WILDLIFE SURVEYS in the Lower KINABATANGAN

YEAR 2016-2017

HUTAN
Kinabatangan Orang-utan Conservation Programme

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Kota Kinabalu – January 2018

EXECUTIVE SUMMARY

In 2016 and 2017 HUTAN-KOCP conducted wildlife surveys across the Lower Kinabatangan Wildlife Sanctuary. The objectives of these surveys were:

- To document the status and population size of primate species in the Sanctuary, namely orang-utans, gibbons, and proboscis monkeys.
- To document population trends of various key species in the Sanctuary: small mammals, monkeys, frog community, birds, etc.
- To compare our results with previous baseline data available for the area: field expeditions of 2001/2002; 2006/2007, and regular river monitoring.
- To identify what are the current threats to wildlife's long-term survival and how to minimize the risks of extinction faced by these populations.

These surveys show that many species are declining in the LKWS, and among them, several iconic animals, such as the orang-utans and the gibbons.

1. The Lower Kinabatangan orang-utan population is about 785 individuals, a 30% decline since 2000.

In 2001, the Kinabatangan orang-utan population was about 1,100 individuals. In 2007, the population was about 812 individuals. **In 2015, the Kinabatangan orang-utan population size was 785 individuals (95% Confidence Interval: 414-1,467 animals). This population has declined by 30% in 15 years. The observed decline of the Kinabatangan orang-utan population is explained by habitat loss and fragmentation.**

From 2005-2014, around 13,000 ha of forests not located within the network of protected areas were lost. Most of these forests were connected with the current network of protected forests – either the LKWS or the Virgin Jungle Reserves found in the floodplain – and thus played a very important function in sustaining remaining wildlife populations. Forest conversion is for example responsible for the collapse of the orang-utan sub-population living in Lot 9 of the LKWS.

2. Less than 300 family groups of gibbons are surviving today in the Lower Kinabatangan: this is five to ten fold decline compared to 30 years ago

Depending on the location surveys, our surveys yielded an overall gibbon group density between 0.2 and 1.5 group/km^2. The overall average for the entire LKWS was 0.84 group/km^2. **This density shows a five to ten fold decline in less than thirty years in Lower Kinabatangan.** Major threats faced by gibbons in the area include forest loss and habitat fragmentation. Being strictly arboreal animals, gibbons cannot cope with forest degradation and fragmentation. Unlike orang-utans, gibbons do not walk on the ground and their dispersal abilities in the highly fragmented Kinabatangan landscape are greatly jeopardized. **Today, the Kinabatangan gibbon is on the verge of extinction. Reconnecting isolated forest fragments is a key management strategy if we want to secure a viable gibbon population in lower Kinabatangan.**

3. Leaf monkeys are declining while proboscis and macaques maintain their number

Sightings of silver and red leaf monkeys are declining in Kinabatangan, this decline being stronger in the lower parts of the floodplain. The pale morph of silver leaf monkey that used to be a common sighting looked after by tourists is becoming increasingly difficult to see. Reasons for decline could include competition with macaques, changes in forest ecology and food production, etc. Rehabilitating riparian areas and planting fig and other fruit trees will certainly support these monkeys in lower Kinabatangan. Overall, the population of proboscis monkeys has been stable over the years in Kinabatangan. However the populations in Kinabatangan are declining fast, especially in the upper parts of the floodplain, where forest fragmentation and destruction of the riparian habitat have a negative impact on their survival.

4. The small mammal and amphibian communities show a strong decline of forest specialist species and an increase of commensal and invasive species.

Results of small mammal trapping showed a decline of the number of species and individuals trapped, especially with the rat community. This can be explained by a lower abundance of food resources or other more complex ecological factors. **The most degraded survey sites were characterized by a lower diversity of their rodent community, but had a larger presence of commensal and invasive species like the common house mouse and Asian house rat.** For Amphibians, our results confirm the strong differentiation between frog assemblages in forests and non-forest sites. Frog surveys indicate that commensal frog species and habitat generalists dominate the non-forest sites; forest-dwelling species do not seem to be adapting in these disturbed habitats.

5. There is still signs of poaching and human activities within protected forests of Lower Kinabatangan

Signs of poaching (cartridges, traps, snares) were found in all Lots that were surveyed by the KOCP teams, although in less quantities than five years ago. However snares remain a serious threat to many protected species, such as elephants, sun bears or clouded leopards. Early 2017, two wild orang-utans were seen with a snare around their wrist in Lot 2 of the LKWS (see our 2017 Yearly activity report). **Snaring is a major threat that needs urgent attention.**

6. Major recommendations

In 2014, 23,100 ha of HCV forest stood outside the protected areas. Preserving viable wildlife populations – and general ecosystem functionality – in the Lower Kinabatangan will primarily depend on what happens to these forests.

Most of them belong to private landowners, with 6,350 ha under Native Title, and 7,170 ha within commercial or Country Land titles (Figure 6). The remaining forests identified on state land, or titles under land application, are most likely already alienated for oil palm. **Increasing the size of forest available for wildlife in Kinabatangan by acquiring land for conservation and/or restoring natural habitat remains the first priority to sustain wildlife in the Kinabatangan area.**

Identifying ways for animals and people to leave in harmony and share the same resources is the other key if we want to secure the long-term viability of animal populations that are still found in Kinabatangan.

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Gonocephalus borneensis

WILDLIFE SURVEYS IN KINABATANGAN

Over the years, KOCP has developed simple standardized methodologies for wildlife monitoring activities in Kinabatangan (Table 1). These methodologies are now commonly used in several wildlife monitoring strategies developed in Sabah[1].

Table 1: List of field activities undertaken for wildlife monitoring in Kinabatangan.

Wildlife species concerned	Methods
Orang-utans	Aerial nest surveys / Ground surveys
Gibbons	Morning call surveys
Proboscis monkeys and other riparian species	River surveys
Small mammals	Small mammal trapping
Birds	Calls – Direct sightings
Frogs	Night surveys
Large terrestrial species	Recce walks

Using the same techniques over time allows for easier and more accurate comparisons between years, and provides better assessments of population trends.

Table 2 shows the location of the different field expeditions across the Lower Kinabatangan Wildlife Sanctuary undertaken during our campaign. In average, each expedition lasted for ten full days of field work.

Table 2: Date and location of field expedition sites across the LKWS.

	Date	GPS Location	
		N	E
Lot 2	16-27.03.2016	5.598031	118.323277
Lot 4	19-30.05.2016	5.479198	118.266703
Lot 3	01-11.08.2016	5.46474	118.253688
Lot 5	21.09-32.10.2016	5.468215	118.147343
Lot 6	21-31.10.2016	5.409965	118.029397
Lot 7 and 8	21.11-02.12.2016	5.532132	117.927799
Lot 10	12-22.03.2017	5.450491	117.70719

[1] Ancrenaz, M. 2013. *Field Manual: Monitoring large terrestrial mammals in Sabah. Part 1: Planning, developing and implementing a wildlife strategy – Part 2: Field activities*. Sabah Forestry Department, Sandakan, Sabah. 153 pp.

Orang-utans are still declining in Kinabatangan

HUTAN-KOCP is regularly monitoring the High Priority population of orang-utan (*Pongo pygmaeus morio*) found in Lower Kinabatangan by using a combination of aerial and ground nest counts[2]: Table 3. Our monitoring surveys aim at estimating orang-utan densities and population sizes in the different forest patches of the Lower Kinabatangan floodplain: Tables 4 and 5.

Table 3: Year and sampling efforts of three comprehensive orang-utan surveys undertaken in Kinabatangan during the period 2001-2015 by KOCP.

YEAR	Ground Survey	Aerial Survey	LKWS	Other forests than LKWS
2001	89.7 km	136.8 km	Totality	Yes
2006/2007	172.9 km	182.5 km	Totality	No
2015	55 km	233.8 km	Totality	Yes

Methods: Aerial surveys were carried out with a helicopter type Bell 206 Jet Ranger. Helicopter speed and height were kept constant at about 70 km/hour and 60-80 meters above the forest canopy. The copilot (in front of the aircraft) recorded the precise flight path: the exact location of the aircraft was recorded every 30 seconds with a GPS. Information about habitat types, signs of wildlife presence, human activities was also recorded by the copilot in a specific data sheet. The ratio between the length of aerial transects and the length flown over unsuitable orang-utan habitat (river, large open areas, etc) gave the proportion of habitat unsuitable for orang-utan for each transect. From the back seats, two observers looked for orang-utan nests from either side of the helicopter. All visible nests were recorded. Data was processed according to the methodology developed in Kinabatangan by KOCP[3] and used across the State[4]. Ground work involved nest surveys along line transects and general recce walks following[8].

A genetic analysis conducted by Hutan and Danau Girang Field Center showed that the total population of orang-utans in the Lower Kinabatangan was in the order of the 20,000's individuals in the early 1900's[5]. In the early 1960's, Yoshiba estimated this population to be down to about 4,000 individuals[6].

In 2001, our baseline surveys concluded that about 70% of all forests identified in the floodplain was suitable habitat for orang-utan, translating in 36,430 ha of forest inhabited by orang-utans, out of the then 51,710 ha of forests found in the area.

[2] Ancrenaz, M., Gimenez, O., Goossens, B., Sawang, A., and I. Lackman-Ancrenaz. 2004. Determination of ape distribution and population size with ground and aerial surveys: a case study with orang-utans in lower Kinabatangan, Sabah, Malaysia. *Animal Conservation,* 7: 375-385.

[3] Ancrenaz, M., Gimenez, O., Goossens, B., Sawang, A., and I. Lackman-Ancrenaz. 2004. Determination of ape distribution and population size with ground and aerial surveys: a case study with orang-utans in lower Kinabatangan, Sabah, Malaysia. *Animal Conservation,* 7: 375-385.

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

[5] Goossens, B., Chikhi, L., **Ancrenaz, M**., Lackman-Ancrenaz, I., Audau, P., and M.W. Bruford. 2006. Genetic Signature of anthopogenic population collapse in orang-utans. *Plos Biology*, 4 (2): 285-291.

[6] Yoshiba, K. 1964. Report of the preliminary survey on the orang-utan in North Borneo. *Primates*, 5: 11-26.

In the early 2000s, our population size estimate for Kinabatangan was 1,125 individuals (with a 95% Confidence Interval of 691 – 1,807 animals)[7]:

- ✓ 670 individuals were found in the then-proposed LKWS;
- ✓ 228 individuals in Protected Forests under the SFD;
- ✓ 227 individuals in non-protected forests belonging to the state or to private individuals.

For most areas, the average orangutan densities fluctuated between 0.5 and 3.5 individuals/km^2. All these results were in the range of what was available for this species in the literature.

In 2006/2007, our new surveys revealed a 28% decline compared to the 2001 orang-utan baseline, with an estimated population size down to 812 individuals (95% Confidence Interval of 425-1418 animals). Over this five years period (2001-2006) densities had declined in Lots 1, 2, 5 and 9, which used to be major orang-utan strongholds in 2001.

In July 2015, our most recent aerial surveys confirmed a further decline, and yielded a total population size of 785 individuals for Kinabatangan (95% Confidence Interval: 414-1,467 animals): Tables 4 and 5.

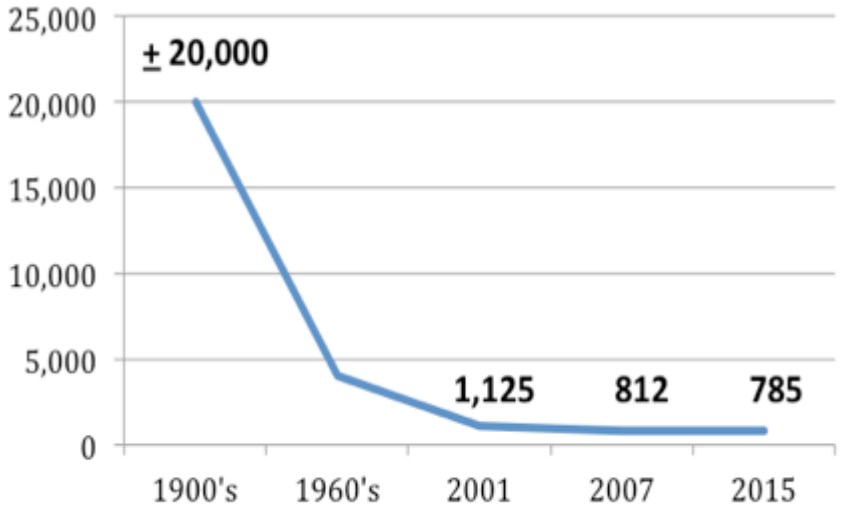


Figure showing the temporal decline of orangutan population in Kinabatangan over the past 120 years (from the 1900's to 2015), with this decline due to forest loss and persecutions.

[7] Ancrenaz, M., Gimenez, O., Goossens, B., Sawang, A., and I. Lackman-Ancrenaz. 2004. Determination of ape distribution and population size with ground and aerial surveys: a case study with orang-utans in lower Kinabatangan, Sabah, Malaysia. *Animal Conservation,* 7: 375-385.

The observed decline of the Kinabatangan orang-utan population is explained by a combination of factors:

- ***Forest and habitat loss***. Conversion to extensive oil palm agriculture leads to intense forest destruction: around 13,000 ha of prime orang-utan forest habitat has been converted to oil palm plantations between 2005 and 2014 in the region. Forest conversion explains for example the collapse of the orang-utan sub-population living in Lot 9 of the LKWS (see detailed results of orang-utan numbers in Annex I);
- ***Habitat fragmentation, population compaction and rebound effect***. On-going research by KOCP shows that excess males that have taken refuge in forest patches following forest conversion will disperse into nearby agricultural landscapes after a few years, in search of new territories where they can settle down. Over the years, some of the animals that accounted for the artificially inflated densities recorded in 2001 left the forest and dispersed into plantations (this particularly applies to Lots 1 and 2)***.;***
- ***Species adaptability***. KOCP studies indicate that orang-utans are more adaptable than previously thought. In Kinabatangan, many animals are currently expanding their range and they start to incorporate palm oil plantations within their habitat (see KOCP Yearly Activity Reports).

Although the number of orang-utans is still declining in Kinabatangan, identifying ways to design better agricultural landscapes is the key element to stop the decline and secure their long-term viability.

*Table 4: Orang-utan abundance in the different lots of forests identified as part of the orang-utan range in the lower Kinabatangan floodplain (results with * are an average taken from literature for forests that were never surveyed).*

Sampling Unit	Forest area	Available habitat (km^2)	Suitable habitat (km^2)	OU density 2001 (Aerial)	OU density 2007/2008 Aerial/Ground	OU density 2015 Aerial
1	Lot 1	33.4	21.3	6.00 (3.9-9.2)	1.35 (0.72-2.50)[a] 1.57 (1.20-2.04)[g]	1.65 (0.89-3.07)
	Other	40.0	25	3.40 (2.20-5.30)		1.00 (0.54-1.85)
2	Lot 2	37.6	33.5	5.00 (2.80-8.90)	3.14 (1.64-6.01)[a] 1.58 (0.86-2.89)[g]	1.75 (0.94-3.27)
	Other	10.0	7.0			
	Kerouak	2.0	2.0	2*	2*	2*
3	Lot 3	22.2	21.8	1.90 (1.00-3.6)	2.15 (1.14-4.02)[a] 1.74 (1.22-2.49)[g]	2.37 (1.26-4.46)
	Other	7.0	3.0			2.90 (1.52-5.52)
	Pangui	4.4	4.0	2.60 (1.80-3.70)	2*	1.51 (0.82-2.81)
4	Lot 4	18.8	13.2	3.10 (2.20-4.50)	3.08 (1.61-5.87)[a] 1.62 (1.21-2.16)[g]	2.38 (1.26-4.49)
	Other	5.0	3.0			0.55 (0.29-1.04)
	Bod Tai	2.5	2.0	2*	3.93 (2.03-7.64)[a]	0.37 (0.19-0.72)
5	Lot 5	74.2	70.1	2.10 (1.10-3.50)	1.11 (0.60-2.06)[a] 0.97 (0.71-1.33)[g]	2.16 (1.15-4.05)
	Gomantong	45.4	38.0	3.80 (2.80-5.40)	2.91 (1.53-2.53)[a]	1.90 (1.01-3.54)
6	Lot 6	26.7	25.8	2.10 (1.30-3.60)	2.34 (1.24-4.40)[a] 1.93 (1.60-2.33)[g]	3.24 (1.69-6.21)
7	Lot 7	10.3	8.5	1.30 (0.80-2.20)	1.14 (0.61-2.11)[a] 0.56 (0.04-7.4)[g]	1.65 (0.89-3.08)
	Pin Supu FR	27.0	13		3.30 (1.72-6.33)[a]	
8	Lot 8	12.0	12.0	0.70 (0.30-1.60)	1.60 (0.86-2.98)[a] 1.54 (1.06-2.26)[g]	1.62 (0.87-3.00)
	Other	24.0	17.6			
9	Lot 9	11.2	7.5	1.60 (1.00-2.60)	0.71 (0.38-1.34)[a]	1.73 (0.93-3.23)
	Safoda	40.0	7		3.34 (1.74-6.42)[a]	2.87 (1.51-5.45)
10	Lot 10 a	8.7	6.9	1.80 (1.10-3.10)	2.72 (1.44-5.16)[a] 0.77 (0.57-1.03)[g]	0.88 (0.47-1.64)
	Other	8.0	6.0			
11	Lot 10 bc	19.4	16.7	2.40 (1.20-4.80)	3.07 (1.61-5.85)[a]	2.52 (1.33-4.77)
	Other	9.0	5			3.46 (1.80-6.67)
	Segaliud FR	18.5	16		4.34 (2.22-8.50)[a]	3.46 (1.80-6.67)
TOTAL		**517.3**	**364.3**			

Table 5: Orang-utan numbers in the different lots of forests identified as part of the orang-utan range in the lower Kinabatangan floodplain

Sampling Unit	Forest area	OU Suitable Habitat (km^2)	Population size 2002	Population size 2008	Population size 2015
1	Lot 1	21.3	128 (87-189)	29 (15-53)	35 (19-65)
	Other	25.0	102 (68-153)	34 (18-62)	30 (16-55)
2	Lot 2	33.5	160 (102-291)	105 (55-201)	54 (34-118)
	Other	7.0	35 (20-62)	22 (11-42)	12 (6-21)
	Keruak	2.0	4*	4*	4*
3	Lot 3	21.8	42 (22-79)	47 (25-88)	52 (28-97)
	Other	3.0	10 (5-18)	6 (3-12)	14 (8-28)
	Pangui	4.0	11 (8-16)	8	7 (4-12)
4	Lot 4	13.2	41 (30-57)	41 (21-77)	32 (17-59)
	Other	3.0	15 (11-21)	9 (5-18)	3 (1-5)
	Bod Tai	2.0	5	8 (4-15)	1 (0-2)
5	Lot 5	70.1	146 (77-266)	78 (42-144)	152 (81-284)
	Gomantong	38.0	147 (107-199)	111 (58-96)	72 (39-135)
6	Lot 6	25.8	55 (33-90)	60 (32-114)	84 (44-160)
7	Lot 7	8.5	11 (7-18)	10 (5-180)	14 (8-26)
	Pin Supu FR	13.0	23 (12-44)	43 (22-82)	40 (21-61)
8	Lot 8	12.0	8 (4-19)	19 (10-36)	19 (10-36)
	Other	2.0	3 (1-6)	3 (2-6)	6 (3-12)
9	Lot 9	7.5	17 (10-26)	5 (3-10)	18 (10-34)
	Safoda	7.0	32 (20-50)	23 (12-45)	5 (3-10)
10	Lot 10 a	6.9	12 (8-21)	19 (10-36)	6 (3-11)
11	Lot 10 bc	16.7	40 (20-80)	51 (27-98)	42 (22-80)
	Other	5.0	19 (9-37)	15 (8-29)	21 (11-40)
	Segaliud FR	16.0	38 (19-77)	69 (36-136)	55 (26-106)
TOTAL		**364.3**	**1,125 (691-1807)**	**812 (425-1,418)**	**785 (414-1,467)**

Gibbons are disappearing fast from Kinabatangan

Gibbons are territorial animals and their morning calls can be used to count the number of families in a given area.

Method: For each survey, we recorded gibbon territorial calls from 06.00 to 08.00 am from two different listening posts interspaced of about 100 m for at least three consecutive days. The maximum audible distance of calls varies according to topography, type of forest and weather conditions. Considering the local conditions encountered in Kinabatangan, we averaged it at about 800 m following[8]. For density estimates, we considered only the number of groups heard by the two listening teams. We judged calls that were heard from only one listening post to be outside the survey area and so we did not plot these points on the map. Each time a duet was heard, we recorded the compass bearing of the call, estimated the distance to the calling group (in one of four classes: close, medium, far, or very far), and the time at which each long call began and ended. Gibbons sometimes move short distances while calling, so we assumed that calls plotted to be less than 500 m apart originated from a single group[9]. A crude gibbon population size estimate can be derived from call surveys by (1) applying a correction factor of 0.8 to the number of groups heard calling (considering that in average, only 80% of the population is calling in the morning), and (2) considering an average group size of 3.5 gibbons per family unit[8]: Table 7.

*Table 3: Density (nb of groups calling/km^2) recorded by the two listening teams during each survey: results are expressed by the average number of groups heard per day (standard deviation) - n=number of days of survey at each location. Average*is the density of groups calling in the morning. Average ** is the density of family groups found in the forest.*

	2007	2015/2016
Lot 1	1.24 (0.95) – n=4	n.a.
Lot 2 (Study Site)	1.35 (0.80) – n=7	1.50 (0.50) – n=3
Lot 2 (Tandu Batu)	0.50 (0.86) – n=3	0.17 (0.29) – n=3
Lot 3	1.33 (0.29) – n=3	0.50 (0.84) – n=6
Lot 4	2.23 (1.22) – n=4	1.00 (0.89) – n=6
Lot 5	1.27 (1.80) – n=4	< 0.5 – n=3
Lot 6	0.83 (0.29) – n=3	0.33 (0.57) – n=3
Lot 7	< 0.5 – n=2	n.a.
Lot 8	n.a.	0.17 (0.29) – n=3
Lot 10A	0.67 (0.29) – n=3	1.33 (0.58) – n=3
Average*	**1.12 (0.52) – n=33**	**0.67 (0.53) – n=30**
Average **	**1.40 group/km^2**	**0.84 group/km^2**

In the late 1980's-early 1990's, researchers estimated gibbon density to fluctuate between 2 and 4 groups/km^2 in the Lower Kinabatangan. **In 2007, our surveys**

[8] Nijman, V., Menken, S.B.J. (2001). Density and biomass estimates of gibbons (*Hylobates muelleri*) in Bornean rainforest: A comparison of techniques. In *Forest (and) Primates: Conservation and Ecology of the Endemic Primates of Java and Borneo* (ed. V. Nijman), PhD thesis, pp. 13-31, Tropenbos International.

[9] Brockelman, W.Y., Ali, R., (1987). Methods of surveying and sampling forest primate populations. In *Primate conservation in the Tropical Rain Forest*, (eds C.W. Marsh, and R.A. Mittermeier), pp. 23-62. Alan R. Liss, New York.

showed that the overall gibbon density had decreased to 1.40 group/km^2, while our 2016/2017 surveys showed a further significant decline, with an overall density estimate of 0.84 group/km^2 across lower Kinabatangan.

In 2006/2007, our surveys yielded a population size of about 500 family groups (or about 1,750 individuals). In 2016/201, we estimate the total population size of gibbons for Kinabatangan to be about 357 family groups (286/0.8) or 1,250 individuals: Table 6. **This represents a 29% decline in a period of ten years only.**

Table 6: Estimated size of forest suitable for gibbons, density of calling groups and number of calling groups in various forest fragments of the Lower Kinabatangan floodplain.

Forest area	Size (km^2)	Calling group density	Group Population size
Lot 1	21.3	1.24	26.4
Other*	25		31
Lot 2	33.5	1.50	50.25
Other	7		10.5
Keruak*	2		3.0
Lot 3	21.8	0.50	10.9
Other	3		1.5
Pangui*	4		2
Lot 4	13.2	1.00	13.2
Other	3		3
Bod Tai*	2		2
Lot 5	70.1	0.5	35.5
Gomantong*	38		19
Lot 6	25.8	0.33	8.5
Lot 7	8.5	0.25	2.1
Pin Supu FR*	13		3.2
Lot 8*	12.0	0.17	2.0
Other*	2		0.3
Lot 9*	7.5	0.50	3.7
Safoda*	7		3.5
Lot 10 a	6.9	0.67	4.6
Lot 10 b+c*	16.7	1.33	22.2
Other*	5		6.65
Segaliud FR*	16		21.3
TOTAL			**286**

Gibbons and orang-utans are sympatric species, and we can consider that food availability in a habitat suitable for orang-utan could also sustain healthy gibbon populations. However gibbon numbers are plummeting in the area, even in the absence of hunting pressure.

Gibbon abundance has shown a five to ten fold decline in less than thirty years in Lower Kinabatangan. Major threats faced by this species in the area include forest loss and habitat fragmentation due to conversion to agriculture. Being strictly arboreal animals, gibbons cannot cope with forest degradation and fragmentation. Unlike orang-utans, gibbons do not walk on the ground and their dispersal abilities in the highly fragmented Kinabatangan landscape are greatly jeopardized. **Today, the gibbon population found in Kinabatangan is on the verge of extinction. Reconnecting isolated forest fragments is a key management strategy if we want to secure a viable gibbon population in lower Kinabatangan.**

Leaf monkeys are declining while proboscis and macaques maintain their number

Riparian forests offer shelter and food resources to wildlife. These ecotones attract many mammals (monkeys in particular), birds and other animals, especially in late afternoon or early morning. The Kinabatangan offers an easy way to assess and to monitor species that are visible from a boat, such as monkeys or hornbills for example. River surveys generally provide a linear encounter index (i.e. number of groups detected per km of river surveyed), but they can also be used to approximate abundance of proboscis monkeys (*Nasalis larvatus*).

Methods: Each survey is conducted by the same team of two to three observers along a stretch of river of about 8 km, between 17.00 and 18.30 pm for a minimum of three consecutive days. Data recorded includes time and location of the sightings, species, group size and composition, etc. River monitoring is also regularly conducted by KOCP along two permanent transects that are surveyed three times a month. The first stretch runs from Resang River to Tomangong (8.6 km) – covering Lot 2/Pangi/Keruak-, while the second one runs from Tenegang Besar to Melapi (8 km) – covering Lot 3 and 4. The team also conducted river surveys during field expeditions to investigate distribution and relative abundance of wildlife along the river across the floodplain. Table 8 gives the kilometric indexes of proboscis sightings, and Table 9 summarizes the composition of the groups detected during our surveys.

1. Proboscis monkeys

Estimates available for proboscis monkeys over the past 25 years fluctuate between 1,000 and 1,500 individuals for Kinabatangan[10,11]. These estimates were confirmed by a recent PHVA conducted in Kota Kinabalu in early 2017 (Goossens, unp. data).

[10] Boonratana R (1993) The ecology and behaviour of the proboscis monkey (Nasalis larvatus) in the Lower Kinabatangan, Sabah, Dissertation, Mahidol University

[11] Sha JCM, Bernard H, Nathan S (2008) Status and conservation of proboscis monkeys (Nasalis larvatus) in Sabah, East Malaysia. Primate Conservation 23:107–120

1.1. Abundance and indexes of encounter rates

Our surveys yielded an overall kilometric encounter index of 0.74 (SD=0.54) group of proboscis monkeys/km throughout the lower Kinabatangan: Table 8.

In average, family units (or One Male Units, OMU) were detected more often (0.57 OMU/km, SD=0.46) than groups of bachelor males (0.14 group/km, SD=0.14) or single males (0.03 encounters/km). OMU encounters were the lowest in the upper Lots of the LKWS: 0.29 group/km in Pin Supu; 0.08 group/km in Lot 9 (Lamag) or 0.00 group/km in Lot 10A. Encounter rate was higher in the lower parts of Kinabatangan or along the small river tributaries (such as Lokan) where riparian forests have retained more functionality.

Table 8: Kilometric index of proboscis encounters (number of groups detected per km of river) during monthly monitoring of permanent river transects (indicated with) and river surveys during expeditions in Kinabatangan (OMU=One Male Unit; BG=Bachelor Group; SM=Single Male).*

	LOCATION	DATES	DISTANCE	OMU	BG	SM	Total
Permanent monitoring	Resang/Lot 2*	2016	180.6 km	0.66	0.05	0	0.71
	Teneggang/Lot 3*	2016	168 km	0.61	0.05	0	0.66
Field Expeditions	Lot 3/Lot 4 - Myne resort	17, 18, 19.05.2016	24.51 km	0.62	0.33	0	0.94
	Lot 5 - Batangan	21, 22, 24.09.2016	25.2 km	0.56	0	0.08	0.63
	Lot 5 - Downriver	26, 28, 29.09.2016	24.0 km	0.54	0.08	0	0.62
	Lot 5 - Lot 6	27, 28, 29.10.2016	24.0 km	0.46	0.29	0.04	0.79
	Lot 6 - Lot 7	23, 24, 25.10.2016	24.0 km	1.46	0.25	0.125	1.83
	Pin Supu FR	24, 26, 27.11.2016	24.0 km	0.29	0.29	0.04	0.63
	Lot 9 - Lamag	02, 03, 04.05.2017	24 km	0.08	0	0	0.08
	Lot 10 A	06, 07, 08.05.2017	24.0 km	0	0.04	0	0.04
	Lot 10B - Sgai Lokan	02, 03, 04.05.2017	25.5 km	1.1	0	0	1.1
	Average (only for expeditions)			**0.57**	**0.14**	**0.03**	**0.74**
	SD (only for expeditions)			**0.47**	**0.14**	**0.05**	**0.54**

In 2007, similar river surveys yielded an encounter rate of about 0.46 group/km in Lot 10 A. Our current results show the serious loss of proboscis monkeys in this particular Lot. This significant decline may be explained by the more aggressive conversion and fragmentation of the riparian forest in the upper parts of Kinabatangan, or by a heavier hunting pressure compared to the lower parts of the floodplain.

1.2. Group composition

Group size and composition compare well and remain within the range of what has been already published for Kinabatangan[6,7]. However, only visible individuals

detected during our surveys were used to estimate the OMU group size, which accounts for the slightly smaller group size documented during our surveys compared to previous estimates[7]. During our surveys, the average group size of a family unit was 11.8 individuals (SD=2.9): one adult male; 5.6 adult females (SD=1.5); 3.1 juveniles (SD=1.2) and 1.4 infant (SD=0.6): Table 9.

Table 9: Group composition of "One Male Units" across the different expedition sites for Proboscis monkeys (Total Group Size includes the alpha male).

Location	Adult female	Juvenile	Infant	Total Group Size
Lot 3/Lot 4 - Myne resort (n=15)	7.60	4.93	2.13	**15.07**
Lot 5 - Batangan (n=14)	5.42	3.00	1.36	**10.15**
Lot 5 - Downriver (n=12)	6.25	3.09	1.58	**12.92**
Lot 5 - Lot 6 (n=11)	4.18	1.91	1.45	**9.55**
Lot 6 - Lot 7 (n=35)	4.91	1.66	1.54	**10.11**
Pin Supu FR (n=7)	6.71	4.57	1.86	**15.14**
Lot 9 - Lamag (n=2)	3.50	2.00	0.00	**7.50**
Lot 10B - Sgai Lokan (n=28)	7.25	3.68	1.29	**14.21**
Average	**5.73**	**3.11**	**1.40**	**11.83**
SD	**1.47**	**1.23**	**0.63**	**2.88**

Overall, proboscis monkeys appear to have maintained their numbers over the years in Kinabatangan. However several sub-populations are declining fast, especially in the upper parts of the floodplain, where forest fragmentation and destruction of the riparian habitat have a negative impact on their survival.

2. Other primates

We estimated encounter kilometric indexes for macaques and leaf monkeys from river surveys. Unlike for proboscis monkeys (see above), these indexes cannot produce abundance estimates. Indeed, an unknown proportion of the groups is not returning to the riverbank to sleep, and thus an unknown proportion of the population remains undetected during afternoon river surveys. However these indexes can still be used as valuable indicators of population trends.

Long tailed macaques (*Macaca fascicularis*) are the primates that are most encountered during river surveys, with indexes fluctuating between 0.5 to more than 2.3 groups/km (distance between two distinct groups is more than 50 m). Encounter indexes were higher in the upper parts of Kinabatangan than in the lower parts. Group size varied from single males to more than 100 individuals (multi-males multi-females groups). Long tailed macaques are often spotted close to, or in the villages along the Kinabatangan. They can cause conflicts and damages when they raid people's houses and crops. This species is highly resilient and adaptable.

Adult male long-tailed macaque resting at the river bank of a small tributaries of Kinabatangan

Pig tailed macaques (*Macaca nemestrina*) are also living in large multi-males multi females groups. This monkey is a wide-ranging species and groups come to the riverbank very infrequently, explaining the relatively low encounter indexes recorded during our boat surveys. However some troops can easily number more than 50 individuals.

Silver leaf monkey (*Trachypithecus cristatus*) were more frequent in the upper parts of the river (index > 0.40 group/km) than in the lower parts; and more often along the main river than along small tributaries: Table 10. The pale form of silver leaf monkeys used to be a common sighting in the lower parts of the River in the 2000's. Today, spotting a pale form of silver leaf monkey in Kinabatangan becomes increasingly difficult, indicating that this morph is disappearing from the area. Red leaf monkeys (*Presbitys rubicunda*) become increasingly rare to spot during boat surveys, and we failed to detect them during the entire survey.

Table 10: River index of encounter (nb of groups/km) of four species of monkeys during regular permanent monitoring and field expeditions across Kinabatangan.

LOCATION		DISTANCE	Long tailed macaque		Pig tailed macaque	Silver leaf monkey	Red leaf monkey
			Group Index	Individual Index			
Permanent Monitoring	Resang Monitoring*	180.6 km	0.66	6.96	0.06	0.1	0.01
	Teneggang Monitoring*	168.0 km	0.52	4.37	0.01	0.06	0
Field Expeditions	Lot 3/Lot 4 - Myne resort	24.5 km	0.81	4.2	0	0.2	0
	Lot 5 - Batangan	25.2 km	0.99	10.8	0.08	0.32	0
	Lot 5 - Downriver	24.0 km	1.08	9.9	0.04	0.29	0
	Lot 5 - Lot 6	24.0 km	1.67	23.5	0.08	0.42	0
	Lot 6 - Lot 7	24.0 km	2.29	32.0	0.08	0.37	0
	Pin Supu FR	24.0 km	1.5	12.5	0.08	0.42	0
	Lot 9 - Lamag	24 km	1.04	14.8	0	0.04	0
	Lot 10 A	24.0 km	1.08	16.2	0.08	0.29	0
	Lot 10B - Sgai Lokan	25.5 km	1.25	21.7	0	0.08	0
	Average (only for expeditions)		**1.30**	**16.2**	**0.05**	**0.27**	**0**
	SD (only for expeditions)		**0.45**	**8.4**	**0.04**	**0.14**	**0**

KOCP has also been conducting a monthly primate monitoring between Rasang and Tennegang Besar (around Sukau area, a hotspot for tourism) since 2005. By compiling this data every year, it is then possible to explore population trends over a ten-year period in this area. A simple data analysis showed that the yearly growth rates of sightings were negative for all species (Table 11), indicating a regular decline of group sightings along the river in late afternoon. This decline is particularly significant for leaf monkeys.

Table 11: Kilometric encounter indexes of monkeys (number of groups/km of river) around Sukau area since 2005 and estimated trend of these indexes ("r").

	Long tailed macaques		Pig tailed macaques		Silver leaf langurs		Red leaf monkeys	
	Index	"r"	Index	"r"	Index	"r"	Index	"r"
2005	1.14		0.15		0.19		0	
2006	n.a.	-0.11	n.a.	0.09	n.a.	0.22	n.a.	
2007	0.97	-0.16	0.17	0.13	0.26	0.31	0.02	0.00
2008	1.21	0.22	0.21	0.21	0.34	0.27	0.02	0.00
2009	1.11	-0.09	0.17	-0.21	0.21	-0.48	0.02	-1.39
2010	n.a.	-0.005	n.a.	-0.05	n.a.	0.03	n.a.	-0.80
2011	n.a.		n.a.		n.a.		n.a.	
2012	1.1	-0.01	0.155	-0.09	0.22	0.05	0.005	1.10
2013	1.125	0.02	0.075	-0.73	0.22	0.00	0.015	0.51
2014	1.045	-0.07	0.075	0.00	0.155	-0.35	0.025	-0.92
2015	0.795	-0.27	0.045	-0.51	0.12	-0.26	0.01	-0.69
2016	0.59	-0.30	0.035	-0.25	0.08	-0.41	0.005	0.00
Average		**-0.068**		**-0.171**		**-0.103**		**-0.273**
Variance		**0.022**		**0.077**		**0.068**		**0.594**

During this regular river monitoring, we also recorded trees where groups of monkeys are sighted. Five taxa of trees represented more than 75% of the trees used by proboscis monkeys as sleeping sites: *Mallotus muticus* (26.4% of sleeping trees), *Ficus sp*. (15.6%), *Nauclea sp*. (15%), *Colona sp*. (10.4%) or *Pterospermum sp.* (9.0%). Fig trees were the commonest species of trees used by macaques and silver leaf monkeys to rest and/or feed in late afternoon, showing the importance of these fruit trees to sustain populations of monkeys: Table 12

Table 12: Tree species where groups of monkeys were detected during river surveys.

Tree taxa	Long tailed macaque	Pig tailed macaque	Proboscis monkey	Silver leaf monkey	Total	Percentage
Nauclea sp.	36	-	32	6	**74**	**13.7%**
Pterospermum sp.	6	1	19	9	**35**	**6.5%**
Ficus sp.	141	10	33	20	**204**	**37.7%**
Colona sp.	17	-	22	2	**41**	**7.6%**
Mallotus sp.	4	-	56	-	**60**	**11.1%**
Unknown/Others	55	2	50	20	**127**	**23.5%**
TOTAL	**259**	**13**	**212**	**57**	**541**	**-**

Male Juvenile pig tailed macaque resting under the shade of the canopy

Table 13 below summarizes the current status of diurnal non-human primate species found in the Lower Kinabatangan (CE: Critically Endangered; E: Endangered; NT: Near threatened; V: Vulnerable; LC: Least Concern; NA: Not Assessed).

Species	Scientific name	IUCN Status	Kinabatangan Population size				Trend
			1960's	2001	2007	2015	
Bornean orang-utan	*Pongo pygmaeus morio*	**CE**	>4,000	1,125	812	785	Declining
Bornean gibbon	*Hylobates muelleri*	**E**	>15,000	n.a.	1,750	1,115	Declining
Proboscis monkey	*Nasalis larvatus*	**E**	n.a.		1,500	1,500	Stable but Declining locally
Red leaf monkey	*Presbytis rubincunda*	**LC**	n.a.				Declining
Silver leaf monkey	*Trachypithecus cristatus*	**NT**	n.a.				Declining
Grey leaf monkey or Sabah Grey langur	*Presbytis sabana*	**NA**	n.a.				Declining
Long tailed macaque	*Macaca fascicularis*	**LC**	n.a				Stable
Pig tailed macaque	*Macaca nemistrina*	**V**	n.a				Stable

Overall, sightings of silver and red leaf monkeys are declining in Kinabatangan, this decline being stronger in the lower parts of the River. The pale morph of silver leaf monkey that used to be a common sighting looked after by tourists is becoming increasingly rare. Reasons for decline could include competition with macaques, changes in forest ecology and food production, etc.

Rehabilitating riparian areas and planting fig- and other fruit-trees will certainly support the populations of "monkey"s in lower Kinabatangan.

Small mammal trapping

Small mammal trapping aimed to:

(1) assess diversity of small mammal community in Kinabatangan;

(2) document variation in species composition according to habitat types and across years;

(3) establish a check list of diurnal and nocturnal small mammals for the particular area studied.

*Method: At each survey site, we set up 10 or 11 small mammal traps at 10 m intervals along four selected transects located in different habitat types. At each trap, we scored from 0 (minimum) to +++ (maximum) the following habitat variables: canopy height and cover, vegetation connectivity, presence of water body, dead wood and log, vine density. For each line, we pooled the habitat variables together and calculated the general average for the line, allowing for comparison between lines and between habitat types: Table 14. Each trap was baited with palm oil kernel. Traps were checked every morning and evening. A trapping session usually involved ten nights and ten days accounting for a total effort of 440 day/trapping and 440 night/trapping events. All captures were identified, anaesthetized (using ether), sexed, aged, weighed, photographed and measured: head and body (HB), tail (T) and right hind foot (HF). Percentage of Trap Success was calculated as the (Number of captures/Number of day)*100. These indexes were established to compare diurnal vs. nocturnal species as well as individuals. The cumulative curve of captures was built every 24-h by pooling results of one day and one night' trapping effort together.*

The "Shannon index" and the "Simpson index" are two diversity indexes that perform relatively well with small data sets (Magurran, 1988)[12]; they were used to measure diversity of our samples. A community has a high species diversity if it is composed of many equally or nearly equally abundant species. The Shannon index increases as both the richness and the evenness of the community increase. Typical values fluctuate between 1.5 and 3.5. This index will be 0 only if we have one species in the sample and will be maximal only if all S species are represented by the same number of individuals (perfectly even distribution of abundance). This index is computed this way:

n_i , the number of individuals in each species (abundance of each species)

S , the number of species (species richness)

N , the total number of all individuals in the sample

p_i , the relative abundance of each species, calculated as the proportion of individuals of a given species to the total number of individuals in the community: n_i/N

The Shannon index becomes: $$H' = -\sum_{i=1}^{s} p_i \ln p_i$$

Simpson's index is calculated by determining, for each species the proportion of individuals that it contributes to the total in the sample (or proportion p_i for the i^{th} species). This index gives more weight to the more abundant species in a sample.

The Simpson index is: $$D = \sum_{i=1}^{s} p_i^2$$

The Simpson index of diversity is: $D^* = 1 - \sum_{i=1}^{s} p_i^2$

The Simpson index is comprised between 0 and 1; it increases with equitability, and for a given equitability, D increases with richness. With this index, 0 represents infinite diversity and 1 no diversity (the bigger the value of D, the lower the diversity).

[12] Magurran, A. E. 1988. Ecological Diversity and its Measurement. Princeton University Press, Princeton, NJ.

Most lines were located in places with relatively low canopy but significant mid-storey vegetation offering good connectivity via climbers, twigs and branches. Quantity of dead wood and litter was relatively constant across the lines and of intermediary quantity (lowest values were recorded in Lots 3 and 8). Lot 8 and 10 were the most degraded of all, in terms of canopy cover and vegetation abundance.

Table 14: Average score for habitat variables recorded during field expeditions.

	Canopy height (m)	Canopy Cover (%)	Mid-storey vagetation	Vegetation Connectivity	Vine	Dead wood	Litter Volume	Water
Lot 2	10-20	37.75	1.50	1.45	1.25	1.05	1.18	0.00
Lot 3	5-15	27.27	0.84	1.00	0.70	0.48	0.91	0.00
Lot 4	5-15	37.27	1.52	1.52	1.36	0.95	1.70	0.05
Lot 5	0-10	19.48	2.74	2.18	1.39	1.25	1.55	0.00
Lot 6	5-15	22.32	1.34	1.41	1.23	1.02	1.00	0.02
Lot 8	0-10	12.52	1.00	1.25	1.00	0.89	0.89	0.00
Lot 10	10-20	6.73	1.00	1.34	1.27	1.00	1.00	0.02

A total of 171 small mammals belonging to 15 different species were caught during the trapping session that were conducted at seven expedition sites: 130 individuals were from diurnal species (*i.e.* belonging to Soricidae and Sciuridae families), while 41 were nocturnal (Muridae): Table 15.

The grey tree rat (*Lenothrix canus*) was captured for the first time in Kinabatangan; this a new record in the area for this species, considered rare in Borneo.

Four species were captured frequently and widely:

- Plain tree shrew (35 ind. captured at seven sites)
- Large tree shrew (34 ind. captured at six sites out of seven)
- Plantain squirrel (41 ind. captured at all seven sites)
- Mueller's rat (14 ind. captured at six sites)

These species are characteristic of degraded habitats and seem to adapt well to the current habitat situation found in Kinabatangan. In the contrary, capture rates of several forest-specialist species were lower than during previous captures of early 2000's and 2007: ear-spot squirrel, horse-tailed squirrel, slender treeshrew, etc., indicating that these specialist species are declining in the forests of Kinabatangan. This could result from inter-species competition with more adaptable generalist species, and further degradation of habitat conditions.

*Table 15: Results of small mammal trapping at seven survey sites (Survey effort=440 days and nights for each survey except *: 400 days).*

		Lot 2*	Lot 3	Lot 4	Lot 5	Lot 6	Lot 8	Lot 10	Total
SORICIDAE									
Common tree shrew (or plain tree shrew)	Tupaia longipes	2	4	4	1	6	10	8	35
Large tree shrew	Tupaia tana	4	5	7	5		5	8	34
Slender tree shrew	Tupaia gracilis		1						1
Lesser tree shew	Tupaia minor			1			2	5	8
SCIURIDAE									
Prevost squirrel	Callosciurus prevostii	3						5	8
Plantain squirrel	Callosciurus notatus	1	1	10	4	3	12	10	41
Horse tailed squirrel	Sundasciurus hippurus							3	3
Number of diurnal Individuals		***10***	***11***	***22***	***10***	***9***	***29***	***39***	***130***
Number of diurnal speciesSpecies		***4***	***4***	***4***	***3***	***2***	***4***	***6***	***7***
Trapping Success Ind.		***2.50***	***2.75***	***5.00***	***2.27***	***2.05***	***6.59***	***8.86***	***4.28***
Trapping Succes species		***1.00***	***0.91***	***0.91***	***0.68***	***0.45***	***0.91***	***1.36***	***0.23***
MURIDAE									
Small spiny rat	Maxomys baeodon	2	2	2	2				8
Whitehead rat	Maxomys whiteheadi	2	2	5				1	10
Red spiny rat	Maxomys surifer				1				1
Muller's rat	Sundamys muelleri		3	3	1	4	1	2	14
Dark tailed rat	Niviventer cremoriventer				3				3
House rat	Rattus rattus		1						1
Grey tree rat	Lenthrix canus		1						1
House mouse	Mus castaneus	1	1			1			3
Number of nocturnal Individuals		***5***	***10***	***10***	***7***	***5***	***1***	***3***	***41***
Number of nocturnal Species		***3***	***6***	***3***	***4***	***2***	***1***	***2***	***8***
Trapping Success Ind.		***1.25***	***2.27***	***2.27***	***1.59***	***1.14***	***0.23***	***0.68***	***9.32***
Trapping Succes species		***0.75***	***1.36***	***0.68***	***0.91***	***0.45***	***0.23***	***0.45***	***0.26***
Total Number of Individuals		***15***	***21***	***32***	***17***	***14***	***30***	***42***	***171***
Total Number of Species		***7***	***10***	***7***	***7***	***4***	***5***	***8***	***15***
Total Trapping Success for individuals		***3.75***	***4.77***	***7.27***	***3.86***	***3.18***	***6.82***	***9.55***	***5.63***
Total Trapping Success for species		***1.75***	***2.27***	***1.59***	***1.59***	***0.91***	***1.14***	***1.82***	***0.49***
SIMPSON INDEX		***0.827***	***0.857***	***0.801***	***0.802***	***0.684***	***0.695***	***0.834***	***0.84***
SHANNON INDEX		***1.841***	***2.108***	***1.749***	***1.758***	***1.24***	***1.325***	***1.902***	***2.12***

The small mammal assemblages found in of Lots 6 and 8 were highly uneven and were dominated by diurnal invasive and commensal species, as indicated by the biodiversity Shannon and Simpson indexes (Table 15).

Overall, the number of captures of the Muridae community (or “rats”) were well below the capture rates of diurnal species at all sites. They were also fewer than during previous capture sessions by KOCP in Kinabatangan. Rodent populations go through very fast cycles depending on food availability in the forest, and this rarefaction could only reflect a lower food abundance at the time of our surveys rather than a collapse of these communities.

Small mammal trapping was conducted at seven Lots of the LKWS. Compared to similar surveys from 2006/2007, our results showed a decline in the number of species and individuals, especially with the rat community. This could result from a lower abundance of food resources or from more complex ecological factors. The most degraded survey sites were characterized by a lower diversity of their rodent community, but had a larger presence of commensal and invasive species like the common house mouse and Asian house rat.

Amphibian surveys

Method: At each expedition site, we established Amphibian transects 400 m in length. Each transect was run between 18.00 and 21.00 pm between one and three times, depending on time availability and weather conditions. Transects were divided in 10 segments of 40 m each, and species presence/absence data was recorded for each segment. Then for each species, we calculated an encounter index summing the number of 40 m fragments where the species was detected divided by the length of transects (in km) run during the surveys. Frogs ID was done from their calls or following capture and handling (all specimen being released following ID).

Overall, the transects were located in four different habitat types:

- dry forest (2.92 km of transects or 39% of the total survey lines);
- riparian forest (2.80 km or 38%);
- semi-inundated forest (1.32 km or 18%);
- forest/oil palm interface (0.40 km or 5%).

A total of 22 different species of frogs was recorded during Amphibian surveys, adding a new species to our previous baseline assessment and bringing the total number of frog species for Lower Kinabatangan to 32: Table 16.

Half of the species were relatively uncommon and were encountered only once or twice during our surveys.

Some species however appear quite common and widespread, such as *Microhyla borniensis, Hylarana glandulosa and H. raniceps*, and *Rhacophorus appendiculatus*.

More species were detected in Lot 2 and Lot 4 than in other Lots, but this reflects a more intensive survey effort in these two Lots compared to other expedition sites. Fewer species were recorded in oil palm plantations (6 species) than in natural types of forest (average of 14 species for the three natural types: dry; riparian and semi-inundated). However, in this particular landscapes, present species were very abundant (with for example presence index of 22.5 positive 40 m segments/km for *H. glandulosa*).

Our results confirm the strong differentiation between frog assemblages in forests and non-forest sites. Frog surveys indicate that commensal frog species and habitat generalists dominate the non-forest sites; forest-dwelling species do not seem to be adapting in these disturbed habitats.

*Table 16: Relative abundance indexes of frog species identified during Amphibian surveys (In bracket, the km distance for each class - Indexes are calculated by number of times a species is identified in a 40 m long segment divided by the total linear distance of all transect in km for each survey - *are endemic frogs to Borneo)*

	LKWS Lots							Habitat Types (km)			
Spesies	**Lot 2 (2.4)**	**Lot 3 (0.4)**	**Lot 4 (2.4)**	**Lot 5 (0.8)**	**Lot 6 (0.8)**	**Lot 8 (0.8)**	**Total (all segments)**	**Dry F (2.92)**	**Riparian F (2.80)**	**Semi inundated (1.32)**	**OP Forest (0.4)**
DICROGLOSSIDAE											
Fejervarya limnocharis	1.67					3.75	**7**	0.3	1.1		7.5
Limnonectes finchi	1.25		0.42				**4**	0.3	0.7	0.8	
Occidozyga laevis			0.42				**1**			0.8	
MICROHYLIDAE											
Chaperina fusca	0.42						**1**		0.4		
Kaloula baleata			1.25		2.5		**5**	1.4		0.8	
Metaphrynella sundana*			2.92	5.0	1.25		**12**	2.7	0.4	2.3	
Microhyla borniensis*	5.0		1.67	1.25	1.25		**18**	2.1	2.9	3.0	
Microhyla perparva*	0.42		0.83		1.25		**4**	0.7		1.5	
Microhyla.sp						1.25	**1**				2.5
RANIDAE											
Hylarana glandulosa	0.42	2.5	1.25	1.25		16.25	**19**	1.0	1.1	3.0	22.5
Hylarana nicobariensis			0.83			7.5	**8**			3.8	7.5
Hylarana raniceps	0.42	2.5	0.42	1.25	3.75	2.5	**9**	1.4	0.7.	0.8	5.0
RHACOPHORIDAE											
Nyctixalus pictus			0.42				**1**			0.8	
Polypedates colletti*	0.42		0.83		1.25		**4**	1.4			
Polypedates leucomystax				2.5		2.5	**4**	0.3	0.4		5.0
Polypedates macrotis	0.42		0.83		3.75		**6**	0.7	0.7	1.5	
Polypedates otilophus		2.5					**1**		0.4		
Rhacophorus appendiculatus	0.83	10.0	7.92	5.0	7.5	3.75	**38**	7.9	1.8	7.6	
Rhacophorus dulitensis			0.42				**1**			0.8	
Rhacophorus harrissoni*		2.5					**1**		0.4		
Rhacophorus pardalis			2.5	1.25	3.75		**10**	2.4	0.4	1.5	
unknown sp	1		1				**2**		0.4	0.8	
Number of presence per 40 m segments	**28**	**8**	**56**	**14**	**21**	**30**	**157**				
Number of species	**11**	**5**	**16**	**7**	**9**	**7**	**21**	**13**	**14**	**15**	**6**

Bird surveys

A bird checklist was compiled during our expedition.

Method: Birds were detected opportunistically throughout the survey period and during specific searches conducted early morning or late afternoon by experienced KOCP researchers. Only birds that could be positively identified through direct sightings and/or calls were recorded. Depending on the number of times bird species were detected, they were assigned the status "Common" (present at five or more field expeditions); "Fairly Common" (three or four field expeditions) or "Rare (one or two field expeditions): see Table below.

During the field expeditions, the team recorded a total number of 152 bird species belonging to 43 families, including five endemic species:

- Bornean falconet (*Microhierax latifrons*),
- Dusky munia (*Lonchura fuscans*),
- Yellow-rumped flowerpecker (*Prionochilus xanthopygius*),
- Bornean blue flycatcher (*Cyornis superbus*),
- White-crowned shama (*Copsychus stricklandi*).

The number of species detected at each Lot fluctuated between 57 (Lot 4) to 97 (Lots 8/9): Fig. 1.

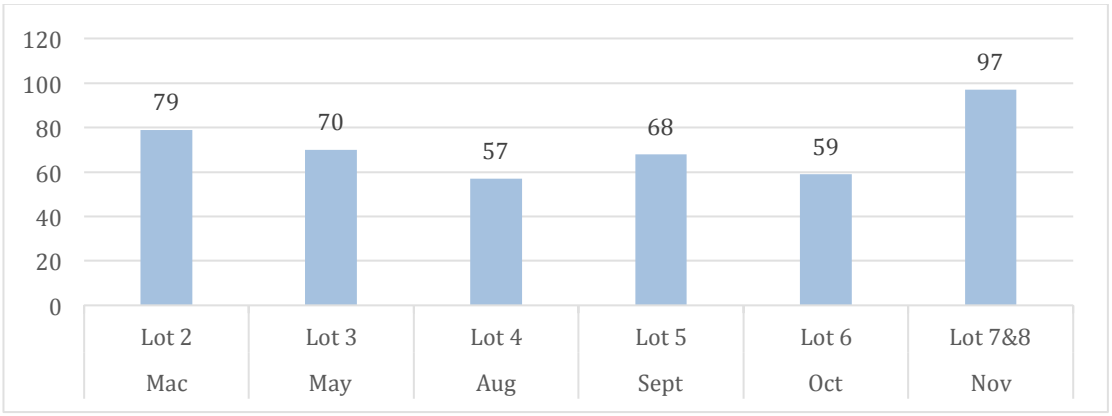
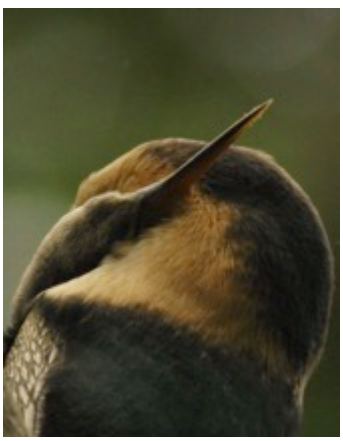


Fig. 1: *Number of bird species detected at each survey Lot during field expeditions.*

A total of 82 species were detected at one or two field expeditions only: they were considered "Rare" (Table 17); a total of 32 species were detected at three or four sites ("Fairly Common": Table 18), while total of 38 species were detected at five or more field expedition sites: ("Common": Table 19).



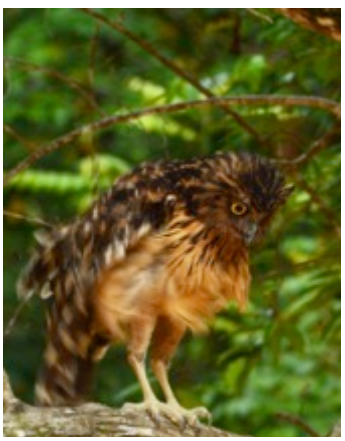


Table 17: "Rare species", or species detected only at one or two expedition sites.

ACCIPITRIDAE	Black-winged Kite	1
	Blyth's hawk-eagle	1
	Jerdon's Baza	1
ALCEDINIDAE	Collared Kingfisher	2
	Ruddy Kingfisher	1
	White-Collared Kingfisher	1
ARDEIDAE	Cinnamon Bittern	1
	Grey Heron	1
	Schrenk bittern	1
	Yellow bittern	1
BUCEROTIDAE	Helmeted Hornbill	1
	Wreathed Hornbill	2
CAMPEPHASIDAE	Scarlet Minivet	1
CAPRIMULGIDAE	Malaysian-eared Nightjar	1
CISTICOLIDAE	Dark-necked tailorbird	2
COLUMBIDAE	Cinnamon-headed Green Pigeon	1
	Grey Imperial Pigeon	2
	Spotted Necked Dove	1
	Zebra Dove	1
CUCULIDAE	Banded-bay Cuckoo	1
	Chestnut-bellied Malkoha	2
	Chestnut-breasted Malkoha	2
	Chestnut-winged Cuckoo	2
	Indian Cuckoo	1
	Lesser coucal	2
	Red-billed Malkoha	2
DICAEIDAE	Crimson-Breasted Flowerpecker	1
	Orange-bellied Flowerpecker	2
	Scarlet-backed Flowepecker	2
	Yellow-rumped flowerpecker	2
DICRURIDAE	Greater Racquet-tailed Drongo	1
ESTRILDIDAE	Chestnut Munia	1
	Dusky Munia	2
EURYLAIMIDAE	Banded Broadbill	2
	Dusky Broadbill	1
FALCONIDAE	White-fronted Falconet	1
IRENIDAE	Asian Fairy Bluebird	2
LANIDAE	Long-tailed Shrike	1
LOCUSTELLIDAE	Striated Grassbird	1

PITTIIDAE	Garnet Pitta	1
PSITTACIDAE (PARROTS)	Long-tailed Parakeet	1
PYCNONOTIDAE	Cream-vented Bulbul	2
	Olive-winged Bulbul	1
	Puff-backed Bulbul	1
	Straw-headed Bulbul	1
	Yellow-vented Bulbul	2
RALLIDAE	White-breasted waterhen	2
RAMPHASTIDAE	Golden-whiskered Barbet	1
	Red-crowned Barbet	1
STRIGIDAE	Oriental Bay Owl	2
STURNIDAE	Asian Glossy Starling	1
	Common Myna	1
	Crested Myna	1
	Javan Myna	1
TIMALIIDAE	Chestnut-rumped Babbler	2
	Ferruginous Babbler	2
	Striped-tit Babbler	1
	White-chested Babbler	1
TROGONIDAE (TROGONS)	Diard's trogon	1
MUSCICAPIDAE	Blue & White Flycatcher	1
	Brown-chested Jungle Flycatcher	1
	Indigo Flycatcher	1
	Oriental Magpie Robin	2
	Rufous-tailed Shama	2
	Asian Brown flycatcher	2
NECTARNIIDAE	Bronze-throated Sunbird	2
	Olive Backed Sunbird	2
	Purple-throated Sunbird	1
	Red-throated Sunbird	1
	Ruby-cheeked Sunbird	1
PASSERIDAE	Eurasian Tree-sparrow	1
PHASIANIDAE	Blue-breasted Quail	1
	Chesnut-necklaced hill Patridge	2
	Crested Fireback	1
	Great Argus	2
	Red Jungle Fowl	1
PICIDAE	Common Flameback woodpecker	1
	Crimson-winged Woodpecker	1
	Greater Goldenback Woodpecker	1
	Orange-backed Woodpecker	1
	Rufous Woodpecker	1
PICUMINAE	Rufous Piculet	1

Table 18: "Fairly common species", detected at three of four sites.

ACCIPITRIDAE	Grey-headed Fish-Eagle	3
	White-bellied Sea-Eagle	4
	Blue-eared kingfisher	4
	Rufous-backed Kingfisher	4
ARDEIDAE	Intermediate Egret	3
	Striated Heron	3
ARTAMIDAE	Pasific Swallow	3
	White-breasted woodswallow	3
CICONIIDAE	Lesser Adjutant	3
COLUMBIDAE	Emerald Dove	3
	Little-green Pigeon	4
CORVIDAE	Large-billed Crow	3
CUCULIDAE	Plaintive Cuckoo	4
	Raffles's Malkoha	3
DICRURIDAE	Bronzed Drongo	4
MUSCICAPIDAE	Borneon Blue flycatcher	3
	Malaysian Blue Flycatcher	4
	Asian Paradise Flycatcher	3
NECTARNIIDAE	Brown-throated Sunbird	4
	Little Spiderhunter	3
PICUMINAE	Buff-necked Woodpecker	4
PICIDAE	White bellied woodpecker	4
PSITTACULIDAE	Blue-crowned hanging Parrot	4
PYCNONOTIDAE	Grey-cheeked Bulbul	3
	Red-eyed Bulbul	3
RAMPHASTIDAE	Blue-eared Barbet	3
SCOLOPACIDAE	Common Sandpiper	3
STERNIDAE	Little Tern	4
STRIGIDAE	Brown wood Owl	3
TIMALIIDAE	Black-capped Babbler	3
TROGONIDAE	Red-naped Trogon	3
	Scarlet-rumped Trogon	4

Table 19: "Common species", detected at five or more expedition sites.

ACCIPITRIDAE	Brahminy Kite	5
	Crested Serpent Eagle	6
	Lesser Fish-Eagle	5
	Wallace's Hawk-Eagle	5
AEGITHINIDAE	Common Iora	5
ALCEDINIDAE	Stork-billed Kingfisher	6
ANHINGIDAE	Oriental Darter	5
ARDEIDAE	Great Egret	6
	Little Egret	6
	Purple Heron	6
BUCEROTIDAE	Black Hornbill	6
	Bushy Crested Hornbill	5
	Oriental Pied Hornbill	6
	Rhinoceros Hornbill	6
	White Crowned Hornbill	6
	Wrinkled Hornbill	5
CICONIIDAE	Storm's Stork	6
CISTICOLIDAE	Red-headed Tailorbird	6
	Rufous-tailed Tailorbird	6
COLUMBIDAE	Green-imperial Pigeon	6
CORACIDAE	Dollarbird	6
CORVIDAE	Slender-billed Crow	5
CUCULIDAE	Greater Coucal	5
EURYLAIMIDAE	Black and Red Broadbill	5
	Black and Yellow Broadbill	5
MEROPIDAE	Blue-throated Bee Eater	6
MONARCHIDAE	Black-naped Monarch	5
MUSCICAPIDAE	White-crowned Shama	6
NECTARNIIDAE	Eastern Crimson Sunbird	5
NYCTICORAX	Black-crowned Night-Heron	5
PITTIDAE	Hooded Pitta	5
RAMPHASTIDAE	Brown Barbet	5
RHIPIDURIDAE	Pied Fantail	6
STRIGIDAE	Buffy Fish-Owl	6
STURNIDAE	Hill Myna	6
TIMALIIDAE	Chestnut-winged Babbler	6
	Short-tailed Babbler	6
	Sooty-capped Babbler	6

Opportunistic sightings

The team recorded opportunistically any wildlife sightings during their field activities, in particular along recce walks conducted during the day and at night.

Method: The basic principle of recce walks (RWs) is to take the path of least resistance to move across the forest. During these investigations, data were recorded about habitat types, length, types of human exploitation, forest structure and composition, wildlife signs of presence, etc. Then index of encounters (number of sightings/length of the recce walk) are estimated to compare sites together.

The team ran 85.8 km of recce walks across the different field sites: Table 20.

Table 20: Distance and habitat types ran during recce surveys of the LKWS Field expeditions

HABITAT	LOT 2	LOT 3	LOT 4	LOT 5	LOT 6	LOT 7	LOT 8	Distance (km)	Percentage
Riparian forest	3.13	2.04	6.16	1.89	1.68	-	-	**14.89**	**17.4%**
Lowland dry forest	5.04	7.96	6.97	8.27	8.71	0.81	2.81	**40.57**	**47.3%**
Semi swamp forest	4.79	5.38	3.45	2.91	0.17	0.81	1.01	**18.52**	**21.6%**
Swamp forest	4.39		2.39	1.53		0.68	0.55	**9.54**	**11.1%**
Border with oil palm plantations	-	0.66	-	-	1.60	-	-	**2.26**	**2.6%**
Distance (km)	**17.35**	**16.04**	**18.97**	**14.59**	**12.16**	**2.30**	**4.38**	**85.79**	
Percentage	**20.2%**	**18.7%**	**22.1%**	**17.0%**	**14.2%**	**2.7%**	**5.1%**		

The list of species presence recorded during these recce walks is given in Table 21.

Table 21: Species recorded during recce walks at seven expedition sites.

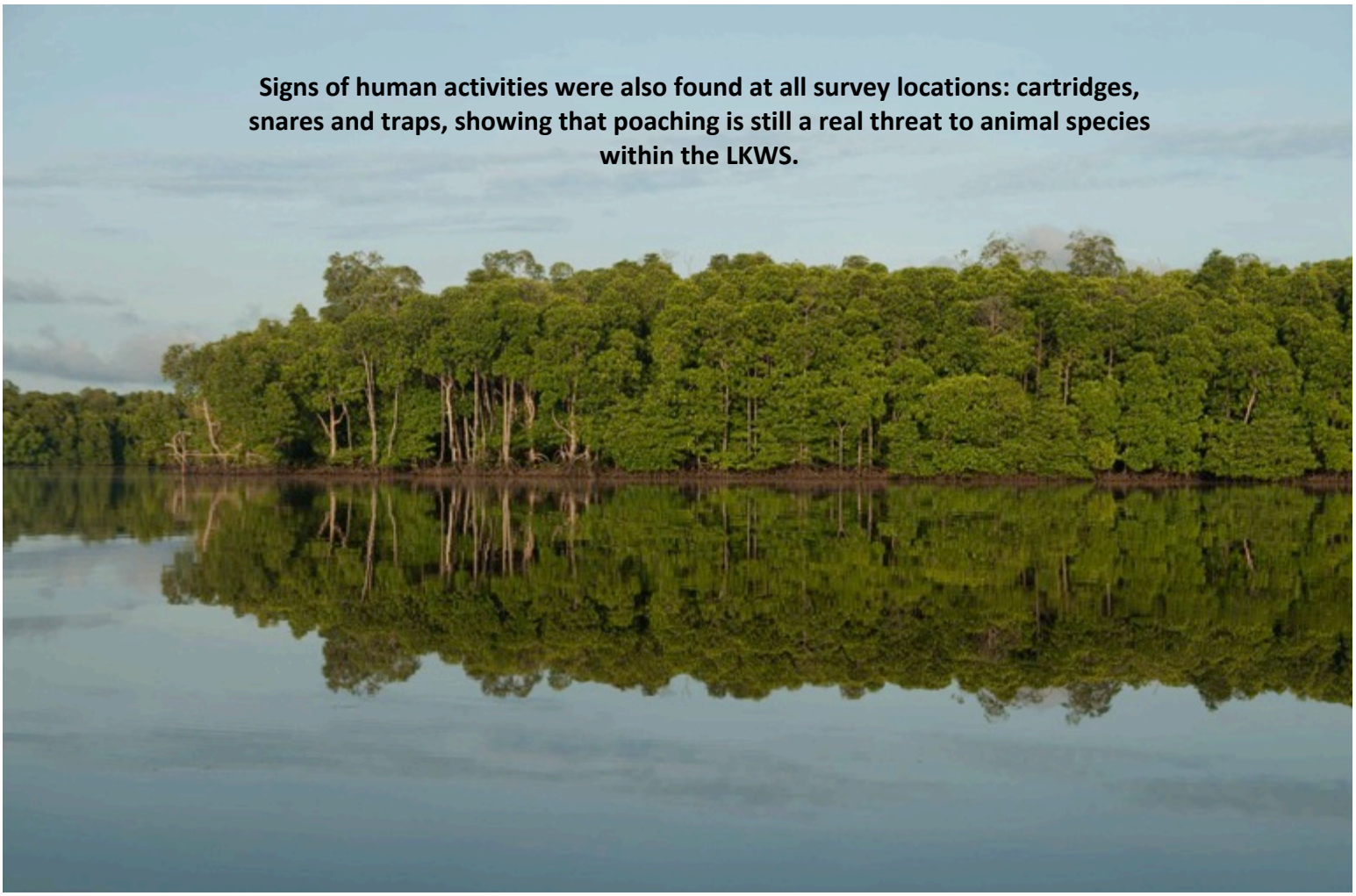
CLASS	SPESIS	LOT 2	LOT 3	LOT 4	LOT 5	LOT6	LOT 7	LOT8
MAMMALIA	Bearded pig	x	x	x	x	x	x	x
	Bornean Elephant	x	x	x	x	x	x	
	Bornean Pygmy Squirrel			x				
	Civet sp.	x	x	x	x	x		
	Flying lemur		x					
	Giant squirrel	x						
	Malay badger		x			x		
	Mouse Deer	x	x			x	x	
	Otter. sp					x		
	Prevost squirrel					x		
	Sambar Deer	x	x	x	x	x	x	x
	Sun Bear	x	x	x	x	x		x
	Wild Cat (unk. sp.)	x		x		x		
REPTILIA	Asian leaf Turtle		x					
	Malasian Box turtle				x			
	Mangrove cat snake		x					
	Rough-necked Monitor					x		
	Saltwater Crocodile					x		
	Water monitor Lizard	x	x		x	x	x	x

The list shows that several species of large mammal still species have a wide distribution in the LKWS: bearded pig (*Sus barbatus*), Sambar deer (*Cervus unicolor*), sunbear (*Helarctos malayanus*) and Bornean elephant (*Elephas maximus borneensis*). These species are rather generalists and adapt fairly well to degraded conditions and low hunting pressure, characteristic of the forests of the Lower Kinabatangan.

Not surprisingly, signs of wild boar presence were widespread and found at all survey locations and in different habitat types: Table 22. Elephant signs were also widespread in the lower part of the floodplain. They were not detected in Lot 8 since this Lot is not accessible to the herd because of the Lahad Datu-Sandakan road. Signs of sambar deer were common in wet habitats (SF and SSF), and were frequent in particular in Lots 2 and 8 of the LKWS. Signs of sun bear were also found in nearly all lots and all habitat types investigated during our surveys.

Table 22: Encounter indexes of several large mammal species in seven Lots of the LKWS and per habitat type (LDF=Lowland Dry Forest; RF=Riparian Forest; SSF=Semi Swamp Forest; SF=Swamp Forest; OP/F=Border Oil Palm/Forest): all numbers expressed by number of sightings/km.

	Km	Bearded pig	Sambar deer	Mouse deer	Sunbear	Elephant
Lot 2	*17.35*	3.39	3.28	0.35	0.35	2.94
Lot 3	*16.04*	3.43	0.50	0.37	0.12	1.31
Lot 4	*18.97*	2.37	0.74	-	0.58	0.68
Lot 5	*14.59*	1.71	0.68	-	0.48	0.89
Lot 6	*12.16*	3.29	0.82	0.41	0.32	1.07
Lot 7	*2.3*	6.96	0.87	0.43	-	1.74
Lot 8	*4.38*	6.39	2.06	-	0.68	-
TOTAL		**3.30**	**1.39**	**0.23**	**0.42**	**1.45**
HABITAT TYPES						
LDF	*40.57*	3.38	0.84	0.20	0.39	1.01
RF	*14.89*	2.08	0.87	0.07	0.47	1.95
SSF	*18.52*	3.24	1.62	0.43	0.49	1.46
SF	*9.54*	3.35	3.46	-	0.10	1.78
OP/F	*2.26*	2.20	-	0.44	2.65	0.44



Signs of human activities were also found at all survey locations: cartridges, snares and traps, showing that poaching is still a real threat to animal species within the LKWS.