The Operation Wallacea Trust in Indonesia and the village of Lesan Dyak to establish an international student field study centre within the Lesan Protection Forest outside of Berau, East Kalimantan. Lesan Protection forest was selected due to its international importance in conserving global biodiversity, the abundance and diversity of flora and fauna it conserves and availability of local logistic support.

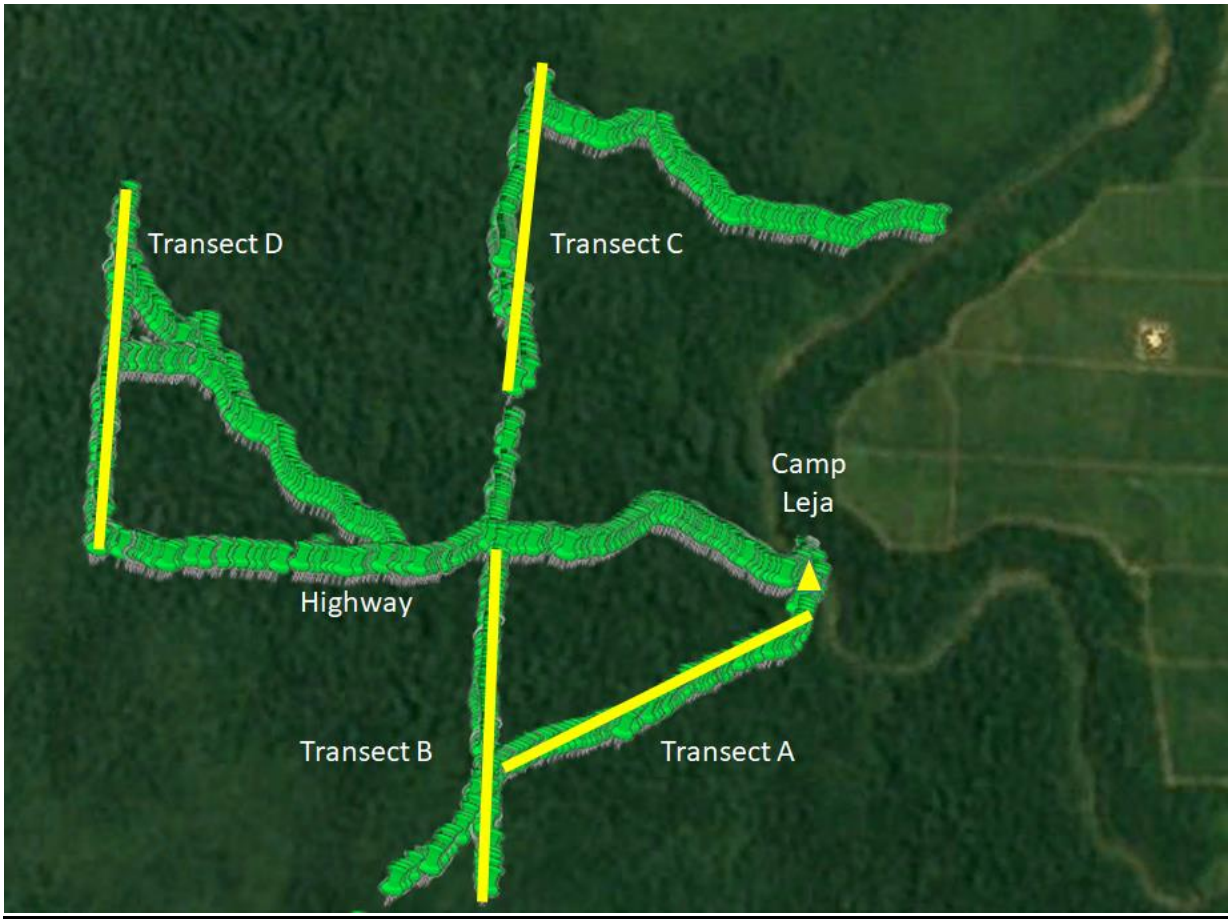
Over the 5 week field season, 139 International students and teachers had the opportunity to visit Lesan Protection Forest to work with Indonesian and international scientists, to learn about Borneo's unique biodiversity and the methods scientists use to study it. Students also learn important skills on how to survive in the Indonesian jungle.

Students studied methods to survey tree community diversity, forest structure and forest carbon. This enhanced their understanding of tropical forest diversity and the global significance of Borneo's forests, and Dipterocarps in particular, to the sequestration of greenhouse gasses. Students also learnt how to research the diversity and abundance of Borneo's birds, reptiles, amphibians, butterflies and mammals, including bats. As a result, they take home with them an increased understanding of important ecological concepts including diversity, endemism, niche theory, food-webs and carbon sequestration. Students and staff were privileged to work daily with villagers from Lesan Dyak, who generously shared their culture, food, dance and lives with us.

Significant opportunities for small-scale low-impact ecotourism using existing infrastructure within Lesan Protection forest have been identified by Operation Wallacea scientists. Tourists seeking birdwatching and wildlife experiences can expect to see a diversity of iconic Bornean flora and fauna providing current protections are upheld and enhanced. Opportunities for education programs for local schools are also a possibility.

Location

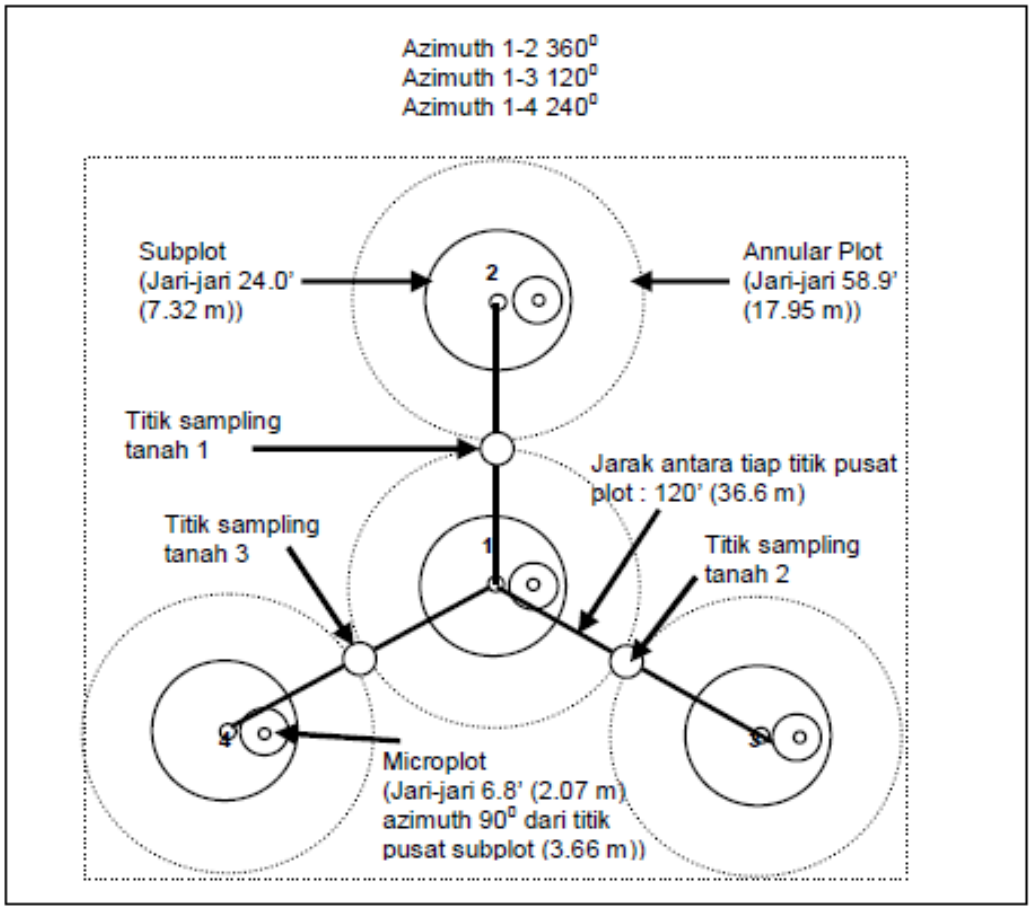
Camp Leja is located approximately 11km by boat from Lesan Dyak on the eastern margin of Lesan Protection Forest. Four 1km transects were established extending from a central path, the ‘highway’, extending 2.3km west from Camp Leja (below). Surveys for birds, mammals, herpetofauna, butterflies and habitat were conducted along the length of the transects and at monitoring points established at 300m intervals. Pitfall traps were established along transects B and C. Mist nets for bats were placed along transects and around camp across flyways. Camera traps were located along transects, along the highway and in locations with evidence of mammal activity. Incidental records for all fauna were collected across the site.

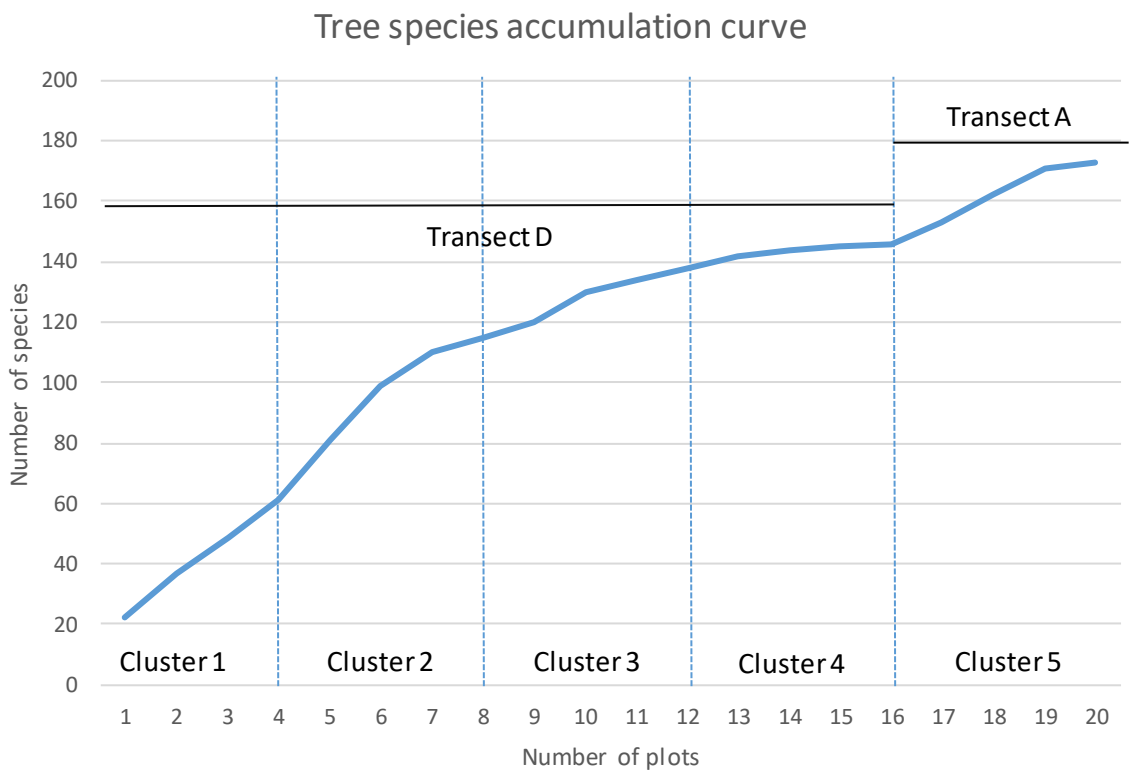


Habitat survey, Lesan Protection Forest

Techniques to quantify the diversity and structure of the tree community in Lesan Protection Forest were demonstrated to international students by forester/botanist Dr Ujang Susep Irawan and lead habitat surveyor Ellen Miller. Students also spent time learning about rainforest ecology and the globally important role tropical forests play in capturing and storing atmospheric carbon. Habitat surveys also gave students a greater appreciation of how habitat impacts faunal diversity and distribution.

Five clusters of 4 Forest Health Monitoring Plots (below) were established within the transect network and surveyed for tree diameter, condition and identified to species where possible. Students assisted in the measurement and mapping of 843 stems ≥10cm dbh as well as other habitat factors including forest regeneration, structure and tree health. The species accumulation curve below shows that at the completion of four clusters along transect D, many of the local tree species had been surveyed. Cluster 5 was established along transect A and sampled a slightly different tree community. The species accumulation curve suggests that the establishment of further FMP plots is likely to detect many more tree species in Lesan Protection Forest. The draft activity report covering habitat assessment methods and results is attached as Appendix A.






Habitat survey – Melinda Laidlaw

Bats of Lesan Protection Forest

Hipposideros diadema – Nick Hart

Students worked with Operation Wallacea's bat scientist Nick Hart to learn about bat ecology, biology and survey techniques. Bat surveys using mist nets were demonstrated by our bat scientist for 18 nights over five weeks. Locations were chosen to sample the widest possible variety of habitats within the vicinity of the transect network and Camp Leja. Within each habitat, sites were selected based on local topography and vegetation structure. Nets were set perpendicular to flyways and streams and opened between 6pm and 10pm wherever possible, however, the period between 6.15pm and 7.30pm was found to have the most bat activity. Nets were checked every 15 minutes to limit stress to captured bats. Bats were released from the net, identified, measured, photographed and quickly released. A total of 109 bats from 15 species were captured during the expedition. The species accumulation curve below suggests that additional survey effort is likely to record more species of bats at this location. One additional species, *Pteropus vampyrus,* was added via incidental records along the highway.

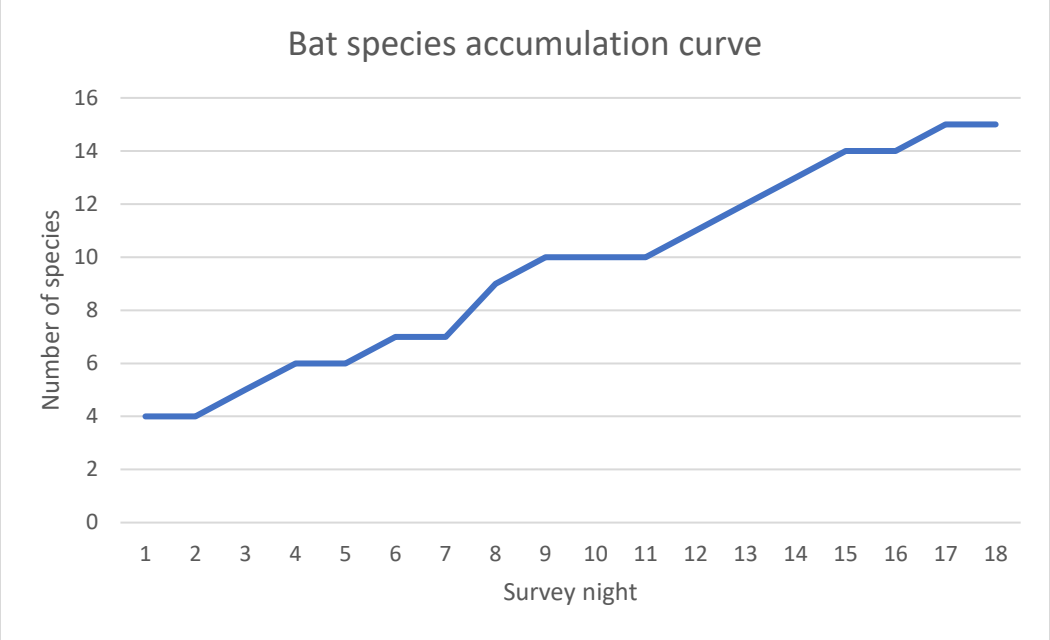


Table 1: Bats of Lesan Protection Forest 2019

Species	**Frequency of observation**
PTEROPODIDAE	
Pteropus vampyrus	Incidental record
Balionycteris maculata	Seen every 3-5 days
Cynopterus brachyotis	Seen less frequently
Cynopterus minutus	Seen less frequently
Penthetor lucasi	Seen less frequently
RHINOLOPHIDAE	
Rhinolophus affinis	Seen every 1-2 days
Rhinolophus borneensis	Seen every 3-5 days
Rhinolophus creaghi	Seen every 1-2 days
Rhinolophus trifoliatus	Seen every 3-5 days
HIPPOSIDERIDAE	
Hipposideros cervinus	Seen every 3-5 days
Hipposideros diadema	Seen every 1-2 days
Hipposideros larvatus	Seen every 3-5 days
EMBALLONURIDAE	
Emballonura monticola	Seen less frequently
VESPERTILIONIDAE	
Kerivoula papillosa	Seen less frequently
Murina cyclotis	Seen less frequently
Myotis horsfieldii	Seen less frequently

Non-volant mammals of Lesan Protection Forest

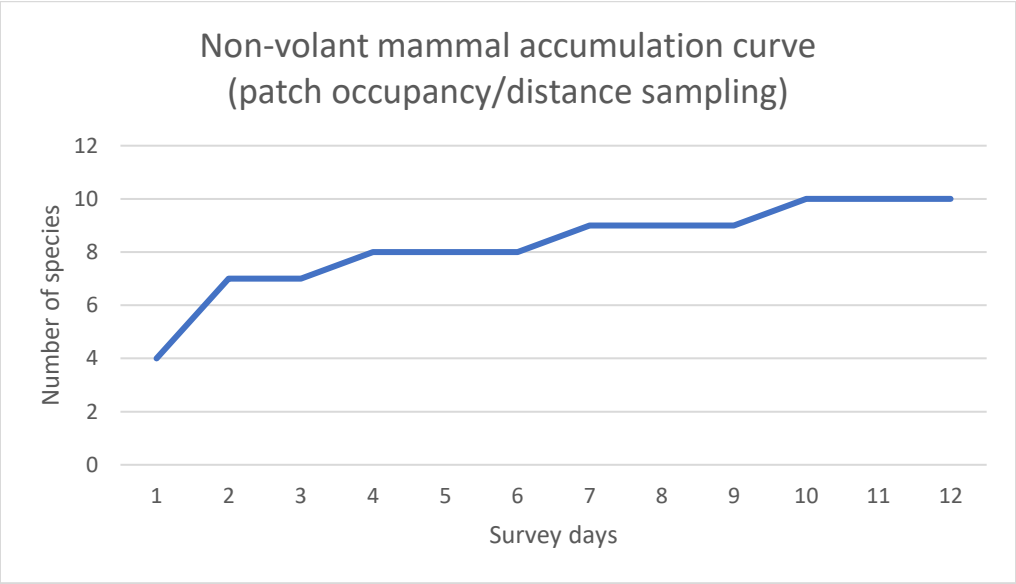
Thirty-eight non-volant mammal species were recorded within Lesan Protection Forest including 13 IUCN listed threatened or near-threatened species (table 2). Mammal ecology, biology and survey techniques were demonstrated to students by Operation Wallacea megafauna scientist, Prof. Graham Forbes. Notable species (according to Phillipps and Phillipps; 2018) recorded during the expedition include tufted ground squirrel ('not previously recorded in East Kalimantan'), grey tree rat '(only few records for Sabah region of Borneo'), and otter civet ('rare in Borneo'). Six of the 8 civet species from Borneo were recorded. A total of 6 primate species were recorded, with at least 3 more expected.

Table 2: Non-volant mammals of Lesan Protection Forest 2019.
† species listed as threatened or near-threatened (IUCN)
* species detected by distance sampling and/or patch occupancy methods

Family	**Common name**	**Scientific name**
Erinaceidae	Moonrat	*Echinosorex gymnura*
Soricidae	Bornean Pygmy Shrew	*Suncus hosei*
	Bornean Shrew	*Crocidura foetida*
Sciuridae	Least Pygmy Squirrel	*Exilisciurus exilis*
	*Black-eared Pygmy Squirrel	*Nannoscirus melanotis*
	Low's Squirrel	*Sundasciurus lowii*
	Plantain Squirrel	*Callosciuris notatus*
	*Prevost's Squirrel	*Callosciurus prevostii*
	†Tufted Ground Squirrel	*Rheithrosciurus macrotis*
	†Cream-coloured Giant Squirrel	*Ratufa affinis*
	Red Giant Flying Squirrel	*Petaurista petaurista*
Hystricidae	Malayan Porcupine	*Hystrix brachyura*
	Thick-spined Porcupine	*Hystrix crassispinis*
	Long-tailed Porcupine	*Trichys fasciculata*
Muridae	Sundaic Lenothrix	*Lenothrix canus*
	†Whitehead's Sundaic Maxomys	*Maxomys whiteheadi*
Tupaiidae	Ruddy Treeshrew	*Tupaia splendidula*
Cynocephalidae	Sunda Colugo	*Galeopterus variegatus*
Hominidae	*†Bornean Orangutan	*Pongo pygmaeus*
Hylobatidae	*†Müeller's Gibbon	*Hylobates muelleri*
Cercopithecidae	†Proboscis Monkey	*Nasalis larvatus*
	Long-tailed Macaque	*Macaca fascicularis*

	*†Southern Pig-tailed Macaque	*Macaca nemestrina*
	*Red Langur	*Presbytis rubicunda*
	†Silvery Langur	*Trachypithecus cristatus*
Prionodontidae	Banded Linsang	*Prionodon linsang*
Viverridae	Banded Palm Civet	*Hemigalus derbyanus*
	Masked Palm Civet	*Paguma larvata*
	*Malay Civet	*Viverra tangalunga*
	†Binturong	*Arctictis binturong*
	†Otter Civet	*Cynogale bennettii*
Herpestidae	Collared Mongoose	*Herpestes semitorquatus*
Felidae	Leopard Cat	*Prionailurus bengalensis*
Ursidae	†Sun Bear	*Helarctos malayanus*
Suidae	*†Bornean Bearded Pig	*Sus barbatus*
Tragulidae	*Greater Mouse Deer	*Tragulus napu*
Cervidae	†Bornean Yellow Muntjac	*Muntiacus atherodes*
	*Indian Muntjac	*Muntiacus muntjak*

Students were taught several mammal survey techniques during the expedition. Transects were surveyed for mammal activity, with **distance sampling** data collected to aid abundance estimates. Transects were also surveyed for mammal tracks, scats and other signs as an indicator of **patch occupancy** and abundance a minimum of three times during the season. A total of 10 mammal species were detected using these transect survey methods (below). Severn camera traps were deployed between June 15 and July 19 2019 at 25 baited and non-baited sites for a total of 4507 survey hours. Details of selected mammal sightings and photographs can be found in Appendix B.



Birds of Lesan Protection Forest

International students studied bird ecology, biology and survey techniques with Operation Wallacea ornithologists Matthew Slaymaker and Indah Sartika Sari. Students learned to identify birds by plumage using binoculars, by their behavior and by their song. A total of 85 10 minute point-count surveys were conducted at 300m intervals along transects at dawn each morning. Incidental records were also made around Camp Leja, via camera traps and during other times during the day. A total of 1584 individuals of 171 bird species were recorded within Lesan Protection Forest including Camp Leja. An additional 16 species recorded around Lesan Dyak Village making a total of 187 species. Despite this high biodiversity, the rising species accumulation curve for Lesan Protection Forest suggests that many more species are likely to be recorded as a result of further surveys.

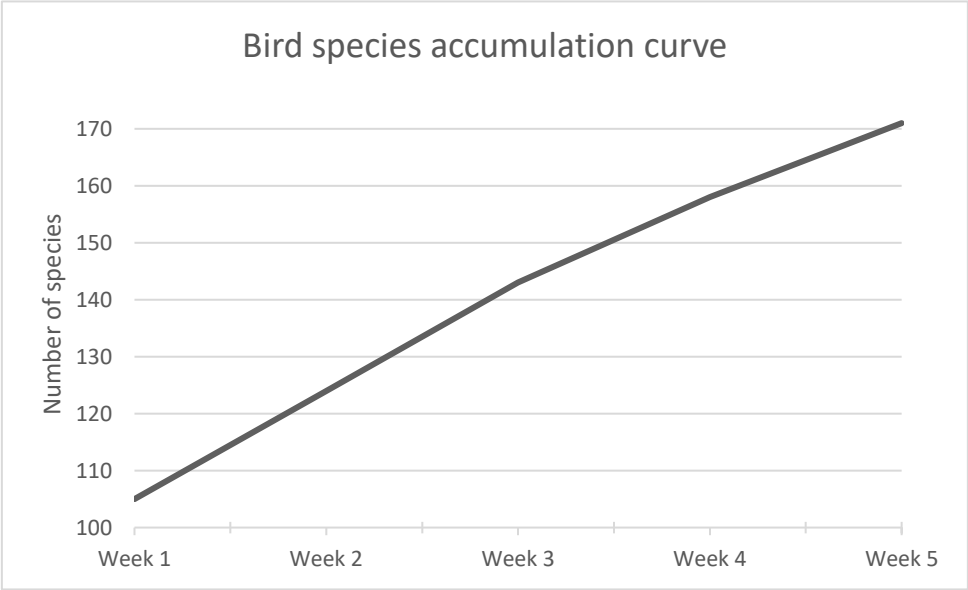


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Table 3: Birds of Lesan Protection Forest and surrounds 2019

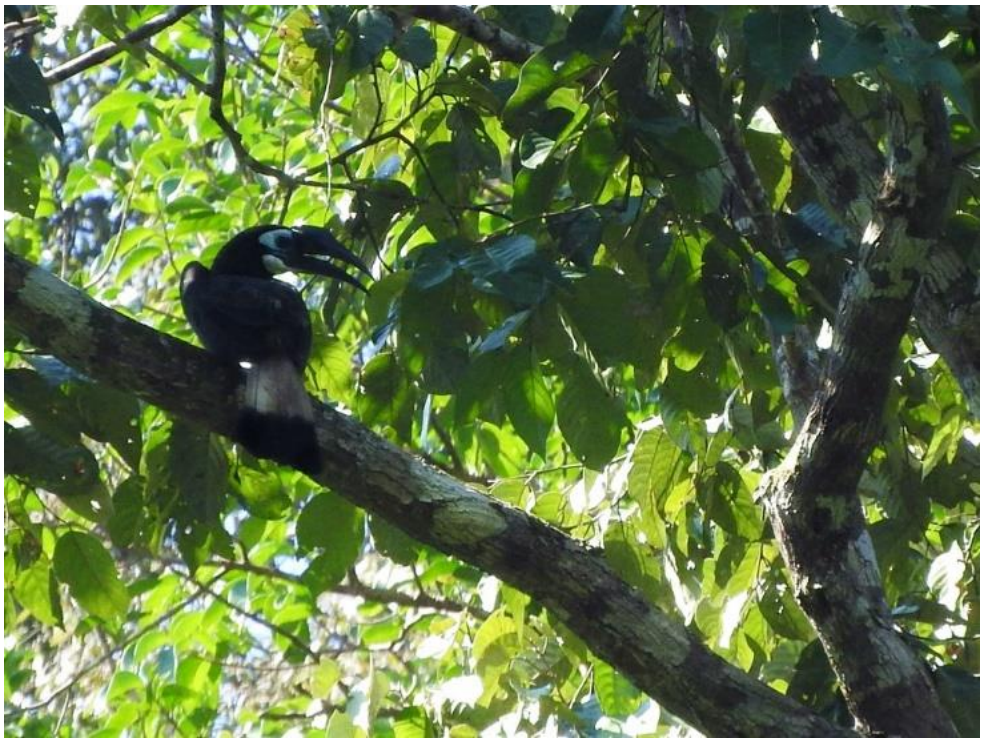
Species	**Lesan Protection Forest**	**Leja Camp & buffer**	**Lesan Dayak Village**	**Total**
Aerodramus sp.	2	20	8	30
Ashy Tailorbird		1	2	3
Asian Fairy Bluebird	1	4	2	7
Asian Glossy Starling			3	3
Banded Broadbill	5	5		10
Banded Kingfisher	5	9	1	15
Banded Woodpecker		1		1
Bar-bellied Cuckooshrike			1	1
Barred Eagle Owl		1		1
Black and White Bulbul		3	5	8
Black Eagle		2		2
Black Hornbill	9	14	5	28
Black Magpie	4	6		10
Black-and-Red Broadbill		6	2	8
Black-and-Yellow Broadbill	17	22	2	41
Black-capped Babbler	1	1		2
Black-headed Bulbul	4	8	5	17
Black-naped Monarch	7	10		17
Black-thighed Falconet		2	2	4
Black-throated Babbler	1	9		10
Black-throated Wren Babbler	1			1
Black-winged Flycatcher-shrike		5	2	7
Black-winged Kite			2	2
Blue-banded Kingfisher		1		1
Blue-crowned Hanging Parrot	2	17	7	26
Blue-eared Barbet	5	27	3	35
Blue-eared Kingfisher	1	6		7
Blue-headed Pitta	5	10		15
Blue-rumped Parrot		2	2	4
Blue-tailed Bee-eater		1		1
Blue-winged Leafbird		15		15
Blyth's Paradise Flycatcher	9	18		27
Bold-striped Tit-Babbler	7	1		8
Bornean Blue Flycatcher	2	4		6
Bornean Bristlehead	2	2		4
Bornean Ground Cuckoo	4	2		6
Brahminy Kite		1	2	3
Bronzed Drongo	1			1
Brown Barbet		10	2	12
Brown Fulvetta	17	12		29

Brown Wood Owl	1	2		3
Brown-throated Sunbird		2	5	7
Buff-necked Woodpecker		1		1
Buff-rumped Woodpecker		2		2
Buff-vented Bulbul		6		6
Buffy Fish Owl		1		1
Bushy-crested Hornbill	2	15		17
Checker-throated Woodpecker		1		1
Chestnut-backed Scimitar Babbler	11	14		25
Chestnut-bellied Malkoha			1	1
Chestnut-breasted Malkoha	1	9		10
Chestnut-naped Forktail	1	4		5
Chestnut-rumped Babbler	16	18		34
Chestnut-winged Babbler	18	23	2	43
Cinnamon-rumped Trogon	1			1
Common Iora		2	1	3
Cream-vented Bulbul		6		6
Crested Fireback	3	8		11
Crested Honey Buzzard		3		3
Crested Jay	5	4		9
Crested Partridge		5		5
Crested Serpent Eagle	1	1		2
Crimson Sunbird	1		1	2
Crimson-breasted Flowerpecker		1		1
Crimson-winged Woodpecker		1		1
Dark-necked Tailorbird	1	2		3
Dark-throated Oriole	2			2
Diard's Trogon	10	6		16
Dusky Broadbill	1	3		4
Dusky Munia		1	2	3
Edible-nest Swiftlet		2	2	4
Emerald Dove	16	30	2	48
Erpornis	1	2		3
Ferruginous Babbler	9	5		14
Fluffy-backed Tit-babbler	9	8		17
Garnet Pitta	13	15		28
Gold-whiskered Barbet	13	12		25
Great Argus	18	32	2	52
Great Slaty Woodpecker		3		3
Greater Coucal			3	3
Greater Green leafbird		7		7
Greater Racket-tailed Drongo	4	2	4	10

Green Broadbill	14	19	1	34
Green Imperial Pigeon		10	8	18
Green Iora		7	1	8
Grey-bellied Bulbul			1	1
Grey-breasted Spiderhunter		2	2	4
Grey-cheeked Bulbul	2	5		7
Grey-chested Jungle Flycatcher	3	2		5
Grey-headed Babbler	2	1		3
Grey-headed Canary Flycatcher	2	1		3
Grey-rumped Treeswift		7	3	10
Hairy-backed Bulbul		5		5
Helmeted Hornbill	1			1
Hill Myna	9	7	4	20
Horsfield's Babbler	8	1		9
Indian Cuckoo	3	1		4
Intermediate Egret		1		1
Jambu Fruit Dove	1	7		8
Javan Myna			3	3
Jerdon's Baza		4		4
Large Frogmouth	1			1
Large Green Pigeon	1	2	6	9
Large Woodshrike	2	1		3
Lesser Adjutant			1	1
Lesser Fish Eagle		7		7
Lesser Green Leafbird		8	1	9
Little Green Pigeon	1	3	7	11
Little Spiderhunter	3	5		8
Long-tailed Parakeet		2	2	4
Malaysian Blue Flycatcher		14		14
Malaysian Honeyguide	6			6
Maroon Woodpecker		2		2
Maroon-breasted Philentoma		1		1
Moustached Babbler	10	6		16
Olive-winged Bulbul		1		1
Orange-backed Woodpecker	2	1		3
Orange-bellied Flowerpecker		6	2	8
Oriental Bay Owl	2	1		3
Oriental Darter		9		9
Oriental Dwarf Kingfisher	1	3		4
Oriental Pied Hornbill		4	1	5
Pacific Swallow		27	5	32
Pied Fantail		1	2	3

Pink-necked Green Pigeon		2		2
Plain Sunbird	2	3		5
Plaintive Cuckoo	3	7	4	14
Plume-toed Swiftlet		2	1	3
Puff-backed Bulbul	1	1		2
Purple-naped Spiderhunter	4	16		20
Raffle's Malkoha	7	10		17
Rail-Babbler		1		1
Red-crowned Barbet	6	10	4	20
Red-eyed Bulbul		12	3	15
Red-naped Trogon	2	3		5
Red-throated Barbet	16	15	1	32
Red-throated Sunbird		1		1
Rhinocerous Hornbill	12	23	3	38
Ruby-cheeked Sunbird		7	1	8
Rufous Piculet	1	1		2
Rufous Woodpecker	2	1		3
Rufous-bellied Eagle		1		1
Rufous-chested Flycatcher	2	7		9
Rufous-crowned Babbler	9	17		26
Rufous-fronted Babbler	13	7		20
Rufous-tailed Tailorbird			1	1
Rufous-winged Philentoma	6	1		7
Scaly-crowned Babbler	11	13		24
Scarlet Minivet		1	1	2
Scarlet-rumped Trogon	5	11	1	17
Short-tailed Babbler	7	2		9
Silver-rumped Spinetail		8	2	10
Slender-billed Crow	3	17	6	26
Sooty-capped Babbler	16	16		32
Sooty-headed Bulbul			1	1
Spectacled Bulbul	10	14	1	25
Spectacled Spiderhunter	1			1
Spotted Dove		1	3	4
Spotted Fantail	11	2		13
Square-tailed Drongo Cuckoo	1	6		7
Stork-billed Kingfisher		11	6	17
Streaked Bulbul		1		1
Striped Wren Babbler	3	1		4
Sunda Blue Flycatcher	3			3
Sunda Frogmouth	1			1
Thick-billed Green Pigeon	6	2		8
Tree Sparrow			6	6

Van Hasselt's Sunbird		1		1
Velvet-fronted Nuthatch			1	1
Violet Cuckoo		1	3	4
Wallace's Hawk Eagle		1	2	3
Whiskered Treeswift		19		19
White-bellied Munia			4	4
White-bellied Woodpecker	2		2	4
White-breasted Waterhen		1		1
White-chested Babbler	2	31	3	36
White-crowned Forktail	2	3		5
White-crowned Hornbill			1	1
White-rumped Shama	8	10	1	19
Wreathed Hornbill	2		1	3
Wrinkled Hornbill	1	5	4	10
Yellow-bellied Bulbul	2	3	2	7
Yellow-bellied Prinia			3	3
Yellow-breasted Flowerpecker		7		7
Yellow-eared Spiderhunter	1	4	1	6
Yellow-rumped Flowerpecker		15	1	16
Yellow-vented Bulbul			6	6
Total	528	1056	213	1797



bushy-crested hornbill - Matt Slaymaker

Reptiles and amphibians (herpetofauna) of Lesan Protection Forest

Bornean Keeled Pit Viper

International students learnt techniques for surveying reptiles and amphibian as well as details on their ecology and biology from Operation Wallacea herpetologist Scott Macor. Herpetofauna were surveyed using multiple techniques. Pitfall surveys utilized 10 lines of 5 pitfall buckets dug into the ground in lines perpendicular to the 300m marks along transects B and C. Arrays of buckets were connected by drift fences of tarpaulin to guide fauna into the buckets. The pitfall buckets were surveyed each morning with students and the captures identified, measured and released. Herpetofauna were also actively surveyed along transects and creek-lines at night. As a result of 18 pitfall nights and 19 night walks, a total of 55 confirmed species recorded, 26 species of frogs and 29 species of reptiles. The species accumulation curve below suggests, however, that many herpetofauna species remain unrecorded in Lesan Protection Forest.

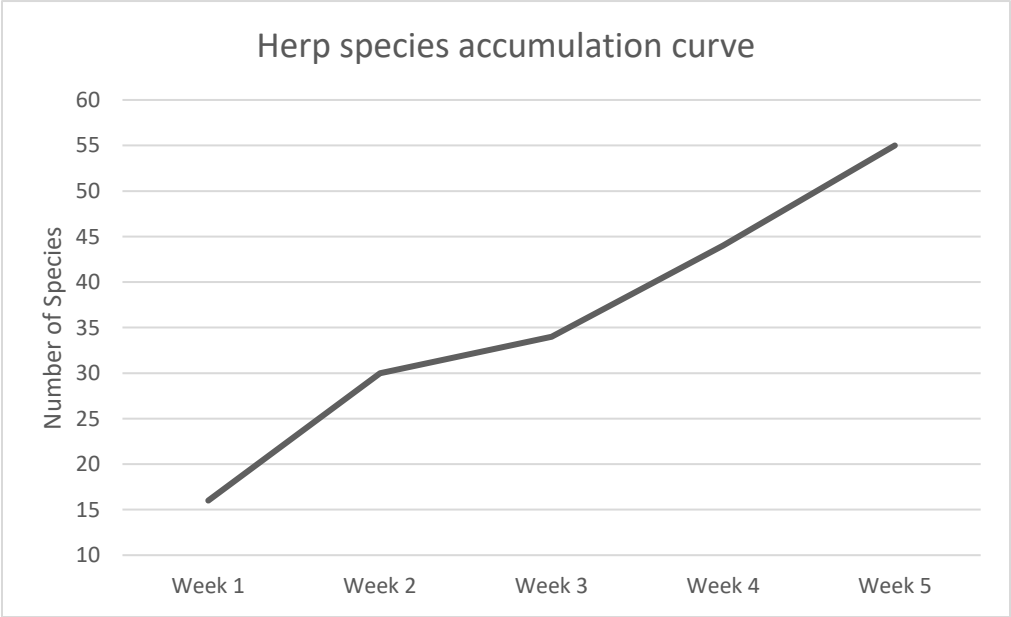


Table 4: Herpetofauna of Lesan Protection Forest 2019

Group	Latin	Common Name
Frog	*Chaperina fusca*	Saffron-bellied Frog
Frog	*Hylarana Megalonesa*	White-lipped Stream Frog
Frog	*Hylarana picturata*	Spotted Stream Frog
Frog	*Kalophrynus heterochirus*	Variable Sticky Frog
Frog	*Kalophrynus meizon*	Bornean Sticky Frog
Frog	*Leptobrachium abbotti*	Lowland Large-eyed Litter Frog
Frog	*Leptolalax* sp.	Slender Litter Frog
Frog	*Limnonectes kuhlii* complex	Kuhl's Creek Frog
Frog	*Limnonectes leporinus*	Giant River Frog
Frog	*Limnonectes paramacrodon*	Lesser Swamp Frog
Frog	*Megophrys nasuta*	Bornean Horned Frog
Frog	*Microhyla malang*	Greater Bornean Narrow-mouth Frog
Frog	*Odorrana hosii*	Poisonous Rock Frog
Frog	*Polypedates colletti*	Collett's Tree Frog
Frog	*Polypedates leucomystax*	Four-lined Tree Frog
Frog	*polypedates macrotis*	Dark-eared Tree Frog
Frog	*Polypedates otilophus*	File-eared Tree Frog
Frog	*Rhacophorus cyanopunctatus*	Blue-spotted Tree Frog
Frog	*Rhacophorus fasciatus*	Banded Tree Frog
Frog	*Rhacophorus rufipes*	Red-legged Tree Frog
Frog	*Staurois guttatus*	Black-spotted Foot-Flagging Frog
Toad	*Ansonia spinulifer*	Spiny Slender Toad
Toad	*Ingerophrynus divergens*	Crested Toad
Toad	*Phrynoides asper*	Rough River Toad
Toad	*Phrynoides juxtasper*	Giant River Frog
Toad	*Rentapia hosii*	Brown Tree Toad
Snake	*Ahaetulla prasina*	Green Vine Snake
Snake	*Aplopeltura boa*	Blunt-headed Snail-eating Snake
Snake	*Asthenodipsas malaccanus*	Dark-necked Slug-eating Snake
Snake	*Boiga dendrophila*	Mangrove Cat Snake
Snake	*Calamaria schlegeli*	Pink-headed Reed Snake
Snake	*Dendrelaphis* sp.	Bronzeback
Snake	*Dryocalamus tristrigatus*	Striped Dwarf Treesnake
Snake	*Liopeltis tricolor*	Masked Ground Snake
Snake	*Macropisthodon rhomdomelas*	Blue-necked Water Snake
Snake	*Tropidolaemus subannulatus*	Bornean Keeled Pit-viper
Snake	*Xenochrophis triangularis*	Triangle Keelback
Snake	*Xenodermus javanicus*	Rough-backed Snake

Gecko	*Cosymbotus craspedotus*	Gliding Gecko
Gecko	*Cyrtodactylus* sp.	Clawed gecko
Gecko	*Gehyra mutilata*	
Gecko	*Gekko monarchus*	
Gecko	*Gekko smithii*	Smith's Gecko
Skink	*Apterygon vittatus*	Tree Skink
Skink	*Lygosoma* sp.	
Skink	*Mabuya multifasciata*	
Skink	*Mabuya rudis*	
Skink	*Sphenomorphus haasi*	
Skink	*Sphenomorphus sp. Yellow*	
Skink	*Tropidophorus beccarii*	Water Skink
Dragon	*Bronchocela cristatella*	Canopy Lizard
Dragon	*Draco* sp.	Flying lizard
Dragon	*Gonocephalus bornensis*	Bornean Angle-headed Dragon
Varanid	*Varanus salvator*	Asian Water Monitor
Turtle		Soft Shell turtle

Bornean Horned Frog

Butterflies of Lesan Protection Forest

Butterfly scientists Nanda Lestari and Dr Roy Wiles instructed international students on butterfly ecology, biology and survey techniques while at Lesan Protection Forest. Understory butterflies were surveyed using hand nets along transects, trails and around camp, as well the deployment of baited Van Sommering traps. Trapped individuals were photographed and identified wherever possible. To date 45-50 species of butterfly have been identified from more than 1600 photographs taken during the expedition, with over 100 species possible once the identification process is completed. The morphospecies accumulation curve below suggests that the survey techniques used may have sampled a large percentage of the butterfly fauna of Lesan Protection Forest. A draft publication on the butterflies of Lesan Protection Forest has been prepared and is attached as Appendix C.

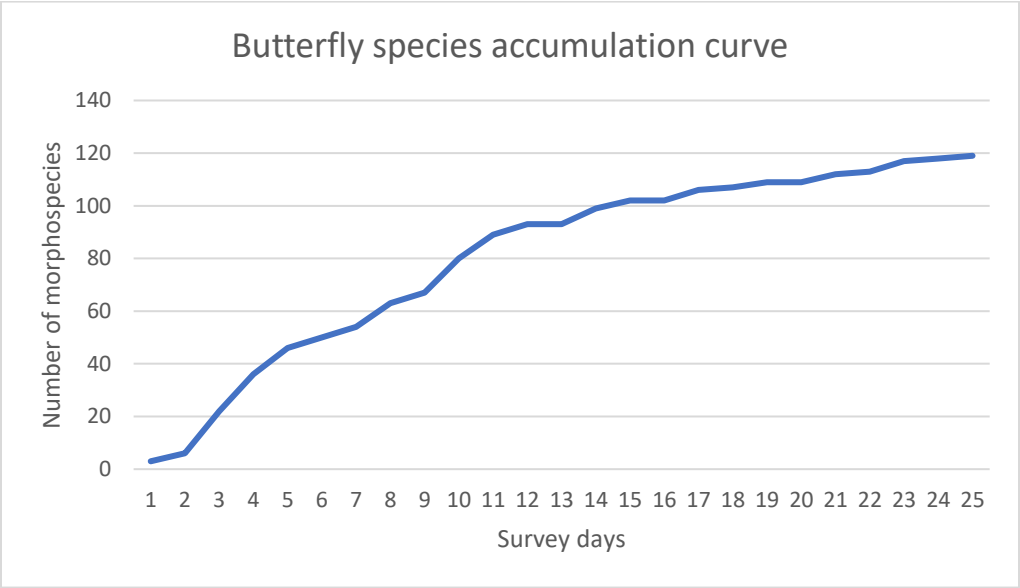


Table 5: Butterflies of Lesan Protection Forest 2019

Allotinus (Paragerydus) leogoron normani Eliot 1967
Arhopala elopura (Druce,1894)
Catapaecilma harmani
Catopsilia pomona Fabricius 1775
Cepora judith (Fabricius, 1787)
Cethosia hypsea (Doubleday 1847)
Charaxes bernardus (Fabricius 1793)
Charaxes durnfordi everetti Rothschild 1894
Chersonesia rahria (Moore 1858)
Cupha erymanthis (Drury 1773)
Curetis santana malayica (C & R Felder 1865)?
Curetis sperthis sperthis (C. & R. Felder 1865)
Cyrestis nivea (Zinken 1831)
Danaus genutia intensa (Moore 1883)
Delias baracasa Semper 1890
Discolampa ethion (Westwood 1851)
Drupadia naisca (Rober 1886)
Elymnias panthera (Fabricius, 1787)
Eulaceura osteria (Westwood 1850)
Euthalia anosia (Moore 1857)
Euthalia dunya (Doubleday 1848)
Euthalia teuta (Doubleday 1848)
Graphium agamemnon (Linneus 1758)
Graphium antiphates (Cramer 1775)
Graphium bathycles bathycloides (Honrath 1884)
Graphium doson (C. & R. Felder 1864)
Graphium sarpedon (Linneus 1758)
Hypolycaena amasa maximinianus (Fruhstorfer 1912)
Ilema vaneeckei callima (Collenette, 1932)
Jamides philatus (Snellen 1887)
Jamides sp
Kallima limborgii limborgii Moore 1878
Lamproptera meges (Zinken-Sommer 1831)
Laringa casteinaui ochus (Fruhstorfer)
Lasippa tiga (Moore 1881)
Melanitis leda (Linnaeus, 1758)
Moduza pocris (Cramer 1777)
Nacaduba kurava (Moore 1858)

Neptis duryodana nesia (Moore 1858)
Neptis leucoporus (Fruhstorfer 1908)
Neptis vikasi ragusa Eliot 1969
Pachliopta antiphus (Fabricius 1793)
Papilio (Menelaides) memnon (Linnaeus 1758)
Papilio helenus enganius (Doherty 1891)
Papilio nephalus (Boisduval, 1836)
Polyura delphis (Staudinger 1886)
Polyura hebe ganymedes (Staudinger 1886)
Ritra aurea (Druce 1873)
Tanaecia pelea (Fabricius 1787)
Trogonoptera brookiana Wallace 1885
Zeuxidia aurelius (Cramer 1777)

Papilio gigon – Tom Martin

Summary

There is interest in ecotourism opportunities for the site and so I kept records of primates heard or seen from camp (Appendix B), and megafauna (*i.e.,* mammals/hornbills/Great Argus Pheasant) heard or seen along the 'Highway Trail' from camp to the intersection with Transects B/C (approximately 1.1km total distance) (Appendix C). Basically, Gibbons were heard each morning, and other primate species were seen approximately every 3 days from the camp area. All primates seen from camp were across the river opposite camp, in the narrow, forested buffer before the oil palm plantation; it is unlikely that the buffer will retain primates (other than Long-tailed Macaques, which were often recorded in farmed areas downstream) if the buffer is not maintained. Assuming that data from June-July reflects the remaining year, tourists walking the Highway Trail or 1km are likely to hear Great Argus Pheasant and hornbill species each morning, and primate species at least once over the course of several days of effort. There seemed to be much less recorded in the afternoon.

Appendix A

LAPORAN KEGIATAN

Perhitungan Stok Karbon
Hutan Lindung Sungai Lesan (HLSL)

Oleh :

Yayasan Operasi Wallacea Terpadu

(OWT)

Daftar Isi

Daftar Tabel

Daftar Gambar

Daftar Lampiran

BAB 1. **Pendahuluan**

1.1 Latar Belakang

Hutan Lindung Sungai Lesan (HLSL) berada di wilayah administrasi Kecamatan Kelay, Kabupaten Berau, Provinsi Kalimantan Timur. HLSL ditetapkan sebagai hutan lindung berdasarkan Surat Keputusan Menteri Kehutanan Nomor: SK. 3924/Menhut-VII/KUH/2014 tanggal 14 Mei 2014, dimana pada SK tersebut disebutkan adanya penetapan kawasan hutan pada kelompok hutan Muara Lasan seluas 13.565,58 ha yang terdiri dari: (1) Kawasan Hutan Lindung seluas 10.240,82 ha dan (2) Kawasan Hutan Produksi seluas 3.324,76 ha.

HLSL menjadi salah satu pewakil hutan tropis dataran rendah di Kabupaten Berau dimana kondisi tutupan lahannya masih baik, hal ini menyebabkan kondisi hidrologi HLSL relatif baik yang ditunjukkan oleh adanya kontinuitas debit yang terjaga sepanjang tahun dan sedimentasi yang rendah, serta iklim mikro dalam batas normal. Meskipun kesuburan tanah di HLSL tergolong rendah, namun vegetasi asli tetap tumbuh baik karena siklus hara masih tetap terjaga.

Kondisi HLSL sebagian besar adalah hutan primer dan sekunder dimana kawasan hutan ini kaya akan berbagai jenis pohon asli Kalimantan. Beberapa jenis pohon yang tumbuh di kawasan HLSL dan banyak dijumpai sebagai sarang orangutan antara lain: Ulin, Meranti, Kayu Arang, Banitan, Bintangur, Jambu-jambu, Kenari, Kacang, Mandarahan, Rengas, Tulang, Rambutan Hutan, Durian Hutan, Empilung, Asam Kandis, Bayur, Pasang dan Putat. Di samping itu juga dijumpai pohon-pohon yang menjadi sumber pakan orangutan, antara lain: agathis, bangkirai, bayur, durian, jambu, jelutung, kenari, keranji, keruing, manggis hutan, medang, nyato, rambutan, petai, tengkawang, dan ulin.

HLSL memiliki keragaman hayati flora dan fauna yang tinggi, kerusakan HLSL akan berdampak pada terjadinya peningkatan emisi karbon secara significant. Untuk menjaga agar HLSL terhindar dari penurunan stok karbon atau peningkatan emisi karbon perlu dilakukan kegiatan membangun plot permanen pengukuran karbon HLSL untuk mengetahui status dan perubahan kandungan karbon HLSL.

1.2 Tujuan Kegiatan :

Tujuan kegiatan perhitungan stok karbon HLSL berdasarkan pedoman perhitungan karbon Litbang Kehutanan adalah untuk mengetahui status cadangan karbon di HLSL saat ini dan dapat digunakan sebagai bahan registrasi nasional ke Direktorat jenderal Pengendalian Perubahan Iklim oleh KPHP Berau Barat.

1.3 Cakupan Dokumen

Tujuan dari dokumen ini adalah untuk mendokumentasikan proses perencanaan, prosedur pelaksanaan hingga hasil dari kegiatan inventarisasi karbon hutan di HLSL berdasarkan pedoman perhitungan karbon Litbang Kehutanan . Sehingga diharapkan pada saat proses verifikasi, yang termasuk dalam sistem MRV (monitoring, reporting and verification) upaya penurunan emisi karbon, dokumen ini dapat dijadikan salah satu perangkat verifikasi (means of verification) terkait dengan data penghitungan cadangan karbon.

BAB 2. **Kondisi Umum HLSL**

2.1 Kondisi geografis

Hutan Lindung Sungai Lesan (HLSL) ditetapkan sebagai hutan lindung berdasarkan Surat Keputusan Menteri Kehutanan Nomor: SK. 3924/Menhut-VII/KUH/2014 tanggal 14 Mei 2014, dimana pada SK tersebut disebutkan adanya penetapan kawasan hutan pada kelompok hutan Muara Lasan seluas 13.565,58 ha yang terdiri dari: (1) Kawasan Hutan Lindung seluas 10.240,82 ha dan (2) Kawasan Hutan Produksi seluas 3.324,76 ha dimana secara geografis berada di posisi 01°32' 20,26" - 01°40'29,67" Lintang Utara dan antara 117° 03'58,19"-117°11'13,47" Bujur Timur sebagaimana disajikan pada Gambar

Gambar 2-1 Peta posisi Hutan Lindung Sungai Lesan di Kabupaten Berau, Provinsi Kalimantan Timur (Sumber: OWT, 2018)

2.2 Kondisi Biofisik

2.2.1 Iklim

Kondisi iklim di kawasan HLSL berdasarkan peta Curah Hujan KPHP Model Berau Barat tahun 2014, kawasan ini terbagi menjadi 2 yaitu dengan curah hujan dari 2000-2500 mm/ tahun dan curah hujan dari 2500-3000 mm/ tahun (Gambar 2.5) dan data curah hujan yang tercatat pada stasiun Kalimaru disajikan pada Tabel 2.1. sd 2.3 menunjukkan bahwa Kondisi curah hujan sepanjang tahun 2011-2017 menunjukkan bahwa puncak musim hujan terjadi pada bulan Mei, dan November – Januari, sedangkan curah hujan terendah terjadi pada Bulan Juli-Agustus. Suhu rata-rata berkisar 26-27°C, dengan suhu terendah berkisar 21-22 ^{o}C dan suhu tertinggi 34-37°C.

Data curah hujan di Binungan site Berau Coal dapat menunjukkan kondisi di sekitar kawasan HLSL pada tahun 2016-2018. Pada tahun 2016 total curah hujan 2080 mm/tahun dengan curah hujan dan hari hujan tertinggi pada bulan Oktober. Tahun 2017 total curah hujan 1905 mm/tahun dengan curah hujan dan hari hujan tertinggi pada bulan November, dan pada tahun 2018 total curah hujan 1871.6 mm/tahun dengan curah hujan tertinggi terjadi pada bulan Januari

Tabel 2-1 Jumlah Curah Hujan dan Hari HujanMenurut Bulan di Binungan site Berau Coal , 2016-2018

Bulan	Curah Hujan(mm)			Hari Hujan		
	2016	2017	2018	2016	2017	2018
Januari	215.8	182.5	279.5	20	24	27
Februari	143.3	224.9	204.0	20	19	21
Maret	120.5	202.4	202.4	9	22	23
April	26.7	134.7	226.5	11	17	28
Mei	186.5	83.7	129.0	17	17	21
Juni	106.8	199.5	112.7	19	19	19
Juli	86.8	124.3	142.0	12	16	22
Agustus	240.3	154.9	54.9	19	22	13
September	273.7	72.5	126.1	20	18	16
Oktober	274.9	154.8	117.5	23	17	22
November	121.3	231.2	77.6	15	24	24
Desember	283.4	139.6	199.4	22	19	25

Sumber: Berau Coal 2019

2.2.2 Sifat Kimia dan Fisik Tanah

Hasil studi diagnostik status kualitas ekosistem HLSL yang dilakukan OWT tahun 2014 di 3 cluster dengan penutupan lahan yang berbeda (Bagian Timur, Barat, dan Selatan HLSL) menunjukkan bahwa kesuburan tanah yang di HLSL tergolong rendah ditandai karakteristik kimianya yang minim unsur-unsur hara dengan kondisi pH tanah sangat masam (Tabel 2.2). Namun kondisi tanah ini masih dapat ditoleransi untuk pertumbuhan alami species lokal secara alami karena adanya siklus hara yang terjaga baik. Untuk sifat fisika tanah kondisinya terjaga baik oleh dukungan ketebalan seresah di lantai hutan sebagai pemasok bahan organik.

Tabel 2-2 Hasil analisis sifat kimia dan fisika tanah pada 3 cluster di HLSL

Karakter	Cluster 1 (Bagian Timur)	Cluster 2 (Bagian Selatan)	Cluster 3 (Bagian Barat)
Sifat Kimia Tanah			
pH H_2O	3,5 (sangat masam)	4,2 (sangat masam)	3,7 (sangat masam)

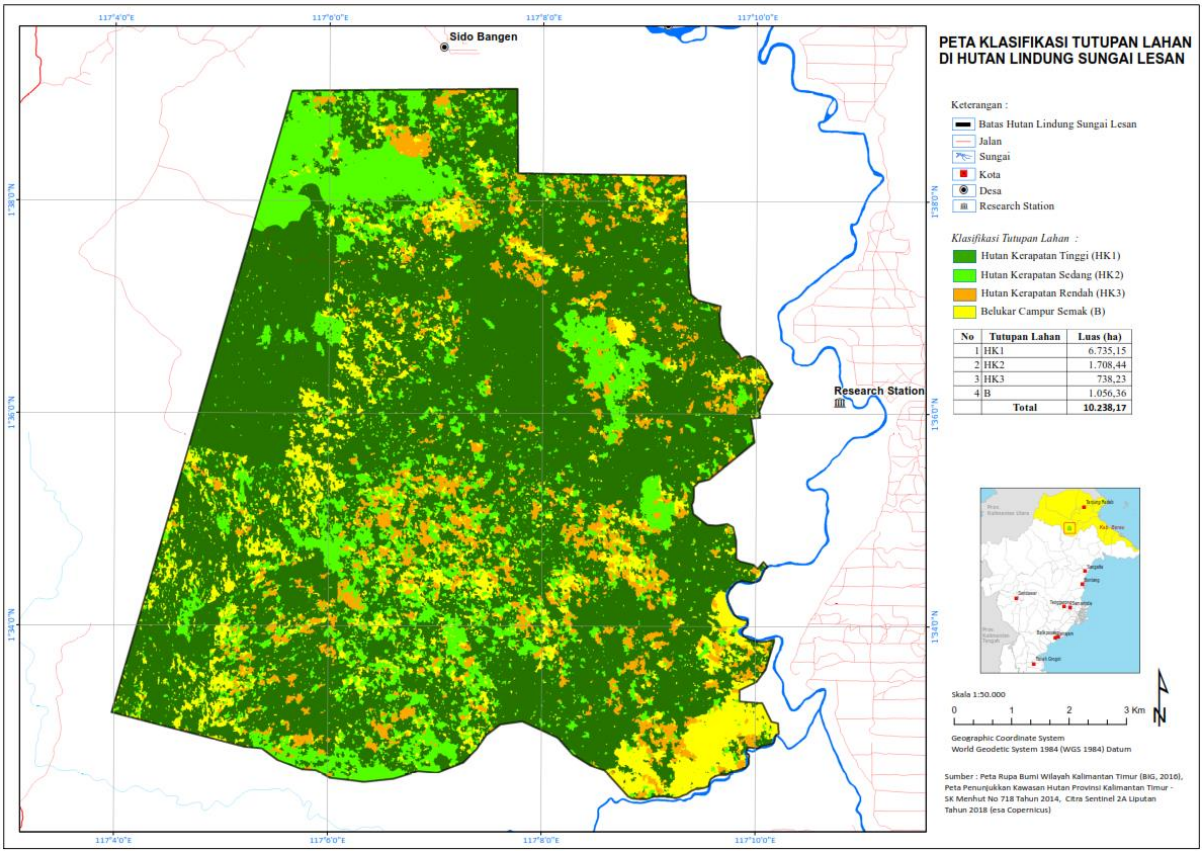
$C_{organik}$ (%)	2,3 (sedang)	0,9 (sangat rendah)	1,6 (rendah)
N_{total} (%)	0,2 (rendah)	0,04 (sangat rendah)	0,1 (rendah)
C/N	12,8 (sedang)	82,4 (sangat tinggi)	11,2 (sedang)
P_2O_5 (Bray)	4,0 (sangat rendah)	6,3 (rendah)	4,3 (sangat rendah)
K_2O (Morgan)	148,2 (sangat tinggi)	90,8 (sangat tinggi)	61,2 (sangat tinggi)
Ca (cmol/kg)	0,9 (sangat rendah)	1,0 (sangat rendah)	1,7 (sangat rendah)
Mg (cmol/kg)	0,5 (rendah)	0,5 (rendah)	1,0 (rendah)
K (cmol/kg)	0,3 (rendah)	0,2 (rendah)	0,1 (rendah)
Na (cmol/kg)	0,1 (rendah)	0,3 (rendah)	0,3 (rendah)
KTK (cmol/kg)	9,5 (rendah)	4,5 (sangat rendah)	10,0 (rendah)
Sifat Fisika Tanah			
Warna tanah	7.5YR 6/8	7.5YR 5/6	7.5YR 5/6
Struktur	Blocky	Granular	Subangular blocky
Ketebalan seresah (cm)	7	6	6
Tekstur:			
Pasir (%)	16,6	64,4	28,2
Debu (%)	21,6	14,4	29,2
Liat (%)	61,8	21,2	42,6
Kelas tekstur	Lempung berliat	Lempung liat berpasir	Lempung berliat
Kadar air (%)	30,4	16,4	32,4
Bulk Density (gr/cc)	0,7	1,0	0,8
Particle Density (gr/cc)	2,1	2,3	2,2
Pori (%)	66,2	58,0	62,5
pF1 (%)	48,8	35,0	52,3
pF2 (%)	41,0	26,4	42,6
pF2.54 (%)	34,0	19,9	37,1
pF4.2 (%)	19,3	5,4	19,0
Pori drainase cepat (%)	25,2	31,6	19,9
Pori drainase lambat (%)	7,0	6,5	5,5
Air tersedia (%)	14,7	14,4	18,1
Permeabilitas (cm/jam)	11,8	16,1	14,7

Sumber: OWT, 2014

2.2.3 Kondisi Tutupan Lahan

Berdasarkan analisis tutupan lahan yang pernah dilakukan oleh Ecositrop tahun 2013 menunjukkan bahwa ± 91% wilayah HLSL masih berupa tutupan hutan, dimana ± 25% berupa hutan sekunder, ± 66% berupa hutan sekunder tua/hutan primer, dan hanya ± 9% berupa semak dan belukar (Gambar 2.8). Sejak ditetapkannya sebagai kawasan hutan lindung hingga saat ini tutupan kawasan HLSL relatif lebih baik, hal ini sejalan dengan rendahnya ancaman, gangguan, dan kerusakan terhadap kawasan. Hal ini dikuatkan dengan hasil analisis *Global Forest Watch* yang menyatakan bahwa kawasan Hutan Lindung Sungai Lesan sepanjang kurun waktu tahun 2001-2017 hanya mengalami deforestasi sebesar ± 110 ha dari 10.240 ha total kawasan. Analisis berdasarkan mosaik data Spot 6/7 tahun 2013-2017 (Lapan) juga menunjukkan bahwa tutupan lahan HL Sungai Lesan relatif baik, dimana tidak ditemukan adanya bukaan lahan baru di lokasi tersebut.

Hasil analisis tutupan lahan tahun di kawasan HLSL 2018 seperti disajikan pada gambar 2.10. adalah sebagai berikut : Hutan dengan kerapatan tinggi seluas 6.735,15 Ha, Hutan kerapatan sedang seluas 1.708,44 Ha, Hutan Kerapatan rendah seluas 738,23 Ha dan Belukar campur semak semuas 1.056,36 Ha



Gambar 2-2 Analisis tutupan lahan di HL Sungai Lesan 2018

BAB 3. **Metodologi**

Acuan yang digunakan untuk pembangunan plot dan perhitungan stok karbon di HLSL berdasarkan pedoman litbang Kehutanan adalah **SNI 7724:2011** tentang Pengukuran dan penghitungan cadangan karbon –Pengukuran lapangan untuk penaksiran cadangan karbon hutan (ground based forest carbon accounting).

3.1 Stratifikasi dan Jumlah plot yang diukur

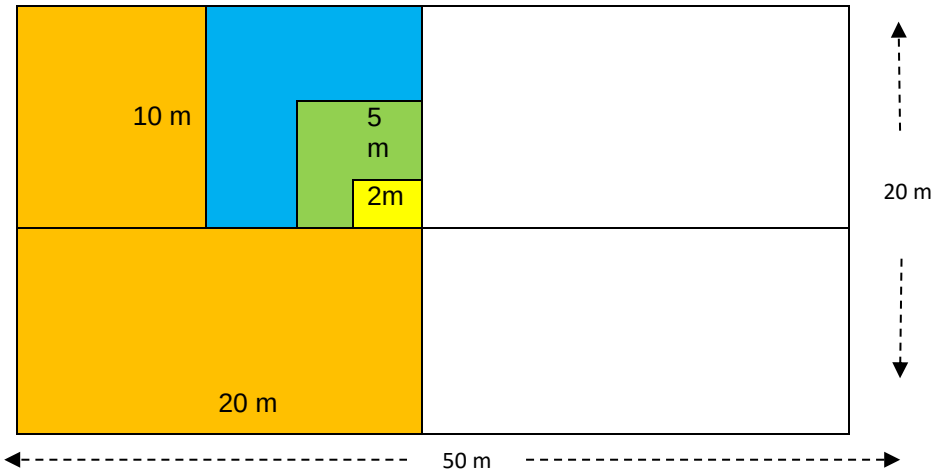
Stratifikasi di kawasan HLSL bertujuan mengelompokkan tapak berdasarkan peta tutupan lahan yang diperoleh dari intrepretasi citra satelit dengan resolusi paling rendah 30 m. Hasil stratifikasi kawasan HLSL dikelompokkan dalam 4 kelas kerapatan pohon yaitu (1) rapat, (2) sedang, (3) jarang dan (4) Belukar campur semak. Pada masing-masing kelas kerapatan dibuat 5 buah plot pengukuran karbon sebagai Pree assessment (pendugaan awal) untuk mengetahui apakah jumlah plot yang dibuat sudah mencukupi atau masih kurang. Jika jumlah plot masih kurang, maka harus dilakukan penambahan pembuatan plot kembali.

Jumlah plot yang akan diukur tergantung dari banyak faktor antara lain:

- Tingkat presisi yang diharapkan atau kesalahan sampling yang diperbolehkan (allowable sampling error)
- Luas areal yang akan disurvey
- Keragaman antar plot atau sub-populasi
- Jumlah strata yang akan diukur

3.2 Luas dan Bentuk Plot

Bentuk plot pengukuran karbon di HLSL berupa persegi panjang



Keterangan:

- Plot ukuran 20 m x 50 m : untuk pengukuran pohon berdiameter ≥ 30 cm
- Plot ukuran 20 m x 20 m : untuk pengukuran pohon berdiamater ≥ 20 cm
- Plot ukuran 10 m x 10 m : untuk pengukuran tiang berdiamater ≥ 10 cm dan < 20 cm
- Plot ukuran 5 m x 5 m : untuk pengukuran pancang tinggi > 1,5 cm, diameter < 10 cm

- Plot ukuran 2 m x 2 m: untuk pengukuran semai, tumbuhan bawah, dan serasah

Gambar 3-1 Pembuatan plot pengukuran karbonHLSL

3.3 Alat

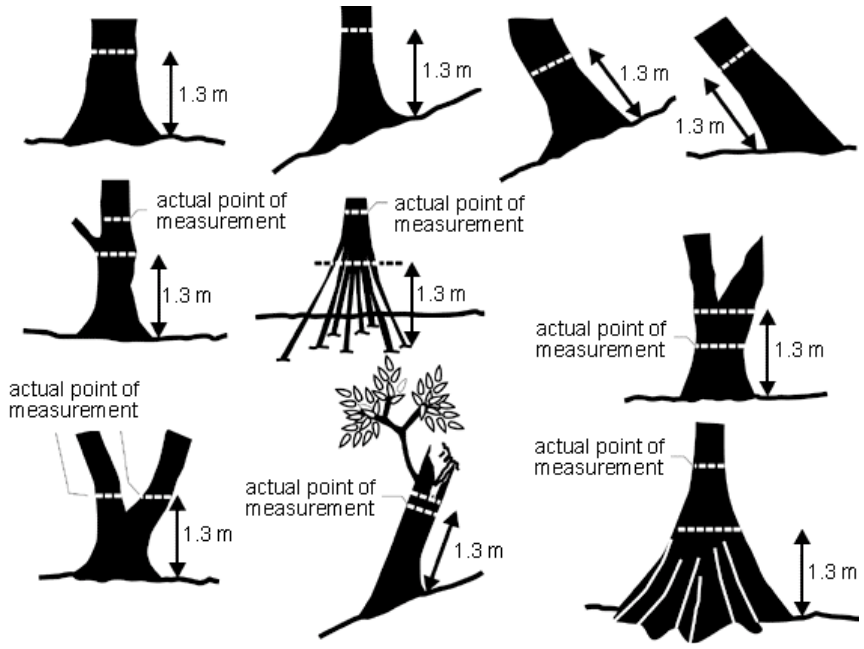
Peralatan yang digunakan dalam kegiatan pengukuran karbon adalah sebagai berikut:

- ✓ GPS
- ✓ Kompas
- ✓ Meteran (50 meter)
- ✓ Tali plastik
- ✓ Tali rafia
- ✓ Tongkat bambu/kayu ukuran 2,5 m
- ✓ Tongkat bambu/kayu ukuran 1,3 m
- ✓ Paralon ukuran 1 m
- ✓ Wadah contoh (plastik)
- ✓ Diameter tape
- ✓ Jangka sorong
- ✓ Parang
- ✓ Gunting tanaman
- ✓ Spidol
- ✓ Tallysheet/blangko pengamatan
- ✓ Timbangan
- ✓ Paralon ukuran 2 m x 2 m
- ✓ Ring tanah
- ✓ Pisau
- ✓ Sekop kecil
- ✓ Penggaris
- ✓ cangkul

3.4 Data yang Dikumpulkan dan Diukur

3.4.1 Pohon.

Data yang dikumpulkan adalah diameter pohon (cm) pada ketinggian 1.3 m. Pengukuran dilakukan pada tingkat pohon, tiang dan pancang. Pengukuran menggunakan jangka sorong untuk kelas pancang dan phiband untuk tiang dan pohon. Pada lokasi yang telah diukur kemudian ditandai dengan cat. Lokasi pengukuran diameter pada beberapa bentuk batang pohon dapat dilihat pada gambar 1-3.



Gambar 3-2 Lokasi pengukuran diameter pada beberapa bentuk batang pohon

Pada plot ukuran 20 m x 50 m diukur seluruh pohon dengan diameter ≥ 30 cm ; plot ukuran 20 m x 20 m untuk pengukuran pohon berdiamater 20-30 cm, plot ukuran 10 m x 10 m untuk pengukuran tiang dengan diameter ≥ 10 cm dan < 20 cm dan plot ukuran 5 m x 5 m untuk pengukuran pancang tinggi > 1,5 cm, diameter < 10 cm.

Gambar 3-3 Pengukuran DBH pohon untuk pohon berbanir

3.4.2 Tumbuhan bawah dan seresah.

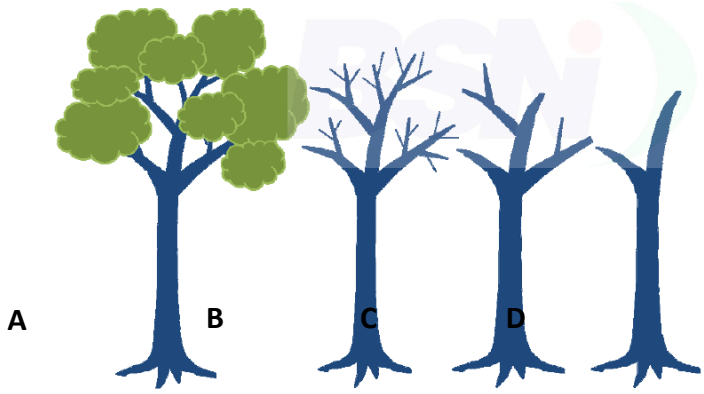
- ✓ Tumbuhan bawah dan seresah diukur pada plot ukuran 2m x 2 m. Data yang dikumpulkan adalah berat basah total (gram) dan berat basah sampel (gram) dan berat kering sampel (gram).
- ✓ Seluruh tumbuhan bawah maupun semai dalam areal plot pengukuran dipotong kemudian ditimbang berat basah total. Ambil contoh semai dan tumbuhan bawah sebanyak 300 gr,

masukkan kedalam plastik sampel dan diberi label identitas plot. Sampel kemudian dibawa kelaboratorium untuk dilakukan pengeringan oven dengan suhu 85ºC selama 24 jam dan ditimbang berat keringnya. Dapat dilakukan analisis kandungan karbon organik atau menggunakan nilai 0.47.

- ✓ Seluruh seresah dalam plot pengukuran dikumpulkan kemudian ditimbang berat basah total. Ambil contoh seresah sebanyak 300 gr masukkan kedalam plastik sampel dan diberi label identitas plot. Sampel kemudian dibawa kelaboratorium untuk dilakukan pengeringan oven dengan suhu 85ºC selama 24 jam dan ditimbang berat keringnya. Dapat dilakukan analisis kandungan karbon organik atau menggunakan nilai 0.47.

3.4.3 Pohon mati dan Kayu mati.

Pohon Mati masih tegak berdiri . Data yang dikumpulkan adalah diameter pohon mati (cm) pada ketinggian 1.3 m dan faktor koreksi berdasarkan tingkat keutuhan pohon mati. Faktor koreksi untuk tingkat keutuhan pohon mati dapat dilihat pada gambar 1-4.



Gambar 3-4 Tingkat keutuhan pohon mati

Keterangan:

A = pohon sehat (faktor koreksi = 1)

B = pohon mati tanpa daun (faktor koreksi = 0,9)

C = pohon mati tanpa daun dan ranting (faktor koreksi = 0,8)

D = pohon mati tanpa daun, ranting, dan cabang (factor koreksi = 0,7)

- ✓ Kayu Mati. Pengukuran kayu mati diameter < 10cm pada plot pengukuran 2 m x 2 m. sedangkan untuk diameter > 10 cm dilakukan pada plot pengukuran 5 m x 5 m, 10 m x 10 m, dan 20 m x 20m
- ✓ Kayu mati dapat diukur berdasarkan volume maupun penimbangan langsung.
- ✓ Data yang dikumpulkan untuk metode penimbangan langsung adalah berat total seluruh kayu mati (gram), berat basah sampel (minimal 300 gram) dan berat kering sampel (gram).
- ✓ Data yang dikumpulkan untuk metode pengukuran berdasarkan volume. adalah diameter pangkal (cm), diameter ujung (cm) dan panjang kayu mati (cm) dan tingkat pelapukan kayu mati. Jika hanya sebagian yang masuk dalam plot, maka ukur dan catat bagian yang masuk plot saja. Pada tiap tingkat pelapukan kayu mati diambil contoh kayu mati dengan potongan melingkar penuh batang selebar 2-3 cm. Simpan dalam amplop dan beri tanda (nomor plot, sub plot dan no batang) untuk dilakukan analisis berat jenis di laboratorium.

Gambar 3-5 Pengambilan dan penimbangan sampel seresah

3.4.4 Tanah

- ✓ Contoh tanah diambil dari 5 titik, yaitu pada keempat arah mata angin dan di tengah tengah plot untuk plot lingkaran atau pada keempat sudut plot dan di tengah-tengah plot untuk plot persegi panjang; Ambil sampel tanah dari masing-masing lapisan kedalaman tanah menggunakan ring sampel.
- ✓ Sampel diambil pada 4 kedalaman 0-5 cm, 5-10 cm, 10-20 cm dan 20-30 cm.
- ✓ Data yang dikumpulkan adalah hasil analisis laboratorium Bulk density (gr cm^{-2}) dan kandungan karbon organik (%).

Gambar 3-6 Pengambilan sampel tanah

3.5 Perhitungan Pendugaan Biomassa

3.5.1 Persamaan Alometrik untuk Pendugaan Biomassa Atas Pohon

Di kawasan HLSL, dapat digunakan persamaan alometrik Basuki 2009 untuk memperkirakan biomassa di atas tanah di hutan Dipterocarp dataran rendah tropis untuk spesies campuran (r^2 : 0.963) dengan menggunakan rumus ,

$$\ln(TAGB) = -1.201 + 2.196 \ln(DBH)$$

Keterangan :
TAGB : Biomassa atas permukaan atau biomassa pucuk (kg)
DBH : diameter setinggi dada (cm)

3.5.2 Pendugaan biomassa bawah pohon (akar)

- ✓ Pengukuran biomassa bawah pohon didekati dengan rumus nisbah akar pucuk. Nisbah Pucuk Akar adalah perbandingan biomassa atas pohon dengan bagian akar. Nilai Nisbah Pucuk Akar disajikan sebagai berikut:

Tabel Angka default nisbah pucuk akar

Tipe Hutan	Nisbah akar pucuk	Contoh lokasi
Hutan hujan tropis	0.37	Hutan campuran dipterokarpa di Kalimantan
Hutan yang menggugurkan daun	0.20 – 0.24	Hutan Jati di Jawa
Hutan daerah kering tropis	0.28 - 0.56	Hutan Savana di NTT
Semak tropis	0.40	Hutan Bekas kebakaran
Hutan penggunungan tropis	0.27(0.27-0.28)	Hutan wilayah dataran tinggi

Sumber data : SNI: 7724 dan IPCC 2006 Guidline for National Gas Inventories

- ✓ Setelah diperoleh biomassa pucuk , biomassa akar dapat dihitung menggunakan rumus

$$\mathbf{Bbp = NAP \times Bap}$$

Keterangan :
Bbp : adalah biomasa di bawah permukaan tanah (kg);
NAP: adalah nilai nisbah akar pucuk; untuk kawasan HLSL gunakan nilai 0.37
Bap :adalah nilai biomasa atas permukaan (kg)

3.5.3 Pendugaan Biomassa Pohon Mati

Pendugaan biomassa pohon mati yang masih tegak berdiri menggunakan persamaan alometrik Basuki 2009 seperti pendugaan biomassa pohon dilakukan dengan faktor koreksi tingkat keutuhan pohon mati.

$$\mathbf{\ln (TAGB) = -1.201 + 2.196 \ln (DBH)}$$

Keterangan :
TAGB : Biomassa atas permukaan atau biomassa pucuk (kg)

DBH : diameter setinggi dada (cm)

Biomassa pohon mati = TAGB x Faktor koreksi

3.5.4 Pendugaan Biomassa Serasah dan Tumbuhan Bawah

Biomassa seresah dan tumbuhan bawah diukur berdasarkan penimbangan langsung. Setelah diperoleh berat basah total , berat basah contoh dan berat kering contoh, biomassa dihitung menggunakan rumus

$$Total\ Berat\ Kering\ (g) = \frac{Berat\ Kering\ \ Contoh\ (g)}{Berat\ Basah\ \ Contoh\ (g)} x\ Total\ Berat\ Basah\ (g)$$

3.5.5 Pendugaan Biomassa Kayu Mati

Pendugaan biomassa kayu mati dapat dihitung berdasarkan volume ataupun penimbangan langsung. Setelah diperoleh data pengukuran diameter pangkal, diameter ujung dan panjang kayu mati Hitung Volume kayu mati menggunakan rumus :

$$Vkm = 0.25\ \pi \left(\frac{dp + du}{2x100}\right)^2\ x\ p$$

Keterangan :
V km = volume kayu mati (m3)
dp = diameter pangkal kayu mati (cm)
du = diameter ujung kayu mati (cm)
p = panjang kayu mati (m)
π = 22/7 atau 3,14

Kemudian hitung biomassa kayu mati menggunakan rumus:

Bkm=Vkm xBJkm

Keterangan :
Bkm = Biomassa kayu mati (kg)
Vkm = volume kayu mati (m^3)
BJkm = berat jenis kayu mati (kg/m^3)

3.6 Perhitungan Cadangan karbon

3.6.1 Perhitungan karbon dari biomassa.

Perhitungan cadangan karbon dari biomassa dapat dhitung menggunakan rumus

Cb = B x % C organik

Keterangan:
Cb: kandungan karbon dari biomassa (kg)
B : total biomass (kg)
% C organik : nilai persentase kandungan karbon, sebesar 0.47 atau menggunakan nilai persen karbon yang diperoleh dari pengukuran di laboratorium

3.6.2 Perhitungan cadangan karbon per hektar pada tiap plot

Perhitungan cadangan karbon per hektar pada tiap plot dapat dihitung menggunakan rumus
Keterangan:

$$\text{Cha} = \frac{\text{CP}}{1000}\ X\ \frac{10000}{L\ plot}$$

Cha : cadangan karbon per hektar pada masing-masing carbon pool pada tiap plot (ton/ha)
Cp : cadangan karbon pada masing-masing carbon pool pada tiap plot (kg)
L plot : luas plot pada masing-masing pool (m^2)

3.6.3 Perhitungan cadangan karbon organik tanah

✓ Perhitungan karbon organik tanah dapat dhitung menggunakan rumus

$$\mathbf{Ct = Kd\ x\ \rho\ x\ \%\ C\ organik}$$

Keterangan:
Ct : kandungan karbon tanah, dinyatakan dalam gram (g/cm2);
Kd : kedalaman contoh tanah, dinyatakan dalam sentimeter (cm)
ρ :kerapatan lindak (*bulk density*), dinyatakan dalam gram per meter kubik (g/cm3);
%C organik : nilai persentase kandungan karbon, sebesar 0,47 atau menggunakan nilai persen karbon yang diperoleh dari hasil pengukuran di laboratorium

✓ Perhitungan karbon tanah per hektar dapat dhitung menggunakan rumus

$$\mathbf{C\ tanah = Ct\ x\ 100}$$

Keterangan:
C tanah : kandungan karbon organik tanah per hektar, dinyatakan dalam ton per hektar (ton/ha);
Ct : kandungan karbon tanah, dinyatakan dalam gram (g/cm2);
100 : faktor konversi dari g/cm2 ke ton/ha.

BAB 4. **Hasil Pelaksanaan Kegiatan**

Kegiatan estimasi cadangan karbon di HLSL telah melalui serangkaian tahapan mulai dari pelatihan inventarisasi cadangan karbon, Pendugaan awal cadangan biomassa karbon untuk menentukan jumlah plot, pembuatan *Permanent Sampling Plot* (PSP) dan pengambilan data yang digunakan untuk menduga cadangan karbon di HLSL. Pembuatan PSP dan perhitungan stok karbon di HLSL berdasarkan pedoman litbang Kehutanan adalah mengacu pada SNI 7724:2011 tentang Pengukuran dan penghitungan cadangan karbon –Pengukuran lapangan untuk penaksiran cadangan karbon hutan (ground based forest carbon accounting).

PSP yang dibangun mewakili kelas tutupan lahan yang telah dipersiapkan sebelumnya (Gambar 2-2). Kegiatan survey dilakukan oleh staff lapangan OWT dan melibatkan masyarakat lokal. PSP yang telah dibuat sebanyak 34 dengan luas 0.1 Ha, yaitu 13 PSP pada kelas tutupan vegetasi rapat, 15 PSP untuk kelas tutupan vegetasi sedang, 3 PSP pada kelas tutupan vegetasi ringan dan 3 PSP untuk kelas tutupan semak dan belukar.

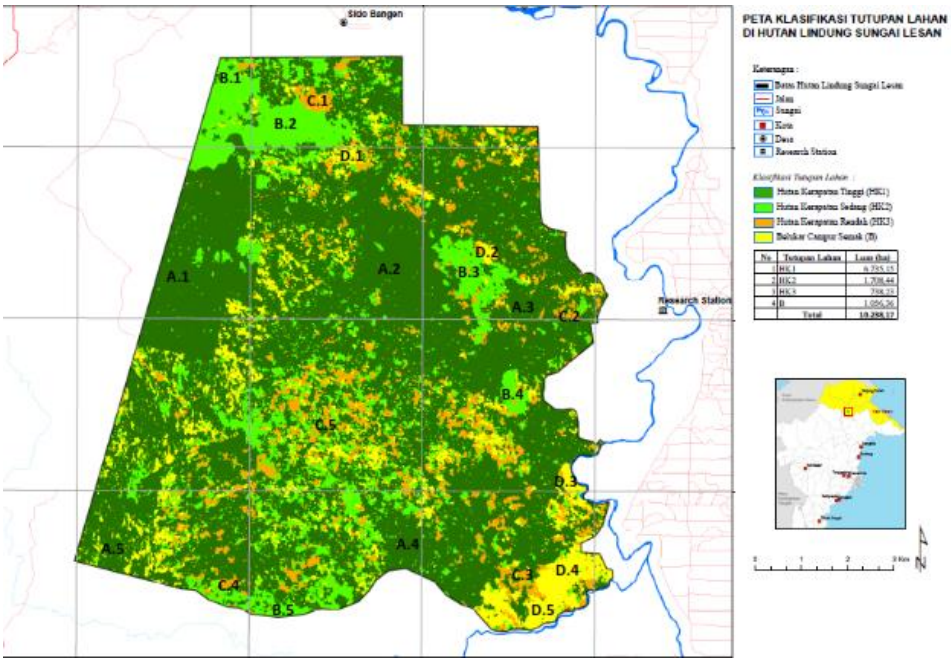
4.1 Pelatihan Inventarisasi Cadangan Karbon

Kegiatan pelatihan inventarisasi Karbon Hutan berupa teori dan praktek telah dilaksanakan pada 11-12 Desember 2018. Peserta yang dilibatkan sebanyak 15 Orang yang berasal dari KSM Nemdoh Nemkay, Makmur Jaya II, staff KPHP Berau Barat.

Dalam kegiatan pelatihan peserta diberikan materi berupa teori tentang karbon, cara pengambilan data karbon di 5 karbon pool dan cara pengolahan data karbon. Kegiatan praktek diisi dengan materi pembuatan plot dan pengambilan data karbon di 5 karbon pool di HLSL dengan tutupan vegetasi sedang yang lokasinya paling dekat dengan persemaian Kampung Sidobangen.

4.2 Preassesment (Pendugaan awal cadangan biomassa karbon untuk menentukan jumlah plot)

Pengambilan data pendahuluan (preassessment) potensi cadangan karbon untuk menentukan jumlah plot minimal yang harus dibangun dilaksanakan pada Januari 2019. Kegiatan ini dilakukan bersama dengan KSM Nemdoh Nemkay. Hasil stratifikasi atau pengelompokan berdasarkan kelas tutupan vegetasi dengan menggunakan citra satelit, di HLSL terdapat 4 kelas tutupan lahan yaitu Rapat seluas 6,735.15 Ha, sedang seluas 1,708.44 Ha , ringan seluas 738.23 Ha dan belukar campur semak seluas 1,056.36 Ha. Dari setiap kelas tutupan vegetasi, direncanakan dibangun masing-masing 5 plot pendahuluan dengan luasan 0.1 Ha, sehingga total direncanakan dibangun 20 plot. Dalam pelaksanaannya dari target 20 plot sampling telah diselesaikan sebanyak 14 plot yaitu 5 plot pada kelas tutupan rapat, 3 plot pada kelas tutupan sedang, 3 plot pada kelas tutupan ringan dan 3 plot pada belukar campur semak. Sebaran kelas tutupan lahan dan penempatan masing-masing plot dapat dilihat pada gambar 1-5.



Gambar 4-1 Penempatan plot pengukuran cadangan karbon untuk preassesment

Gambar 4-2 Kondisi tutupan lahan A : Rapat, B: Sedang, C: Ringan, D: Belukar campur semak

Komposisi tegakan pada masing-masing kelas tutupan lahan dapat dilihat pada tabel 4-1.

Tabel 4-1Komposisi tegakan (jumlah populasi pancang, tiang dan pohon) tiap ha

Kelas	Jumlah/ ha

	Rapat	Sedang	Ringan	Belukar campur semak
Pancang H> 1.5 m, DBH < 10 cm	7,200	6,667	6,533	10,400
Tiang DBH:10-20 cm	400	633	700	525
Pohon DBH 20-30 cm	115	142	83	63
Pohon DBH > 30 cm	110	70	63	43

Hasil perhitungan cadangan karbon dari biomassa atas pohon yang diperoleh dari dapat dilihat pada tabe plot pendahuluan yang telah dibangun dapat dilihat pada tabel 4-2 berikut

Tabel 4-2 Cadangan Karbon dari Biomassa Atas Pohon

Tutupan Lahan	Plot	Biomassa Atas Pohon (Ton/ Ha)	Cadangan C dari Bap (Ton/Ha)	Rata-rata Cadangan C (Ton/Ha)	Standar deviasi rata-rata cadangan C (ton/Ha)
Rapat (A)	2	347.16	163.17	165.33	81.19
	3	334.63	157.28		
	4	136.37	64.09		
	5	321.09	150.91		
	6	619.54	291.18		
Sedang (B)	3	231.25	108.69	108.63	17.50
	1	268.30	126.10		
	5	193.84	91.10		
Ringan (C)	2	293.30	137.85	112.19	23.11
	3	197.89	93.01		
	4	224.91	105.71		
Belukar Campur semak (D)	2	33.38	15.69	88.31	78.96
	4	336.73	172.36		
	5	163.6	76.89		

Nilai rata-rata dan standar deviasi cadangan karbon dari Biomassa atas pohon kemudian digunakan untuk menghitung jumlah plot karbon minimal yang perlu dibangun menggunakan kalkulator winrock dengan toleransi kesalahan (sampling eror) 20%. Hasilnya jumlah plot untuk pengukuran karbon yang harus dibangun di HLSL adalah sebanyak 25 PSP dengan rincian 19 plot untuk kerapatan tinggi, 2 plot untuk kerapatan sedang,1 plot untuk kerapatan ringan dan 3 plot untuk belukar campur semak.

4.3 Hasil Pengukuran Karbon pada 34 Plot Permanen di HLSL

Sesuai dengan hasil preassesment cadangan karbon di HLSL maka 20 PSP dibuat pada kelas tutupan vegetasi rapat dan sedang untuk memenuhi jumlah PSP yang harus dibangun di HLSL. Total PSP untuk pengukuran cadangan karbon yang telah dibuat sampai dengan akhir

kegiatan sebanyak 34 PSP, yaitu 13 PSP pada kelas tutupan vegetasi rapat, 15 PSP untuk kelas tutupan vegetasi sedang, 3 PSP pada kelas tutupan vegetasi ringan dan 3 PSP untuk kelas tutupan semak dan belukar. Pada 20 PSP lanjutan tersebut dari 5 karbon pool, pengukuran yang dilakukan disetiap plot hanya AGB sedangkan untuk karbon pool yang lain hanya dilakukan pengukuran pada 1 plot sehingga nilainya merujuk pada pengukuran di 14 PSP yang dibangun sebelumnya.

Dalam pendugaan ABG (biomassa atas pohon) perhitungan dilakukan dengan menggunakan persamaan Basuki et al (2009) dengan parameter tunggal yaitu diameter setinggi dada (DBH-Diameter Breast Height). Pendugaan biomassa bawah pohon didekati dengan rumus nisbah akar pucuk dengan nilai default 0.37. Nilai default Carbon Fraction (CF) yang digunakan adalah 0,47. Berdasarkan proses penghitungan, diketahui bahwa estimasi cadangan karbon dari biomassa di HLSL untuk kerapatan tinggi adalah 212.75 tonC/Ha, kerapatan sedang 128.34 tonC/Ha, kerapatan rendah 153.70 tonC/Ha dan Belukar campur semak 120.99 tonC/Ha.

Estimasi cadangan karbon dari 5 karbon pool di HLSL dengan kerapatan tinggi adalah 250.87 ton C/Ha, kerapatan sedang 172.03 ton C/Ha, kerapatan rendah 178.76 ton C/Ha dan Belukar campur semak 171.39 ton C/ Ha. Pendugaan total stok karbon di wilayah HLSL pada 5 carbon pool dilakukan dengan mengalikan luasan masing-masing kelas tutupan lahan (strata) dengan densitas karbon masing-masing strata. Melalui perhitungan ini, diperoleh hasil bahwa stok karbon sebesar 2,296,558.53 ton C atau CO2 equivalen sebesar 8,420,714.61. Cadangan karbon yang terbesar yaitu 1,698,635. 30 ton C tersimpan pada kerapatan tinggi, setara dengan 73.5 7% dari total cadangan karbon di HLSL. Informasi lebih detail mengenai cadangan karbon di wilayah HLSL tersaji dalam Tabel 4-4.

Tabel 4-3 Cadangan karbon dari 5 karbon pool di HLSL tahun 2019

Kelas Tutupan Lahan	Rapat	Sedang	Ringan	Belukar Campur Semak
Cadangan karbon dari Biomassa atas Pohon (Ton)/Ha	155.53	93.98	112.40	88.39
Cadangan karbon dari Biomassa Bawah	57.54	34.77	41.59	32.71

Permukaan Pohon (Ton)/Ha				
Cadangan karbon dari Seresah (Ton)/Ha	0.98	0.91	1.09	0.76
Cadangan karbon dari nekromass	22.53	19.66	7.26	38.14
Cadangan Karbon dari Tanah (Ton)/Ha	14.29	22.71	16.42	11.40
Total Cadangan Karbon dari 5 carbon pool (Ton)/Ha	250.87	172.03	178.76	171.39
Luas yang diwakili (Ha)	6,735.15	1,708.44	738.23	1,056.36
Total cadangan karbon dari 5 karbon pool/ tutupan lahan (Ton)	1,698,635.30	293,905.59	131,965.86	181,051.78
Cadangan karbon HLSL (Ton)	**2,296,558.53**			
CO2 Equivalen (Ton)	**8,420,714.61**			

BAB 5. **Kesimpulan**

1) Pre-assesment cadangan karbon di HLSL telah dilakukan pada plot yang tersebar di 4 kelas tutupan lahan. Stratifikasi penutupan lahan dilakukan menggunakan citra satelitdengan distribusi luas masing-masing kelas tutupan lahan yaitu rapat seluas 6,735.15 Ha, sedang seluas 1,708.44 Ha, ringan seluas 738.23 Ha dan belukar campur semak seluas 1,056.36 Ha.
2) Dari hasil preassesment cadangan karbon di HLSL tersebut berdasarkan data rata-rata dan standar deviasi cadangan karbon dari biomassa atas pohon, dengan menggunakan *sampling eror* 20 % maka jumlah plot karbon minimal yang perlu dibangun di HLSL adalah sebanyak 25 plot seluas 0.1 Ha dengan rincian pada kelas tutupan rapat adalah 19 plot, sedang 2 plot, ringan 1 plot dan belukar campur semak sebanyak 3 plot dengan luas masing-masing plot 0.1 Ha.
3) Estimasi cadangan karbon dari biomassa di HLSL untuk kerapatan tinggi adalah 212.75 tonC/Ha, kerapatan sedang 128.34 tonC/Ha, kerapatan rendah 153.70 tonC/Ha dan Belukar campur semak 120.99 tonC/Ha.
4) Estimasi cadangan karbon dari 5 karbon pool di HLSL dengan kerapatan tinggi adalah 250.87 ton C/Ha, kerapatan sedang 172.03 ton C/Ha, kerapatan rendah 178.76 ton C/Ha dan Belukar campur semak 171.39 ton C/ Ha.
5) Estimasi total Cadangan karbon HLSL pada tahun 2019 yang dilakukan pada 34 PSP yang dibuat di HLSL adalah sebesar 2,296,558.53 ton C atau CO_2 equivalen sebesar 8,420,714.61.

Lampiran 1 Data Pengukuran di Lapangan

1) Tally sheet data lapangan untuk pengukuran DBH pancang, tiang dan pohon
2) Tally sheet data lapangan untuk pengukuran DBH pohon mati
3) Tally sheet data lapangan untuk pengukuran Semai
4) Tally sheet data lapangan untuk pengukuran kayu mati pengukuran berdasarkan volume
5) Tally sheet data lapangan untuk pengukuran kayu mati pengukuran berdasarkan penimbangan langsung
6) Tally sheet data lapangan untuk pengukuran Seresah
7) Tally sheet data lapangan untuk pengukuran tanah

Data selengkapnya dapat dilihat pada pada file berikut :

Lampiran 1. Data Pengukuran.xlsx

Lampiran 2 Hasil analisis laboratorium analisa seresah, semai dan tanah

LABORATORIUM DEPARTEMEN ILMU TANAH DAN SUMBERDAYA LAHAN
FAKULTAS PERTANIAN INSTITUT PERTANIAN BOGOR
Jl. MERANTI, KAMPUS IPB DARMAGA BOGOR 16680, Telp./Fax. (0251) 8627792

LAPORAN HASIL PENGUJIAN
No.022/LHP/Lab DITSL/I/2019

NAMA PENGIRIM : Operasi Wallace Terpadu
ALAMAT PENGIRIM : Jl. Akasia Raya Blok P3 No.14
TANGGAL KIRIM : 14 Januari 2019
TANGGAL SELESAI : 28 Januari 2019

LOKASI SAMPEL : HLSL Kalimantan
JUMLAH SAMPEL : 4 (Empat)
JENIS SAMPEL : Tanaman

No. Lab	No. Lapang	Gravimetri	Berat Kering
		C-org	
		..(%)..	...(g)...
AD 0348	Semai	50.92	72.13
AD 0349	Serasah (Daun)	48.95	88.87
AD 0350	Serasah (Batang)	32.83	85.94
AD 0351	Sampel kayu lapuk ringan	55.43	61.30
AD 0352	Sampel kayu lapuk berat	40.96	84.57

Bogor, 28 Januari 2019
Koordinator Laboratorium
Departemen Ilmu Tanah dan Sumberdaya Lahan
Fakultas Pertanian IPB

LABORATORIUM
Departemen Tanah
Fakultas Pertanian
Institut Pertanian Bogor

Dr Ir Arief Hartono, M.Sc.agr.

Catatan :
1. Hasil pengujian hanya berlaku untuk sampel yang diuji

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FAKULTAS PERTANIAN INSTITUT PERTANIAN BOGOR
Jl. MERANTI, KAMPUS IPB DARMAGA BOGOR 16680, Telp./Fax. (0251) 8627792

NAMA PENGIRIM : Operasi Wallace Terpadu
ALAMAT PENGIRIM :
LOKASI SAMPEL : HLSL (Kalimantan)
TANGGAL KIRIM : 14 Januari 2019

HASIL ANALISIS SIFAT FISIK TANAH

No Lab	No	Lokasi	Kedalaman (cm)	Bulkdensity (g/cm^3)	Keterangan
LF. 0011	1	B.I	0 - 5	1.02	
LF. 0012	2	B.I	5 - 10	0.99	
LF. 0013	3	B.I	10 - 20	1.12	
LF. 0014	4	B.I	20 - 30	1.01	

Bogor, 22 Januari 2019
Koordinator Laboratorium
Departemen Ilmu Tanah dan Sumberdaya Lahan
Fakultas Pertanian IPB

LABORATORIUM
Departemen Tanah
Fakultas Pertanian
Institut Pertanian Bogor

Dr Ir Arief Hartono, M.Sc.agr.

Halaman 1/1

LABORATORIUM DEPARTEMEN ILMU TANAH DAN SUMBERDAYA LAHAN
FAKULTAS PERTANIAN - INSTITUT PERTANIAN BOGOR
Jl. MERANTI, KAMPUS IPB DARMAGA BOGOR 16680, Telp./ Fax. (0251) 8627792
No. Hp : 085714459811, E-mail: labtanahipb@gmail.com

KAN
Komite Akreditasi Nasional
LP-067-IDN

LAPORAN HASIL PENGUJIAN
No.021/LHP/Lab DITSUM/2019

NAMA PENGIRIM : Operasi Wallace Terpadu
ALAMAT PENGIRIM : Jl. Akasia Raya Blok P3 No.14
TANGGAL KIRIM : 14 Januari 2019
TANGGAL SELESAI : 11 Februari 2019

LOKASI SAMPEL : HLSL Kalimantan
JUMLAH SAMPEL : 4 (Empat)
JENIS SAMPEL : Tanah

No. Lab	No. Lapang	Walkley & Black	Gravimetri
		C-org	Kadar Air
		..(%)..	...(%)...
AD 0344	Tanah kedalama 0-5 cm	1.61	2.33
AD 0345	Tanah kedalaman 5-10 cm	1.12	2.18
AD 0346	Tanah kedalaman 10-20 cm	0.45	2.19
AD 0347	Tanah kedalaman 20-30 cm	0.48	2.14

Bogor, 11 Februari 2019
Koordinator Laboratorium
Departemen Ilmu Tanah dan Sumberdaya Lahan
Fakultas Pertanian IPB

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Institut Pertanian Bogor

Dr Ir Arief Hartono, M.Sc.agr.

Catatan :
1. Hasil pengujian hanya berlaku untuk sampel yang diuji

Appendix B – Mammals of Lesan Protection Forest Species Accounts

Prepared by Prof. Graham Forbes

Moonrat (*Echinosorex gymnurus*). (EWAU-EMLUUK). Recorded as single or paired animals every few days since week 1. Animals were often foraging in creek, and along bank of creek at beginning of Transect A. Also recorded at the pig wallow on Transect C in week 3, and along a dry ridge (Pangolin Ridge) in week 5. Location: Likely throughout.

Moonrat at Transect C pig wallow, June 30 2019.

Hose's Pygmy Shrew (*Suncus hosei*). Single live shrew ('a few centimetres-long body') capture July 12 in herpetofauna survey pitfall on transect C. Photographed and released. Location; transect C.

Hose's Pygmy Shrew, captured in pitfall trap, July 12, 2019 (photo by Scott Macor).

Bornean Shrew (*Crocidura foetida*). Single juvenile male captured June 25 in herpetofauna survey pitfall bucket; dead. Transect B. Single animal (not measured, but quite large) caught in pitfall bucket and released during herpetofauna survey on Transect C July 17. Location: Uncertain, but likely widespread.

Bornean Shrew caught in pitfall trap, June 24, 2019 (photo by Graham Forbes).

Note: all squirrels and treeshrews (except red-tailed treeshrew [EMGAS] and pygmy squirrels [LIANG-KENG] are called LIANG by local Dayak.

Bornean Pygmy Squirrel (*Exilisciurus exilis*) [LIANG-KENG). Visual records of single animals recorded in week 1 and 2: Location: Transect A, near the first creek crossing.

Bornean Pygmy Squirrel were recorded several times along Transect A (photo by Nick Hart).

Black-eared Pygmy Squirrel (*Nannoscirus melanotis*) (LIANG-KENG). Visual records of single

Animals recorded in week 1 and 2: Location: Transect A, near the first creek crossing and across the river, opposite camp.

Low's Squirrel (*Sundasciurus lowi*). Single individual sighted by Matt Slaymaker on June 20. Location: Highway, near camp.

Plantain Squirrel (*Callosciuris notatus*). Individuals recorded several times along the Highway, likely widespread.

Plantain Squirrel June 16, 2019 (photo by Nick Hart).

Prevost's Squirrel (*Callosciurus prevostii*). Recorded by sight on June 30 and July 2, July 5 on Highway, July 19 on river. Local specimens were dark brown with red underbelly and white stripe on side. Location: Throughout.

Prevost's Squirrel were most often recorded along transect A (photo by Nick Hart).

Tufted Ground Squirrel (*Rheithrosciurus macrotis*). Single animals on camera trap along creeks on July 6 (creek above cabin 2) and 8 (Transect D). Note: considered very rare in east Kalimantan.

Tufted Ground Squirrel at creek above 2nd ponduk, July 6, 2019.

Giant Squirrel (*Ratufa affinis*). Single sighted by Nick Hart along Highway July 17; very large, white bellied squirrel with long tail that had obvious clump at end.

Red Giant Flying Squirrel (*Petaurista petaurista*). Separate animals sighted on July 17 evening at 2nd cabin (Matt Slaymaker), and closer to camp along Highway (Graham Forbes/Nick Hart).

Malayan Porcupine (*Hystrix brachyura*) (TEHTONG). Recorded June 27 by sight along Highway, around 8pm, and on camera trap on June 28, near second hut (video of porcupine accidentally deleted). Location: Highway before 2nd ponduk.

Bornean Porcupine (*Thecarus crassispinis*). Recorded on camera trap at highway on right arm past 2nd ponduk on evening July 13.

Bornean Porcupine (lower right) recorded on trail to tower, July 13, 2019.

Long-tailed Porcupine (*Trichys fasciculata*). Single record on camera trap on June 18, along transect A. Location: Transect A, near first creek crossing.

Long-tailed Porcupine (note tuft at end of tail) recorded on Transect A, June 17, 2019

Grey Tree Rat (*Lemothrix canus*). Single sighted by Melinda Laidlaw in camp, evening of July 15; large rat with large amount of distinctive white on end of tail (Note: Dr. Laidlaw readily familiar with similar species in Australia). (Note: considered rare in Borneo).

Whitehead's Maxomys (*Maxomys whiteheadi*). A single animal was tentatively recorded on a rice pile at a trail camera near camp. The size, colour, and purported relative abundance (Philipps and Phillipps 2018) suggests this species; future surveys should focus on the capture of rodents.

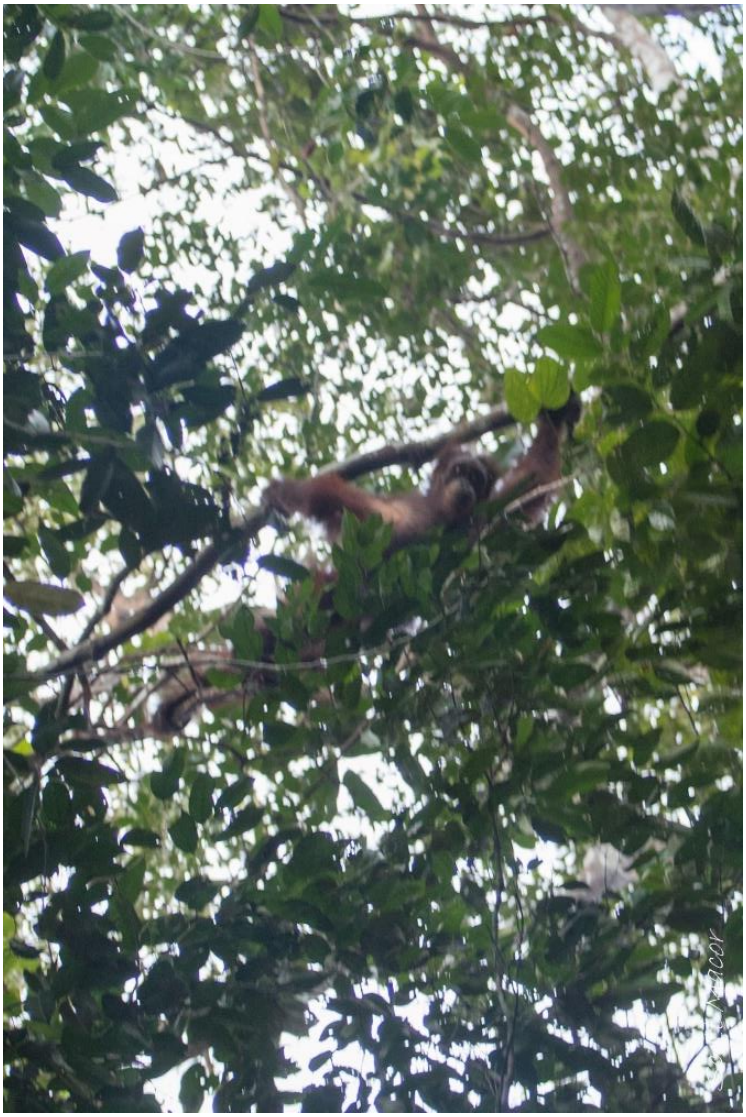
Probable record of Whitehead's Maxomys at camera baited with cooked rice, June 2019 (note: camera date on image is incorrect).

Splendid Treeshrew (*Tupaia splendiduda*). (EMGAS). Single visual of a large tree shrew by Nick Hart on July 2. Tail; long, bushy and red for most of its length. Large body, plain brown with white shoulder strip and partial spectacle – no back black stripe apparent. Only species that fits description is Splendid Treeshrew. Location: Transect A, near entrance to camp.

Colugo (*Galeopterus borneanus*) (KWUNG). Single animals (large glider, no tail) sighted on June 13 and 22, gliding across Lesan River, downstream of camp, likely disturbed by loud boats approaching. One female recorded in camp evening of July 15, another (gender unknown) recorded along highway on July 17.

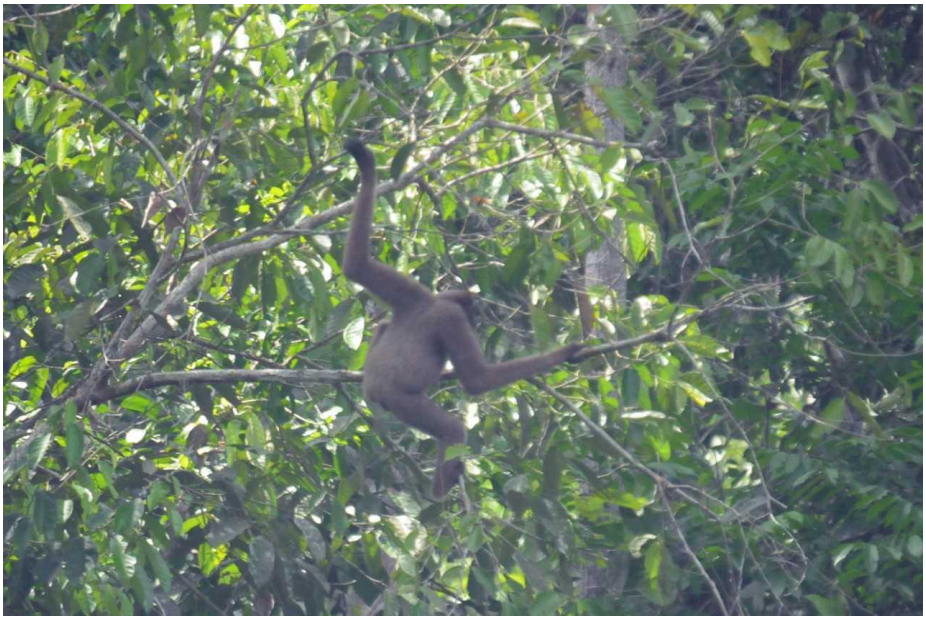
Female colugo recorded July 15, 2019 at camp (photo by Scott Macor).

Orangutan (*Pongo pygmaeus*) (KEHJEW). Old nests throughout, with new nests, sounds, and odour recorded on Transect A and B from week 3 onwards. Individuals recorded separately on July 11-16 along highway and near tower, with quality sightings of 8-year old male (identified by dark colour by Centre for Orangutan Protection [COP] for an animal that had been released in April); a large male with flanges on Transect D; and a female with subadult on the Highway. Location: Throughout.



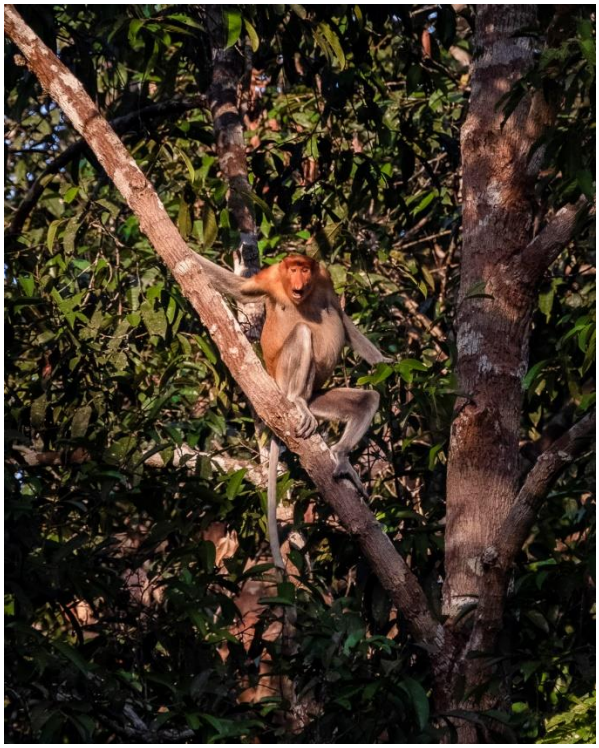
Adult male orangutan recorded July 14, 2019 on Transect D (photo by Scott Macor).

North Bornean Gibbon (*Hylobates funereus*) (KELWAT). Recorded near daily calling in morning in forest opposite camp since week 1, and on all transects. Visuals on most transects weekly. Location: Throughout.



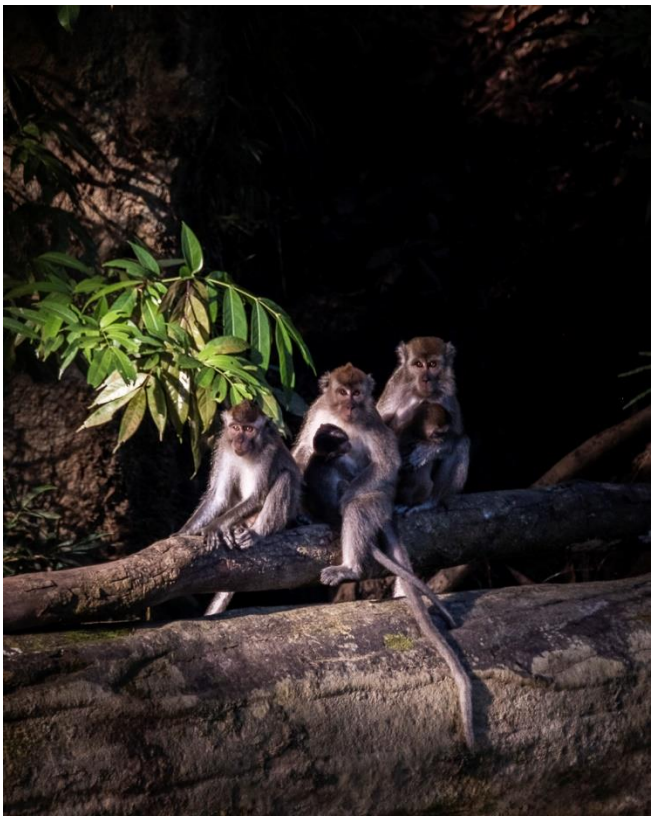
North Bornean Gibbon recorded in the buffer forest opposite camp, July 2019 (photo by Nick Hart).

Proboscis Monkey (*Nasalis narvatus*) (BEKLA). Recorded along river bank during boat trips, but also along Transect A and Highway from week 1 onwards. Location: Throughout.



Proboscis Monkey (adult male) sighted along river, opposite camp, July 5, 2019 (photo by Jack Hague).

Long-tailed Macaque (*Macaca fascicularis*) (EKJIL). Recorded near daily on river bank/forest opposite camp since week 1, and on Highway. The number of troops in the vicinity is unknown; 1 troop was often seen in the buffer forest opposite camp, and another in the Highway area on the camp side but it is uncertain if they cross the river. The river likely is too wide for leaping along the canopy (narrowest distance was >15m tree to tree), but Samuel notes that they have been seen in the river and exposed rocks almost connect both sides during low water levels. Location: Throughout.



A troop of approximately 15 Long-tailed Macaque would drink at water's edge opposite camp, at least weekly (photo by Jack Hague).

Pig-tailed Macaque (*Macaca nemestrina*) (YOK). Troops recorded on Transect A in week 2 and individuals on camera throughout from week 2 onwards at many locations. Location: Throughout.

A lone male Pig-tailed Macaque (shown here) was frequently sighted along the Highway, but troops also recorded throughout.

Red Langur (*Presbytis rubicunda*). (UHIS for *P.r. rubicunda*). Several recorded on June 19 by Nick Hart across the river, and well above a troop of Long-tailed Macaques. Four recorded July 12 opposite camp; singles sighted on Transect B., and Highway in week 4,5. Single recorded on trail camera at Pangolin Ridge. Location: Throughout.

Red Langur recorded on camera trap on ground July 17, 2019.

Silvered Langur (*Trachypithecus cristatus*) (KELSSAI). Three recorded near Long-tailed Macaques on July 3, along river bank trees across from camp. Location: Opposite camp along river.

Silvered Langurs were recorded once, near a troop of Long-tailed Macaques, on July 3 (photo by Nick Hart).

Banded Linsang (*Prionodon linsang*). A single record of an animal July 14 on Transect A camera trap (baited with soap bar). Location: Uncertain, but likely widespread.

Banded Linsang (top left) along creek of Transect A, July 14, 2019.

Banded Civet (*Hemigalus derbyanus*) (TONG-KLANG). Recorded by sight/camera phone in week 1, 3, 5 at Transect A, near the first creek, and creek above 2nd ponduk in week 5, and on camera on Pangolin Ridge (waterfall trail). The animal on Transect A was generally unconcerned by presence of people, 5-10 m away. Location: Throughout.

Banded Civet recorded at Pangolin Ridge July 16, 2019.

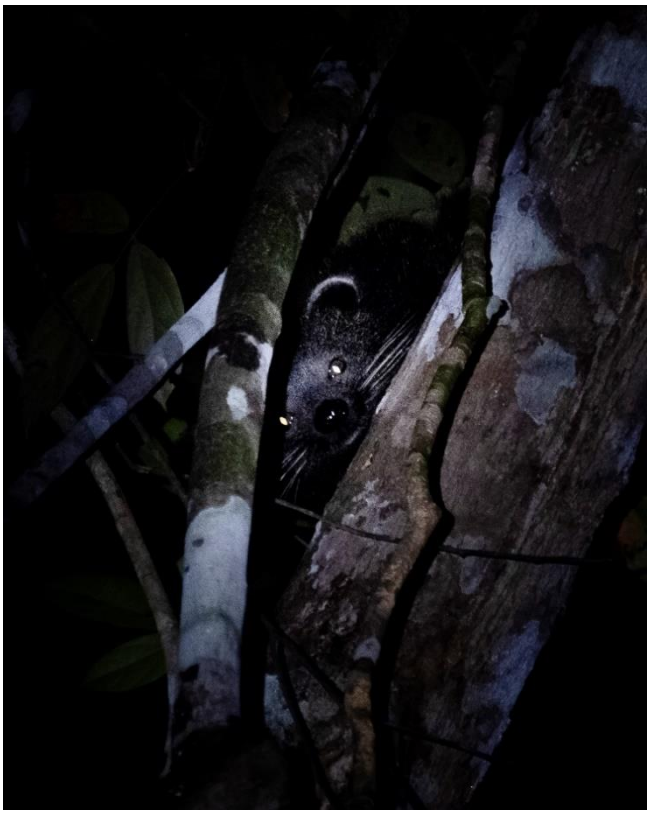
Malay Civet (*Viverra tangalunga*) (SNUL). Recorded weekly on camera traps along transect A and B; both traps had been baited with sardines, and recorded along Highway by sight and trail cameras to the 2nd ponduk. Location: Throughout.

Malay Civet were recorded on numerous cameras; this animal on the creek at Transect B, July 6, 2019.

Masked Palm Civet (*Paguma larvata*) (TIN). Recorded on Highway near camp on July 7, and again July 14 on Transect A near first creek crossing. Location: Highway, Transect A.

Masked Palm Civet on Transect A July 14 (the white-tipped tailed is hidden in this photo) (phot by Nick Hart).

Binturong (*Arctictis binturong*) (TIN). First record on June 28 of single animal sighted in fruiting tree. Team was away until June 30, then recorded again in same area on June 30, July 1. Location: Highway, about halfway to first hut. Note: rare in Borneo.



A Binturong was recorded along the Highway in an area of heavily fruiting trees for a 1-week period (photo by Jack Hague).

Otter Civet (*Cynogale bennettii*). Single animals on camera on June 30, July 14. Single animal along bank of first creek crossing of Transect B, spray marked a tree and moved off; did not inspect sardine bait. Single animal along creek at 2nd crossing of Transect A – which is < 1km from the same creek at Transect B and we suspect it is the same individual in both locations. Location: Note: scarce in Borneo.

Otter Civet were recorded on the same creek on 2 separate dates, early July 2019.

Collared Mongoose (*Urva semitorquata*). Two records of animal on same camera trap on June 30 and July 2, travelling along creek edge, as well as 2 animals together on creek above 2nd ponduk. Location: Throughout.

Two Collared Mongoose along creek above the 2nd ponduk, July 3, 2019.

Leopard Cat (*Prionailurus bengalensis*) (KLIH-UT). Single animal, likely juvenile on camera trap along Highway (July 11), on trail to tower. Single animal sighted at Highway intersection with Transects B/C same area by Matt Slaymaker on July 15/16, and on nearby Transect B creek camera July 18, 2019. Location: Likely throughout.

Leopard Cat recorded at baited site on trail to the tower, July 11, 2019.

Sun Bear (*Helarctos malayanus*) (WEHGUANG). Local guides heard sounds of sun bear on July 5-6 along transect B. Matt Slaymaker recorded track along trail to Transect D on July 12. Samuel saw one in May 2019, on site.

Bearded Pig (*Sus barbatus*) (DAAK). Recorded on camera trap weekly and by track throughout. Location: Throughout.

Bearded Pig were recorded on most cameras, often in groups of 2-9 throughout the site; this animal recorded on the creek at Transect B July 19, 2019.

Greater Mousedeer (*Tragulus napu*) (PELNUK-UTEANG). Recorded weekly throughout by visual or camera trap. Location: Transect B, Highway.

Greater Mousedeer (note the neck markings) recorded July 4, 2019 at a Great Argus Pheasant display site.

Bornean Yellow Muntjac (*Muntiacus atherodes*) (OS). Single sighted on June 17 along Highway, and on camera on Pangolin Ridge in mid-July. Possibly not as abundant as the Red Muntjac. Location: Uncertain but likely throughout.

Male Bornean Yellow Muntjac (left side, note the single tine on the antler) recorded on the Pangolin Ridge site, July 18, 2019.

Red Muntjac (*Muntiacus muntjak*) (OS-UTAU). Heard barking every few days during various surveys throughout. Recorded on camera trap along Highway, Transect A, B, C. Location: Throughout.

Female Red Muntjac recorded feeding on fruit along the Highway, June 27, 2019.

Additional Species recorded by Camp Staff in Previous Period (according to Samuel Hatsong)

Pangolin (*Manis javanica*) (HAM). Samuel saw one in 2018 on the highway
Flying squirrel (large gray body = KWUNG-PELNUK; smaller brown body = KWUNG-LIANG)
Rats/mice = EWAW
Western Tarsier (*Cephalopachus bancanus*) (YOK-EWUN). Several seen together in 2017 on the highway
Grey Langur (*Prebytis frontata*) (BEHNGEAL). White mark on forehead well noted in some langurs seen in area, often called leaf monkeys.
Slow Loris (*Nycticebus* sp.) (SONG NUNG). Samuel saw one in early 2109 along the highway
River Otter sp. (ELNGAN)
Clouded Leopard (*Neofelis diardi*) (KLIH-LONG). Samuel saw one in winter 2018-2019.
Lesser Mousedeer (*Tragulus kanchil*) (PELNUK-LIH)
Sambar (*Cervus unicolor*) (EBJIU).
Bornean Banteng (*Bos javanicus*) (LEMBU). Samuel recalls seeing one in snare, near the village in 1993.

Species not Recognized by Camp Staff (according to Samuel Hatsong)

Sunda Skunk
Malay Weasel
Bay Cat
Small-headed Cat
Giant Squirrel (note; species was recorded by Hart/Forbes during expedition)
Rhinoceras (EBDEAK)…'Some old people in the village remember rhinos', according to Samuel.

Summary of Camera Trap Effort, June 15-July 19, 2019, Lesan Forest, Borneo.

UTM (50N)	SITE DESCRIPTION	DATE RANGE	HOURS OPEN	BAITED
0517965 0178257	10m off transect C, pig wallow on creek	June 17-24	168	no
0519125 0177941	3m off transect A, young forest (8m)	June 17-24	171	camp refuse
0518768 0178076	top of large log, 5m long, edge of highway	June 17-21	86	sardines
0519090 0177872	end of 0.5m wide, 4m long log across creek	June 17-24	163	sardines
0516754 0177991	transect D, creek pool and stone beach	June 18-July 11	552	no
0519090 0177891	opposite flat log across creek off transect A	June 15-19	32	no
0519716 0177895	on creek and trail crossing of transect A	June 15-24	216	no
0517973 0178014	highway, orangutan fig scrape	June 21-july 5	330	no
0518642 0177530	transect a argus lek	June 19-21	65	no
0517927 0177952	highway before cabin 2	June 24-July 8	337	no
0518107 0178029	highway before cabin 1, fruit pile	June 24-28	101	natural fruit pile
0519076 0178025	river bank at camp	June 26-28	62	no
0518066 0177911	first creek on transect b	June 24-July 18	769	sardines
0518556 0178051	ellens argus lek	June 28-July 9	271	no
0518538 0178109	highway fruit tree	July 8-11	91	no
0519062 0177951	highway tree shrew log	July 6-8	76	sunflower seeds
0517690 0175095	highway tower sun bear	July 9-19	253	honey, sardines
0517766 0177953	highway 2nd house creek	July 5-12	175	no
0518874 0178005	highway jungle skills site	July 10-12	37	banana, papaya
0518057 0179137	transect c flying sq tree	July 8-13	136	peanut butter
0519079 0177923	transect a 2nd creek crossing soap bar	July 12-14	52	soap
	waterfall trail pangolin ridge	July 13-19	145	no
0517766 0177953	highway 2nd house	July 12-19	173	no
0518827 0178044	highway banana pile, sunny glade	July 14-16	46	banana
			TOTAL: 4507	

Summary of Primate Species Recorded from Camp, June 13 – July 19, 2019, Lesan Forest, Borneo.

DATE	NUMBER OF GIBBONS HEARD	OTHER PRIMATE SPECIES SEEN
13-Jun	1	
14-Jun	1	
15-Jun	1	
17-Jun	0	
18-Jun	1	
19-Jun	2	+15 LT Macaque, + 1 Red Langur
20-Jun	1	
21-Jun	0	+15 LT Macaque
24-Jun	1	+4 Pig Tailed Macaque
25-Jun	2	
26-Jun	1	
27-Jun	0	+7 LT Macaque, + 3 Proboscis
28-Jun	1	
30-Jun	1	
1-Jul	0	6 LT Macaque
2-Jul	2	
3-Jul	2	+15 LT Macaque, + 3 Silvered Langur
4-Jul	1	
5-Jul	1	
6-Jul	2	
Jul-08	1	+4 Red Langur
Jul-09	0	
Jul-10	2	
Jul-11	2	+8 LT Macaque
Jul-12	2	+5 Gibbon; +6 LTMacaque
Jul-13	2	
Jul-14	2	+ 3 PT Macaque
Jul-15	2	+10 LT Macaque
Jul-18	2	

Summary of Megafauna Recorded along Highway Trail, from Camp to Transect B/C, June 14-July 18, 2019.

DATE	9 AM	1 PM	GIBBON	PROBOSCIS	PT MACAQUE	LT MACAQUE	ORANGUTAN	RED MUNTJAC	BORNEAN MUNTJAC	GREATER MOUSEDEER	ARGUS	RHINO HORNBILL	BLACK HORNBILL
14-Jun	X		1	>2							1		
15-Jun		X									1		
17-Jun	X			3		3					1		
17-Jun		X									1		
18-Jun	X			3				1			1	2	2
19-Jun	X										1		2
21-Jun	X		1	>2							1		
24-Jun		X											
25-Jun	X										1		
26-Jun											1		
27-Jun	X		1								2		
28-Jun	X					3					2	3	2
1-Jul	X										2	2	
2-Jul	X									1	2		
3-Jul	X		2								2	2	
4-Jul	X						1				1		
5-Jul	X				5	3	1			1	2		
6-Jul	X		1		6					1	2	2	
9-Jul	X										2		
Jul-10	X										3		
Jul-11		X	2								3		
Jul-12		X			1						3		
Jul-13	X				1						2		
Jul-14	X				1						3		
Jul-15		X									2		
Jul-16	X										3		
Jul-17		X								1	3		
Jul-18	X											1	