Biomonitoring in the Proposed Grebo-Krahn National Park

REPORT ON PHASE 2 IN THE PROPOSED GREBO-KRAHN NATIONAL PARK
(February-June 2015)

Prepared by Wild Chimpanzee Foundation

In collaboration with Forestry Development Authority, Liberia

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Executive summary

A- Generalities and methods of biomonitoring program

This report presents results from the biomonitoring program in 2015 in the Proposed Grebo-Krahn National Park (PGKNP), undertaken by survey team members from the Forestry Development Authority (FDA) and local communities, and with the supervision of the Wild Chimpanzee Foundation (WCF). Data was collected between the 26th February 2015 and the 17th of June 2015. A total of 249.32km of line transects were surveyed across the park, following the same systematic design from 2014. Data was collected on the signs of presence of large mammals, hunting and habitat disturbance (farming, mining, etc.). It was then analysed to determine the current status of wildlife and threats within the proposed park, as well as monitor their population trends.

B- Abundance and spatial distribution of large mammals in Proposed Grebo-Krahn National Park (PGKNP)

Two types of information were recorded: direct observations of large mammals and other animals and their indirect observations (dung, footprints, vocalizations, feeding sites and sleeping nests for chimpanzee...). Data was analysed to determine the encounter rates for each species and the spatial distribution of target species (chimpanzees, monkeys, duikers, etc.). A population estimate of chimpanzees was also calculated and provided the current estimate of 313 individuals. The data supports the idea of a stabilisation of the chimpanzee population as it is within the confidence limits of the 2014 population estimate. Some variation in distribution and encounter rates of other mammals have been documented but a longer time perspective is needed before confirming potential population trends. The isolated patch in the south of the park is an important area for biodiversity and endangered species and signs of wildlife along the Cavalla River have increased since the first phase of biomonitoring.

C-Threats to wildlife of the PGNP

The data collected on anthropogenic activities was treated in the same way as the wildlife data. Results seem do show a marked decrease in hunting activity, but these results must be treated with caution as the Ivorian border has been closed and there has been a ban on bush meat since the Ebola outbreak in Liberia. The expansion of Boley Village is now clearly having a negative effect of the wildlife in the horn in the north of the park. Chewing stick signs were still high within the park, but since the end of data collection law enforcement missions have taken place targeting chewing stick camps within PGKNP.

D-Conclusion and Recommendations

Though PGKNP still harbours high levels of biodiversity and hunting levels have decreased, FDA needs to remain vigilant that hunting pressures do not increase in a post-Ebola environment. The eviction of Boley Village must be a priority as the negative impact of hunting and farming in this settlement is having an effect on the distribution of wildlife in the north of the park. Continuing the process leading to the pre-gazettement of the park is essential in 2016 with activities such as boundary line flagging, community consultations, regional and national level meetings needed before the gazettement package can be submitted.

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LIST OF ACRONYMS

CV: Coefficient of variation
FDA: Forestry Development Authority
GNF: Grebo National Forest
IUCN: International Union for the Conservation of Nature
PGKNP: Proposed Grebo-Krahn National Park
TGSFC: Taï-Grebo-Sapo Forest Complex
TNP: Taï National Park
UTM: Universal Transverse Mercator
WCF: Wild Chimpanzee Foundation

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1. INTRODUCTION

As part of the Liberian Government's Protected Area Network Strategy, the Wild Chimpanzee Foundation (WCF) is working in close collaboration with the Forestry Development Authority (FDA) to create the Grebo-Krahn National Park in southwest Liberia (Grand Gedeh and River Gee counties). Located in the heart of the Taï-Grebo-Sapo Forest Complex (TGSFC), its creation and management is crucial to the integrity of this last block of forest of the Upper Guinean Forest Ecosystem.

WCF and FDA have been working together for the creation of the PGKNP since 2012, and have completed two wildlife surveys (in 2012 and 2013). In 2014, the WCF and FDA launched the 1st phase of biomonitoring for the proposed park. Since the 2012, and 2013 results have assisted FDA and WCF in redesigning the new boundary lines of the park, to reduce impact on local communities, while including other areas of the original Grebo National Forest that harbour high levels of biodiversity, the 2014 survey provided the new baseline data to guide management decisions and with which to compare new biomonitoring data to monitor trends in wildlife populations and anthropogenic threats

This report presents the methodology used, and the major results of the second phase of biomonitoring, which was undertaken from February 2015 to July 2015. Results include spatial distribution of large mammals (including chimpanzees and elephants), anthropogenic threats and a population estimate on chimpanzees in PGKNP. We conclude with various recommendations to continue long-term conservation and sustainable management in PGKNP and the Taï-Grebo-Sapo Forest Complex.

2. METHODS

2.1. Study area

The Proposed Grebo-Krahn National Park (PGKNP) is located in a forest previously known as Grebo National Forest (GNF), existing since the 1950s. PGKNP forms part of Liberia's Proposed Protected Area network. Figure 1 shows the new proposed boundary lines (currently being ground-truthed and flagged by the FDA), and highlights areas of overlap with the Grebo NF, and areas that belonged to communities and have thus been removed for the park. The Glaro Native Reserve is land that belongs to the community of Glaro for example and thus is no longer to form part of the park. The northern area that extends to form a natural corridor linkage with the Cavally Classified Forest in Côte d'Ivoire has been included, as this area was shown to harbour high levels of chimpanzees, other biodiversity and some species such as leopards and golden cats that have not been observed in any other area of the proposed park. This would also ensure the connectivity between these two important forests.

The new Proposed Grebo-Krahn National Park now covers 106,712 ha, though this might change slightly once the boundary line has been ground-truthed completely. The Proposed Park is located in two counties, River Gee and Grand Gedeh. The western border is formed by the Dugbe River while the eastern border is formed by the Cavalla River, also the border with Côte d'Ivoire. The rest of the border largely follows the original border of the Grebo National Forest, always known and respected by the local communities. The Proposed Park is separated into two distinct areas, one of which is an isolated patch surrounded by the Glaro Native Reserve and the Cavalla River. In the future, land use to establish linkages between the two distinct areas should be done.

We conducted the study across the whole of the new Proposed Grebo-Krahn National Park and the Glaro Reserve, as the final decision to not include this in the park was based on some

of these results and work led simultaneously with local communities. Additionally, the use of transects in the Glaro Native Reserve were walked to allow for better comparison with the data and results from 2014. The forest here is a wet evergreen forest contiguous with the Cavally Classified Forest and very close to Taï National Park, both situated in Côte d'Ivoire. It lies in the heart of the Taï-Grebo-Sapo Forest Complex, the largest remaining forest bloc of the Upper Guinean Forest Ecosystem, a biodiversity hotspot. Its creation and location is key to the Taï-Grebo-Sapo Forest Complex Transboundary Initiative between Côte d'Ivoire and Liberia. Several big mammal species are known to inhabit the Proposed Grebo-Krahn NP including the critically endangered Western chimpanzee *(Pan troglodytes verus*), the forest elephant subspecies *(Loxodonta africana cyclotis*) and other endangered species such as the pygmy hippopotamus *(Hexaprotodon liberiensis)*, Jentink's duiker *(Cephalophus jentinki)*, red colobus monkey *(Procolobus [Piliocolobus] badius)* and Diana monkeys *(Cercopithecus diana diana*) (see IUCN red data list 2012).

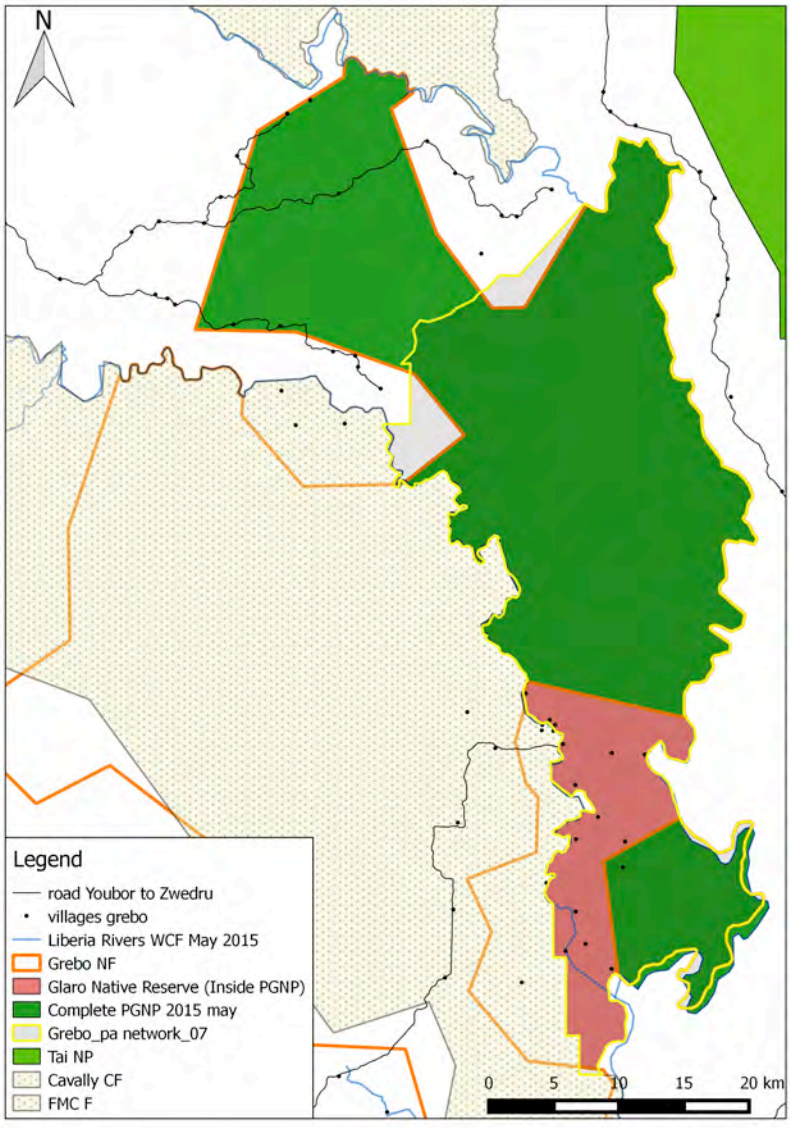

Figure 1 Map showing the location of the new Proposed Grebo-Krahn National Park in comparison to the Grebo National Forest, the original Proposed Grebo Park that included at the time the Glaro Native Reserve

2.1. Biomonitoring survey design

To allow for robust analysis, we used a systematic survey design covering the entire new Proposed Grebo-Krahn National Park, called Grebo-Krahn NP subsequently. The design was originally prepared in 2014 for the 1st phase of biomonitoring in Grebo-Krahn NP. The use of the same design allows for direct comparison with the data collected previously following the same design and methods.

The design follows IUCN standards for transect surveys for great apes (Kühl et al., 2008), in which the whole of the Grebo-Krahn NP is covered using a systematic arrangement of transects. Such a spatial arrangement of survey transects is known to be effective for unbiased studies of the distribution and densities of large wild mammals in tropical forests (Norton-Griffiths 1978; Plumptre, 2000; Buckland et al, 2001) (Figure 2a).

The groups of transects, composed of four transects each, were regularly spaced to allow for accurate estimates of abundance as well as accurate estimates of spatial distribution of animal species (Norton-Griffiths 1978; Plumptre, 2000, Buckland et al., 2001). Each transect is composed of 4 segments of 500 m each, meaning a total length 2 km per transect and 8 km per group. For clarity we provided details of the group of transects Gr9 in Figure 2b (below) with Gr9A, Gr9B, Gr9C and Gr9D being the 4 transects of the group**.** Overall, the targeted sampling effort in Grebo-Krahn NP is 264 km.

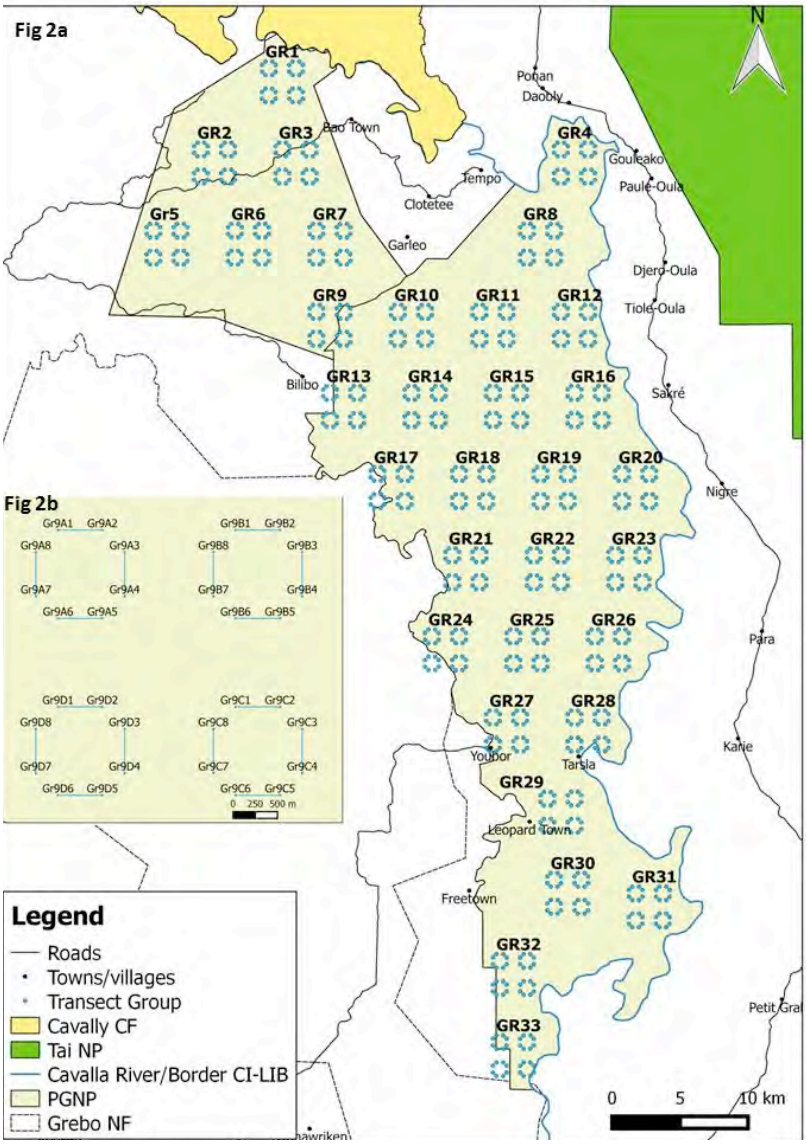

Figure 2: Overall survey design for the biomonitoring 2015 in the Grebo-Krahn NP (2a) and an example of a group of transects (2b).

2.2. Field data collection along line transects and local capacity building

Data were collected from the 26th February 2015 to the 17th June 2015 by three teams supervised by individuals from the Wild Chimpanzee Foundation (Zoro Goné Bi Irié Berenger, Jimmy Parker) alongside individuals from FDA (Clement Tweh). Team members were composed of FDA auxiliaries and local community members, most of which have extensive experience in data collection, having completed biomonitoring and other surveys in Grebo Forest in the past and other surveys across the country with WCF and other partners.

Each of the three teams is made of 6 data collectors (names are provided in Appendix 1), all of whom followed a re-training workshop in February 2015. The workshop lasted seven days and allowed the team members to revise data collection methodology, use of equipment and species identification. An evaluation process showed that the team members increased their knowledge overall by 20.1%. Each team consisted of six Liberians, either rangers/auxiliaries of the FDA, or local community members (details in Annexe 1). Training included animal

identification, tracking signs, GPS training, reading of UTM coordinates, and how to measure perpendicular distances, fill in data sheets, and walk along the transects, etc.

When conducting the survey, the teams walk one transect (2 km) on average per day, following the GPS. 4 team members walk directly on the transect, while 2 others walk either side. Data is collected following the IUCN Great Ape Survey Standards (Kuhl et al., 2008). Data on all direct observations of large mammals is recorded as well as on indirect observations for monkeys, duikers, elephants, chimpanzees and other important species. Indirect observations can be vocalizations, tracks, dung and nests (specifically for chimpanzees). For the latter, perpendicular distances are also recorded to provide data needed to quantify the population numbers of chimpanzees. Details of nest counts on line transects using distance sampling methodology are described elsewhere by Buckland et al. (2001) and Kouakou et al. (2009). Lastly, any sign of anthropogenic activity was also recorded (e.g. hunting, farming, mining, etc.) as well as ecological factors (habitat type). The detailed methodology is available upon request.

2.3. Data analysis

The collected data were saved and organized in an Excel file using mainly the following options: filter, sort, pivot table and pivot chart. Globally, analysis consisted of calculations of survey efforts and estimations of animals' population sizes and spatial distribution using the programs Excel, Distance 6.0 and ArcMap 10.2. Encounter rates were then compared with the data from 2014.

2.4.1. Survey effort and encounter rates of species

Survey effort was calculated by summing the total distance effectively walked by team members along each transect during data collection. Encounter rates of species were calculated by dividing the number of all observations of species presence signs (vocalization, dung, footprint, feeding signs and sleeping nests for chimpanzee) by the distance walked during the survey.

2.4.2. Chimpanzee population status analysis

To estimate the population size of chimpanzees in Grebo-Krahn NP, the density of nests along transects was calculated using the Distance 6.0 program (Plumptre, 1996, Buckland 2001; Kühl et al. 2008**;**). Nest density was converted to chimpanzee density using the mean lifetime of nests and the nest production rate following the methodology described by Kouakou et al. (2009). Given that no habituated chimpanzee group exists in Grebo-Krahn NP, for our conversions, we used the value of nest production (1.14 days) and decay rates (91.22 days) estimated from Taï NP, due to the proximity and similarity of habitat conditions to the study area (Kouakou et al. 2009). The population estimate was then compared with that of 2014.

2.4.3. Spatial distribution and population dynamics of large mammals and their threats in the Proposed Grebo National Park

To estimate the spatial distribution of chimpanzees and other large mammals as well as anthropogenic activities in the proposed park, we used presence signs assigned to each species, and all anthropogenic activities, and performed spatial analysis in ArcGIS 10.2. We used the Inverse Distance Weighted (IDW) option from the spatial analysis tools to estimate abundance and encounter rates of the distribution of animal presence and anthropogenic

activities in the entire study area, including un-sampled locations (Li and Heap 2008). The spatial distribution was then compared with the spatial distribution from 2014.

3. RESULTS

3.1. Survey effort and review of observations along line transects

In 2015, the three teams walked a total of **249.32 km** of line transects, representing **94.44%** of the theoretical survey effort targeted (L= 264 km). The main reason for not completing the total target effort was due to large obstacles such as watercourses, valleys and "sacred forests" of the local communities for which the survey teams were not given permission from the communities to enter. For example, Dugbe River could not be crossed and so transect Gr24D could not be sampled. The survey effort of 2015 is marginally higher than the 242.73 km walked during the 2014 survey. Given that is the first year where the methodology has been replicated, direct comparisons with the results from the 2014 phase can be made.

In total, **5,353** observations confirming the presence of wild animals in Grebo-Krahn NP were recorded (both direct and indirect). 79.5% (i.e. 4,256) of observations were of mammals, 15.8% (843) were of birds and the rest were other species. These figures compare well with the 2014 data which showed that 79.01% of observations were of mammals and 17.7% were of birds. **Error! Reference source not found.** summarizes the number of observations made with **more than 30 species encountered** (including birds and reptiles, etc.)**.** Note that signs of bovids and suidae were the most common of mammals, whilst signs of elephants, rodents, pygmy hippopotamus, water chevrotain and giant pangolin were relatively rare. Observations recorded on carnivores were surprisingly high, with 878 recorded in comparison to 70 in 2014. They included presence signs of the leopard, Liberian mongoose, golden cat, African civet and the Padrine genet. Concerning threats to the wildlife in Grebo-Krahn NP, we recorded **976** signs of human activities (compared to 1,472 in 2014), of which 597 were poaching signs and 379 were signs of habitat disturbance (cut trees, farms, mining sites, etc.…).

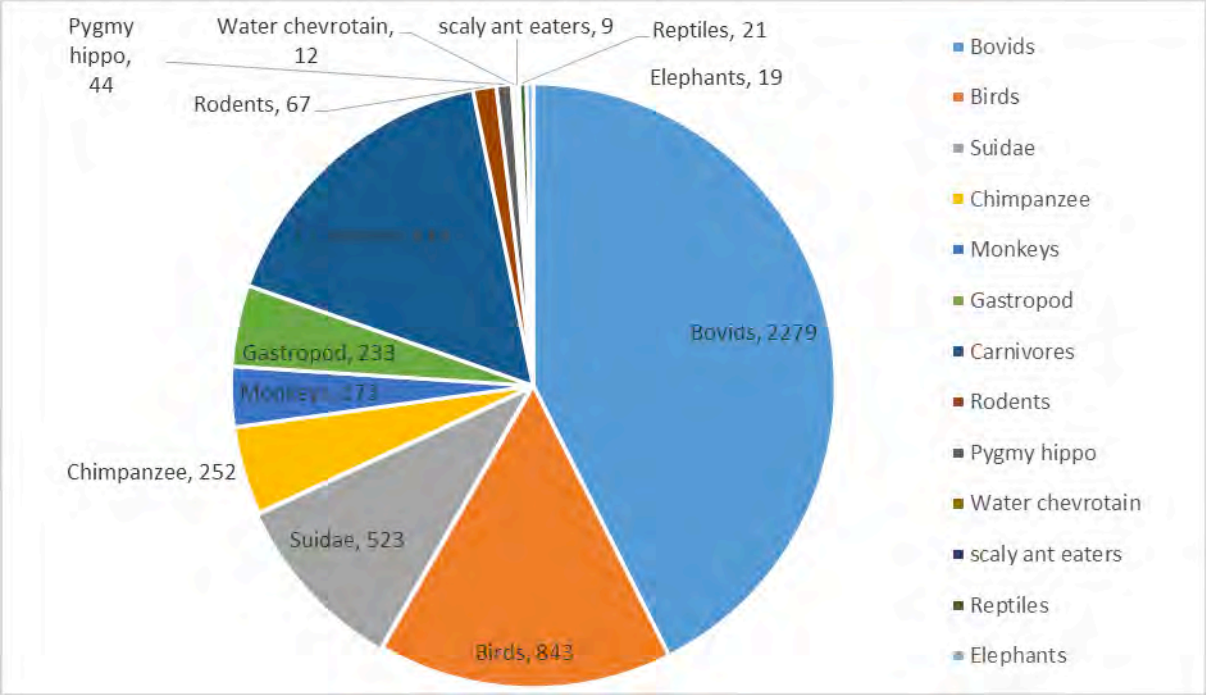

Figure 3: Numbers of all direct and indirect observations of animals along line transects during the 2014 survey in the Grebo-Krahn NP.

Globally, we found a high array of biodiversity in the new Grebo-*Krahn* NP, with more than two signs observed per kilometre walked throughout the forest (Figure 4). When comparing phase 1 (2014) and phase 2 (2015), signs of large mammals have seemingly decreased in the northern region of the park and increased in the southern areas of the park. Figure 4-A1 and B1 shows that in phase 1 in the horn of Grebo-*Krahn* NP there were more than 32 signs/km of large mammals throughout this area of the park, whereas in phase 2, this area of high density has been severely constricted and high densities are now only found in the area of forest contiguous with Cavally Classified Forest (Figure 4-B1). Even though the number of observations of large mammals seemed to have decreased between the two phases, there are still more than 24 signs/km of large mammals almost throughout the horn in the north.

In the centre of the park (Figure 4-A2 and B2) in phase 1, there was an area of high concentration of large mammals, but closer to the Cavalla River, there seemed to be a marked decrease in large mammal signs. In phase 2 (Figure 4-B2), the data suggests there are still large patches of high large mammal signs, but the overall spread of large mammal signs has increased, with an increased presence of large mammal signs along the Cavalla River, possibly caused by reduced hunting levels in this area of the park since the border with Côte d'Ivoire has been closed due to the Ebola outbreak.

In the isolated patch in the south of *Grebo-Krahn* NP (Figure 4-A3 and B3), the first phase of biomonitoring showed a relatively low presence of large mammal species with the majority of the isolated patch showing less than 24 signs/km of large mammals. In the second phase of biomonitoring, the results show that there has been a drastic increase in large mammal signs in the isolate patch, almost the entire area giving results of more than 24 signs/km and some areas producing results of over 32 signs/km of large mammals.

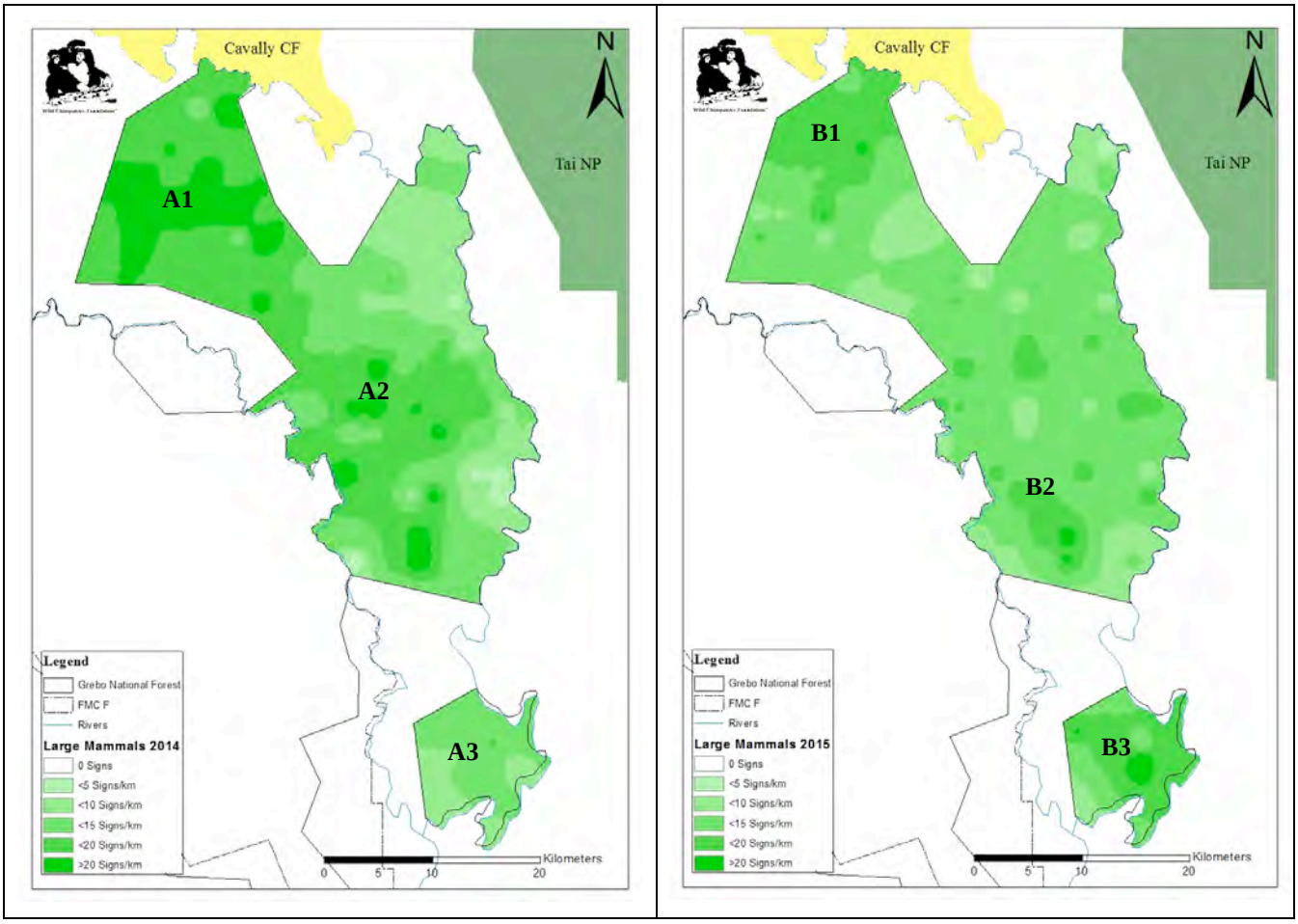

Figure 4: Spatial distribution maps of large mammal diversity observed in 2014 (left) and 2015 (right) in Grebo-Krahn NP. Areas A1 and A2 indicate areas of high abundance in phase 1, whereas A3 indicates an area of relatively low abundance. B1, B2 and B3 all indicate areas of high abundance in phase 2 of biomonitoring in PGKNP.

The spatial distribution of endangered large mammal species, observed during biomonitoring surveys is indicated in Figure 5. Throughout the two phases it is possible to find endangered species throughout Grebo-*Krahn* NP although the distribution has changed between phase 1 and phase 2.

In the north of the park, the distribution of endangered species has seen a dramatic change between the two phases (Figure 5-A1 and B1). In phase 1, the majority of the horn of the park showed more than 6 sings/km of endangered species(Figure 5-A1), whereas in phase 2, drastic changes are displayed (Figure 5-B1), with only two small patches near to Cavally Classified forest showing more than 6 signs/km of endangered species.

In the centre of the park, the area of the park just north of the Glaro Native Reserve is showing high signs of endangered species in both phase 1 and 2 (Figure 5-A2 and B2). In phase 2, there are small pockets within the park not present in the phase 1 that show more than 6 signs/km of endangered species. What has also changed between the two phases in the centre of the park is a seeming increase in signs of endangered species along the Cavalla River in the second phase.

The isolated patch in the south of the park seemed to show an increase in signs of endangered species between the two phases (Figure 5-A3 and B3). In the first phase of biomonitoring,

there were two small areas that showed more than 6 signs/km of endangered species. In the second phase of biomonitoring, the isolated patch, displays a much larger area that has more than 6 signs/km of endangered species (Figure 5-B3).

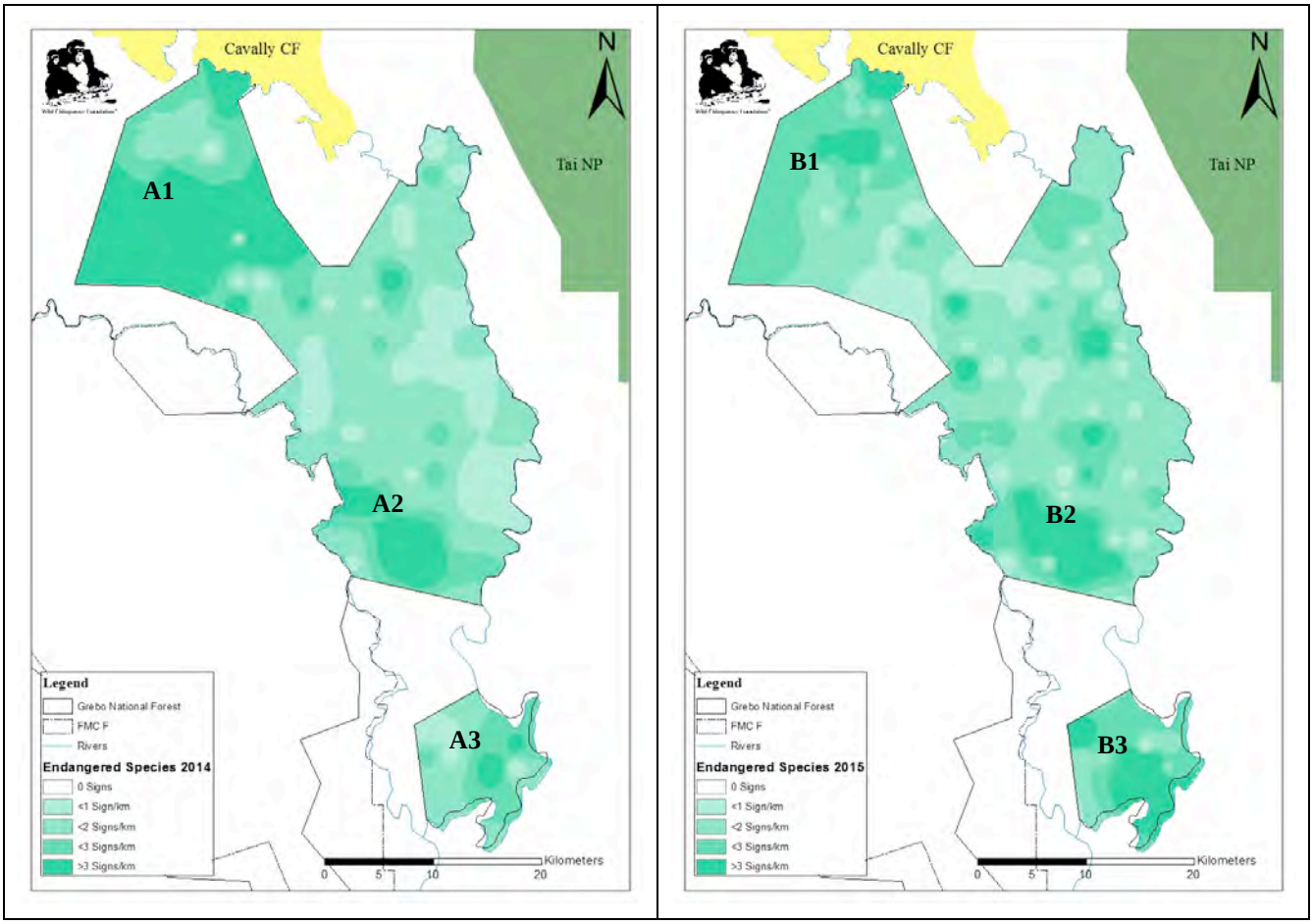

*Figure 5: Spatial distribution maps of endangered and critically endangered species (*chimpanzees, red colobus, Jentink's duiker and pygmy hippopotamus*) observed in 2014 (left) and 2015 (right) in Grebo-Krahn NP. Areas A1 and A2 indicate areas of high abundance in phase 1, whereas A3 indicates an area of relatively low abundance. B1, B2 and B3 all indicate areas of high abundance in phase 2 of biomonitoring in PGKNP.*

For vulnerable species, there are large changes in the spatial distribution of these species within the park (Figure 6). In the north of the park, there was a severe decrease in signs of vulnerable species with the majority of the horn of the park now displaying less than 2 signs/km of endangered species, with only a tiny section showing more than 4 signs/km (Figure 6-A1 and B1).

The center of the park is the only area which displays regions with over 6 signs/km of vulnerable species (Figure 6-A2 and B2). Between the first and second phases of biomonitoring, this area has constricted, leaving a smaller area in the center of the park that shows high signs of vulnerable species.

In the isolated patch in the south of the park, there are still relatively few signs of vulnerable species in the two phases. In the second phase of biomonitoring there is a small increase in

the size of the darker yellow areas (showing more than 2 signs/km) than in phase one which showed small patches of higher signs (Figure 6-A3 and B3).

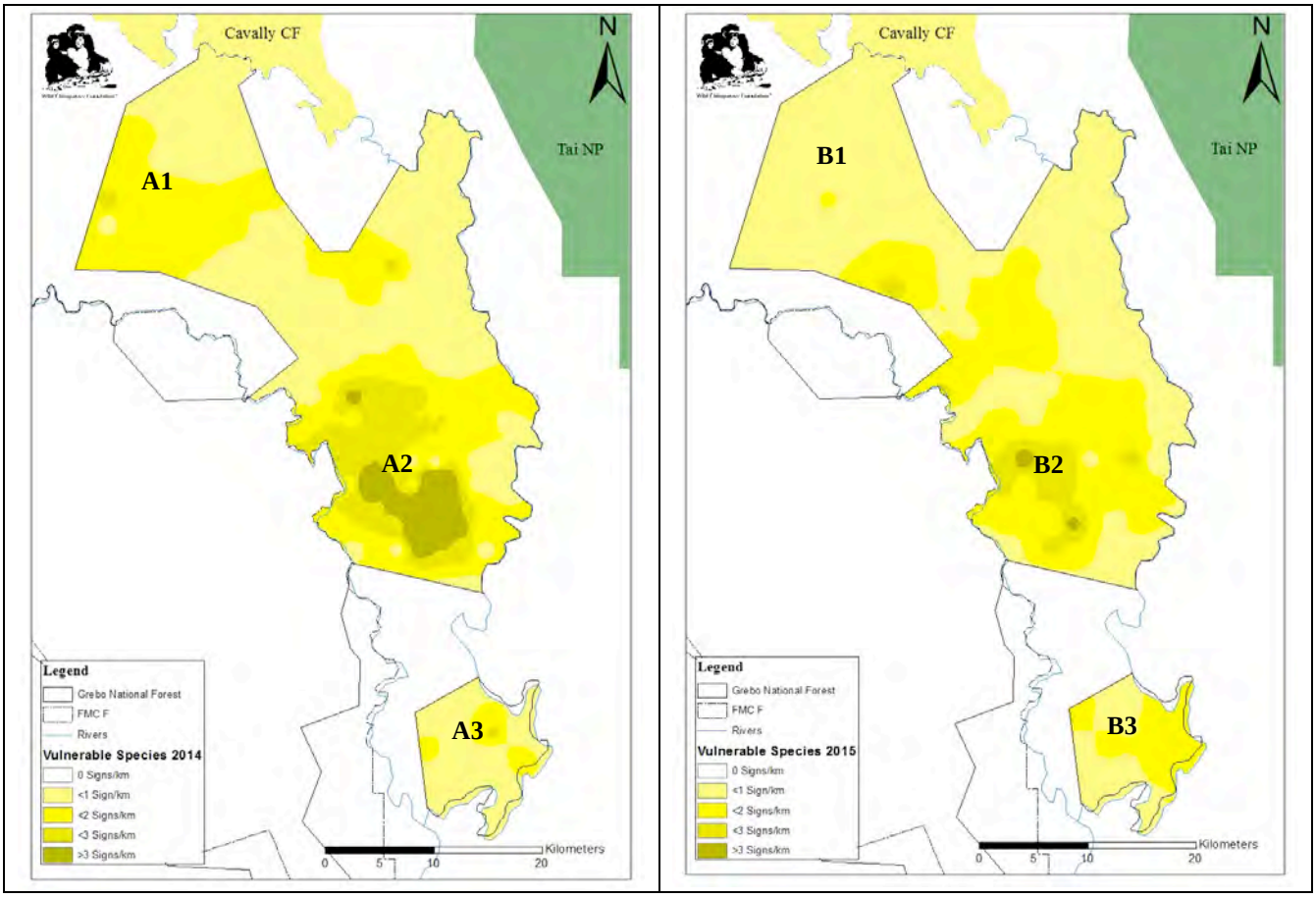

*Figure 6: Spatial distribution maps of vulnerable species (*forest elephant, black and white colobus, Diana monkey, Liberian mongoose and zebra duiker) *observed in 2014 (left) and 2015 (right) in Grebo-Krahn NP. Areas A1 and A2 indicate areas of high abundance in phase 1, whereas A3 indicates an area of relatively low abundance. B2 and B3 all indicate areas of high abundance in phase 2, whereas B1 shows an area of low abundance during phase 2 of biomonitoring in PGKNP.*

3.2. Bovid population

Encounter rates of bovids (including both direct and indirect observations) were relatively high in the Grebo-Krahn NP (Table 1). Few individuals were observed directly and therefore we can only confirm the presence of certain species (number of direct observation is in brackets): Maxwell's duiker (2), bay duiker (7), royal antelope (1), and Ogilby's duiker (2). The small sample size ($n < 60$) did not allow for a population estimate calculation. The comparison of signs of presence of bovids from 2014 to 2015 shown in Table 1 indicates no clear evolution. For encounter rates of indirect observations (dung and tracks), all bovid observations were grouped together, as it is difficult to differentiate between species using only such observations.

Table 1 Observations and encounter rates of bovid species within Grebo-Krahn NP in 2015 and 2014

Bovids			
Type of Observation	**Observations in 2015**	**Encounter Rates (N/km) 2015**	**Encounter Rates(N/km) 2014**
Direct	12	0.05	0.07
Dung	1162	4.66	3.37
Footprint/Track	1105	4.43	7.21
TOTAL	**2279**	**9.14**	**10.64**

Concerning the distribution, over both biomonitoring phases, bovids are present throughout the park (Figure 7). There have been clear changes in their distribution between the two phases of biomonitoring in 2014 and 2015. Signs of bovids in phase 1 were high (more than 20 signs/km) in the north and center of the park (Figure 7-A1 and A2), whereas in phase 2, this high density has become more dispersed (Figure 7-B1 and B2). It is also clear that bovid signs seemed to have increased along the Cavalla River between the two phases. In the isolated patch in the south of the park, bovid signs have increased in phase 2 (Figure 7-B3).

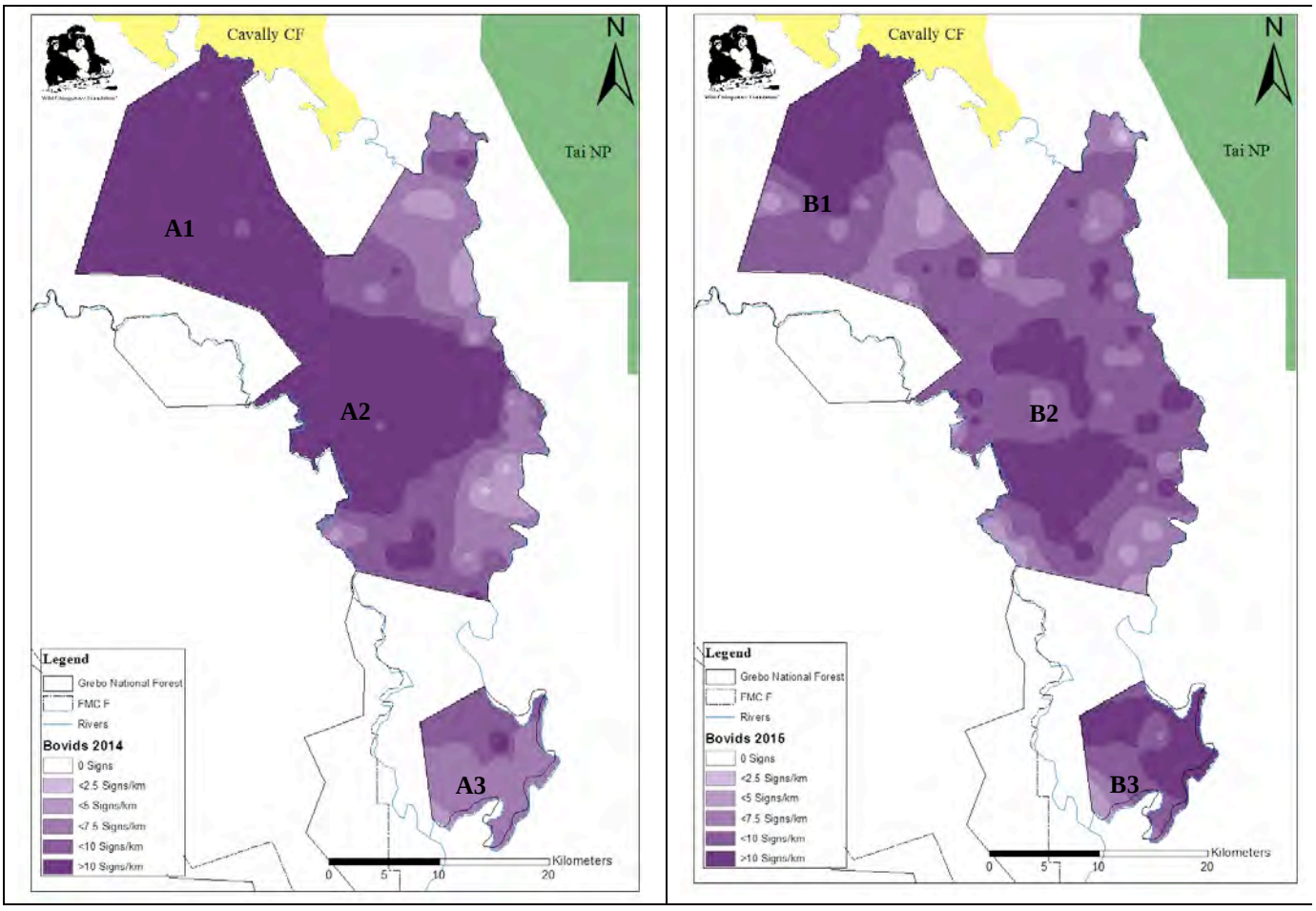

Figure 7. Spatial distribution maps of bovid species observed in 2014 (left) and 2015 (right) in Grebo-Krahn NP. Areas A1, A2 and A3 indicate areas of high abundance in phase 1. B1, B2 and B3 all indicate areas of high abundance in phase 2 of biomonitoring.

3.3. Primate population

In total 7 different primate species were observed directly during the second phase of biomonitoring in Grebo-Krahn NP, compared to 6 primate species in phase 1 (the extra primate species in 2015 comes from a single observation of a nocturnal potto). Indirect signs of 8 different species were also heard during the second phase of biomonitoring (
Table 2). For the overall encounter rate of monkeys within Grebo-Krahn NP the figure of 0.65 signs/km seems to have remained stable from phase one of biomonitoring (0.63 signs/km). Overall, 10 different species of primates (including the chimpanzee) were observed in the Grebo-Krahn NP. Only the galago (nocturnal) was not observed on transect. 5NB. the greater spot-nosed money and the potto were not observed in 2014.

Table 2 Numbers of observations and encounter rates of monkey species in Grebo-Krahn NP during biomonitoring in 2015.

Primate Species					
Primate Species	**2015 RESULTS**				**2014 RESULTS**
	Direct Observations of individuals	**Indirect observations of groups (heard)**	**Direct Observations of groups (seen)**	**Encounter Rates (N/km) of all groups of monkeys**	**Encounter Rates (N/km) of all groups of monkeys**
Diana monkey (*Cercopithecus diana*)	3	48	3	**0.20**	0.27
Red colobus monkey (*Procolobus badius*)	9	27	1	**0.11**	0.07
Mona monkey (*Cercopithecus mona*)	3	23	2	**0.10**	0.08
Western Black-and-white Colobus monkey (*Colobus polykomos*)	5	13	2	**0.06**	0.08
Sooty mangabey (*Cercocebus atys*)	0	19	0	**0.08**	0.04
Lesser spot-nosed monkey (*Cercopithecus petaurista*)	5	9	5	**0.06**	0.05
Greater spot-nosed monkey (*Cercopithecus nictitans nictitans*)	0	5	0	**0.02**	0.00
Potto (*Perodicticus potto*)	1	0	1	**0.00**	0.00
Olive colobus monkey (*Procolobus verus*)	1	3	1	**0.02**	0.04
Total for monkeys	**27**	**147**	**15**	**0.65**	**0.63**

The distribution of monkey species within Grebo-Krahn NP has also remained stable with signs of their presence being found throughout the park in both phases of biomonitoring (Figure 8). Areas displaying higher signs were patchy in both phases of biomonitoring, but in the north of the park, there seems to have been a reduction of signs between the two phases (Figure 8-A1 and B1). In the middle of the park, the small areas where more than 3 signs/km could have remained stable over the two phases of biomonitoring in 2014 and 2015 (Figure 8-A2 and B2). The isolated patch in the southern area of the park still shows very few signs of monkey species in both phases.

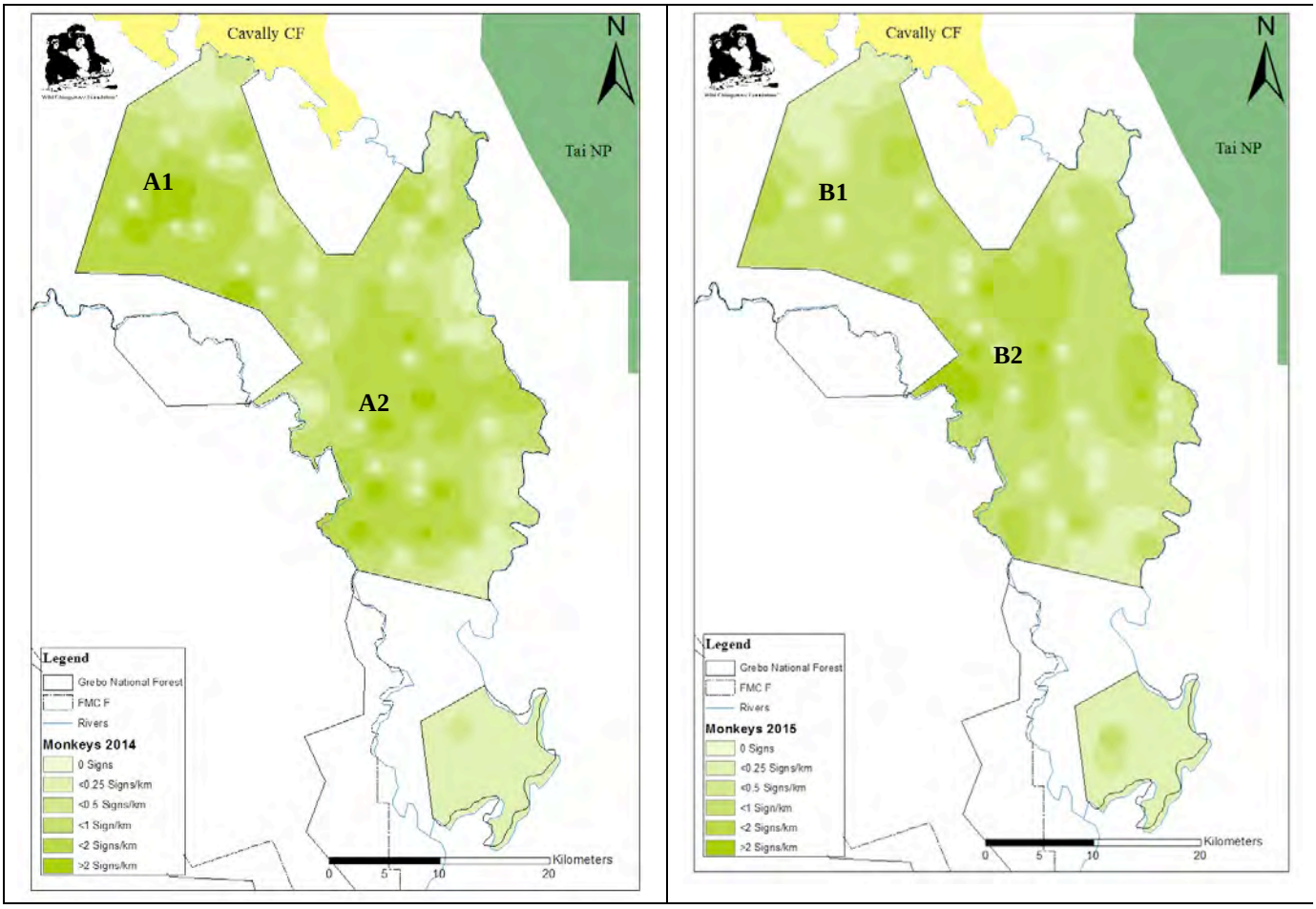

Figure 8: Spatial distribution maps of monkey species observed in 2014 (left) and 2015 (right) in Grebo-Krahn NP. Areas A1 and A2 indicate areas of high abundance in phase 1. B2 indicates an area of high abundance in phase 2 whereas B1 indicates an area of relatively low abundance in phase 2 of biomonitoring.

As in 2014, no direct signs of chimpanzees were observed during the 2015 phase of biomonitoring in Grebo-*Krahn* NP. The number of indirect observations (nests, nut-cracking sites, vocalizations, drumming, dung and footprints) increased from 221 observations in 2014, to 252 observations in 2015. This, in turn led to an increase of the encounter rate of

chimpanzees from 0.91 observations/km in 2014, to 1.01 observations/km in 2015 that seemed to be within the natural variations to be expected with our method.

Table 3 Comparison of encounter rates for chimpanzee signs in Grebo-Krahn NP in 2014 and 2015

Year	Chimpanzees			
	Species	**Direct Observations of individuals**	**Indirect Observations**	**Encounter rate of all signs of chimpanzees (N/km)**
2015	Chimpanzee (*Pan troglodytes verus*)	0	252	**1.01**
2014		0	221	**0.91**

Signs of chimpanzees were found throughout Grebo-*Krahn* NP, except for a small area along the Cavalla River (near the town of Taï and the village of Daobly) during the 2015 phase of biomonitoring (Figure 9). In the north of the park, areas of more than 3 signs/km were maintained and the area of the park contiguous with Cavally Classified Forest still contains an important area with high signs of chimpanzees (Figure 9-A1 and B1). In the center of the park, just to the north of the Glaro Native Reserve, an area of high chimpanzee density is maintained in both the 2014 and 2015 phase (Figure 9-A2 and B2). Signs of chimpanzees in the isolated patch in the south of *Grebo-Krahn* NP, seemed to have increased during the 2015 phase, with the majority of the isolated patch displaying results of more than 3 signs/km (Figure 9-A3 and B3).

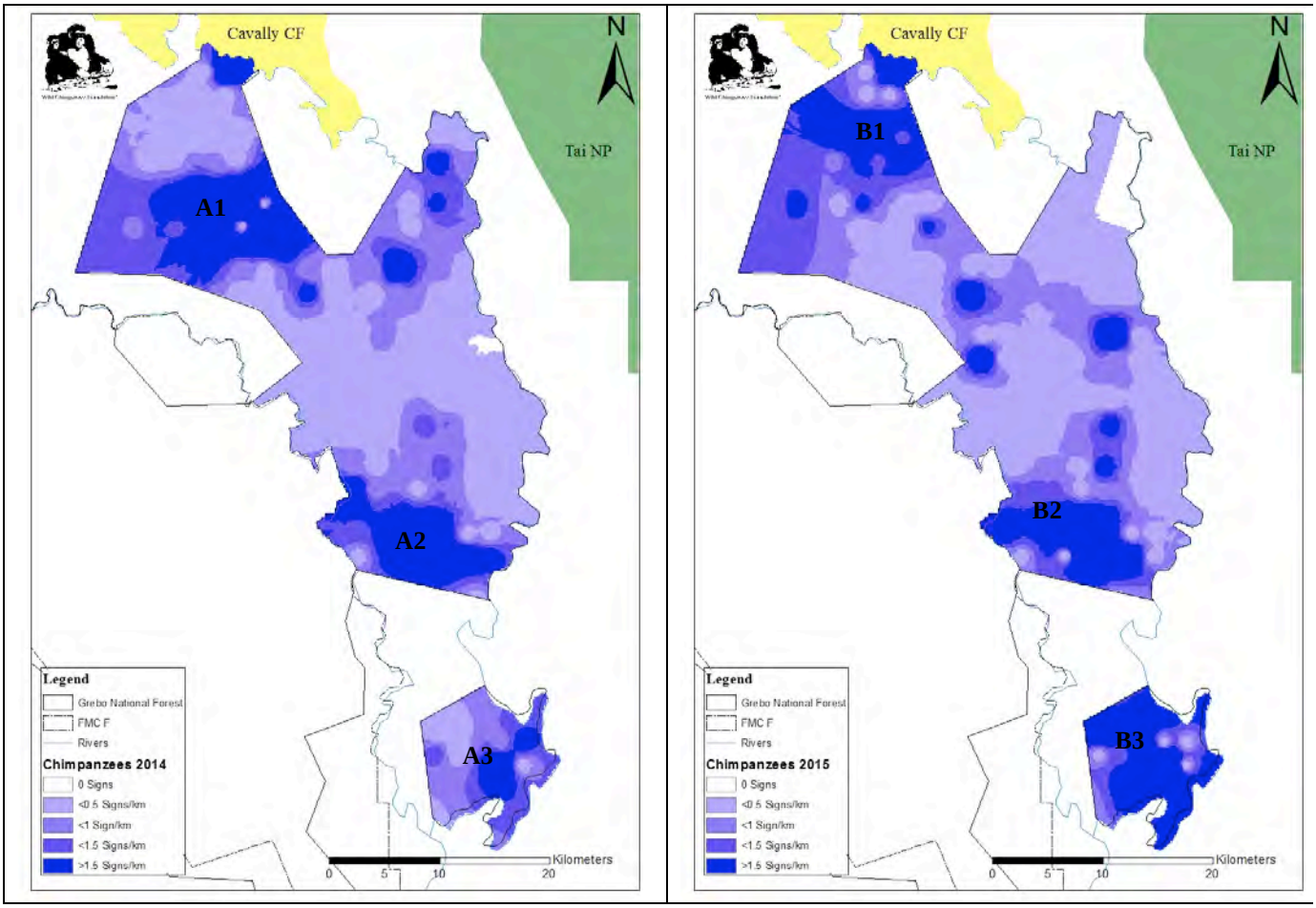

Figure 9: Spatial distribution maps of chimpanzees observed in 2014 (left) and 2015 (right) in Grebo-Krahn NP. Areas A1, A2 and A3 indicate areas of high abundance in phase 1. B1, B2 and B3 all indicate areas of high abundance in phase 2 of biomonitoring.

Density and abundance of chimpanzees:

Among the 252 indirect signs of chimpanzees observed, 194 sleeping nests were detected directly from the transect. This quantity of observations was large enough to reliably estimate the population density of chimpanzees in the study area (n > 60). The results from the analysis using the software Distance 6.0 are given in
Table 4 for 2014 and 2015.

Table 4 Population estimates of chimpanzees in the Grebo-Krahn National Park

	Population parameters	Point Estimate	Coefficient of variation	95% Confidence Interval
2015 Results	Densities of chimpanzees (ind./km²)	0.230	22.60%	0.148 – 0.358

	Abundance of chimpanzees (weaned ind.)	246	22.60%	158 – 382
	Chimpanzee abundance (all ind.)*	**289**	**22.60%**	**186 - 449**
2014 Results	Densities of chimpanzees (ind./km²)	0.161	24.15%	0.101 – 0.257
	Abundance of chimpanzees (weaned ind.)	204	24.15%	128 – 327
	Chimpanzee abundance (all ind.)	**247**	**24. 15%**	**155 – 396**

* The total number of chimpanzees in Grebo-Krahn NP was estimated to be 289 individuals, considering that 17.5% of the individuals of a population are infants that don't build a nest at night as they still sleep with their mother (as estimated by Plumptre and Reynolds, 1996).

Using conversion factors, we estimated 0.230 weaned chimpanzees per km². Consequently, their population size was 246 weaned individuals and a total population of 289 including juveniles/infants.

3.4. Other mammal species

In addition to bovids and primates, signs of presence of other large mammal species were detected during the survey (Table 5). Direct observations of the brush-tailed porcupine, cusimanse, flying squirrel and marsh cane-rat were made. All other presence of mammals was confirmed by indirect observations (tracks, feeding sites and dung). Signs of presence of the Suidae species were most often encountered with 1.91 signs detected per kilometre walked. The encounter rate of other large mammals seemed to have increased from 1.95 signs/km in phase one to 3.29 signs/km in 2015.

Table 5 Observations on other large mammal signs in the new Grebo-Krahn NP in 2015

Other Large mammal Species								**Encounter Rate (N/km)**
Family	**Species**	**Observations**						
		Direct Obs.	**Dung**	**Feeding Site**	**Track**	**Trail**	**Total**	
Mustelidae	African Clawless Otter (*Aonyx capensis*)	0	5	0	3	0	8	**0.03**

Viverridae	African palm civet (*Nandinia binotata*), African civet (*Civettictis civetta*), Padrine genet (*Genetta pardina*)	0	47	0	3	0	50	**0.20**
Hystricidae	Brush-tailed porcupine (*Atherurus africanus*), Crested porcupine (*Hystrix cristata*)	1	2	16	4	0	23	**0.09**
Herpestidae	Cusimanse (*Crossarchus obscurus*), Liberian mongoose (*Liberiictus kuhni*), Marsh mongoose (*Atilax paludinosis*)	4	2	164	12	0	182	**0.73**
Anumaluridae	Flying squirrel (*Anomalurus peli*)	1	0	0	0	0	1	**0.00**
Elephantidae	Forest elephant (*Loxodontis Africana cyclotis*)	0	2	0	12	5	19	**0.08**
Felidae	Golden cat (*Felis aurata*), Leopard (*Panthera pardus leopardus*	0	1	0	1	0	2	**0.01**
Suidae	Giant hog (*Hyloc. meinertzhageni*), Red river hog (Potamochoerus porcus)	0	59	319	98	0	476	**1.91**
Manidae	Giant pangolin (*Smutsia gigantia*)	0	0	8	1	0	9	**0.04**
Cricetomyinae	Giant pouched rat (*Cricetomys emini*)	0	0	0	1	0	1	**0.00**
Thryonomidae	Marsh cane rat (*Thryonomys swinderianus*)	1	1	2	0	0	4	**0.02**
Hippopotamidae	Pygmy Hippopotamus (*Choeropsis liberiensis*)	0	22	0	21	0	43	**0.17**
TOTAL		**7**	**141**	**509**	**156**	**5**	**818**	**3.29**

The spatial distribution of elephants shows that the core area inhabited by elephants in the centre of the park is still present (Figure 10). Signs of elephant presence are restricted to the centre of the park, where elephant signs are found seemed to have reduced between 2014 and 2015 (Figure 10-A1 and B1). A worrying finding from ecoguard data collection and off-transect biomonitoring data collection is that five elephant carcasses have been found in and around the park during data collection in 2015 (see appendix 2).

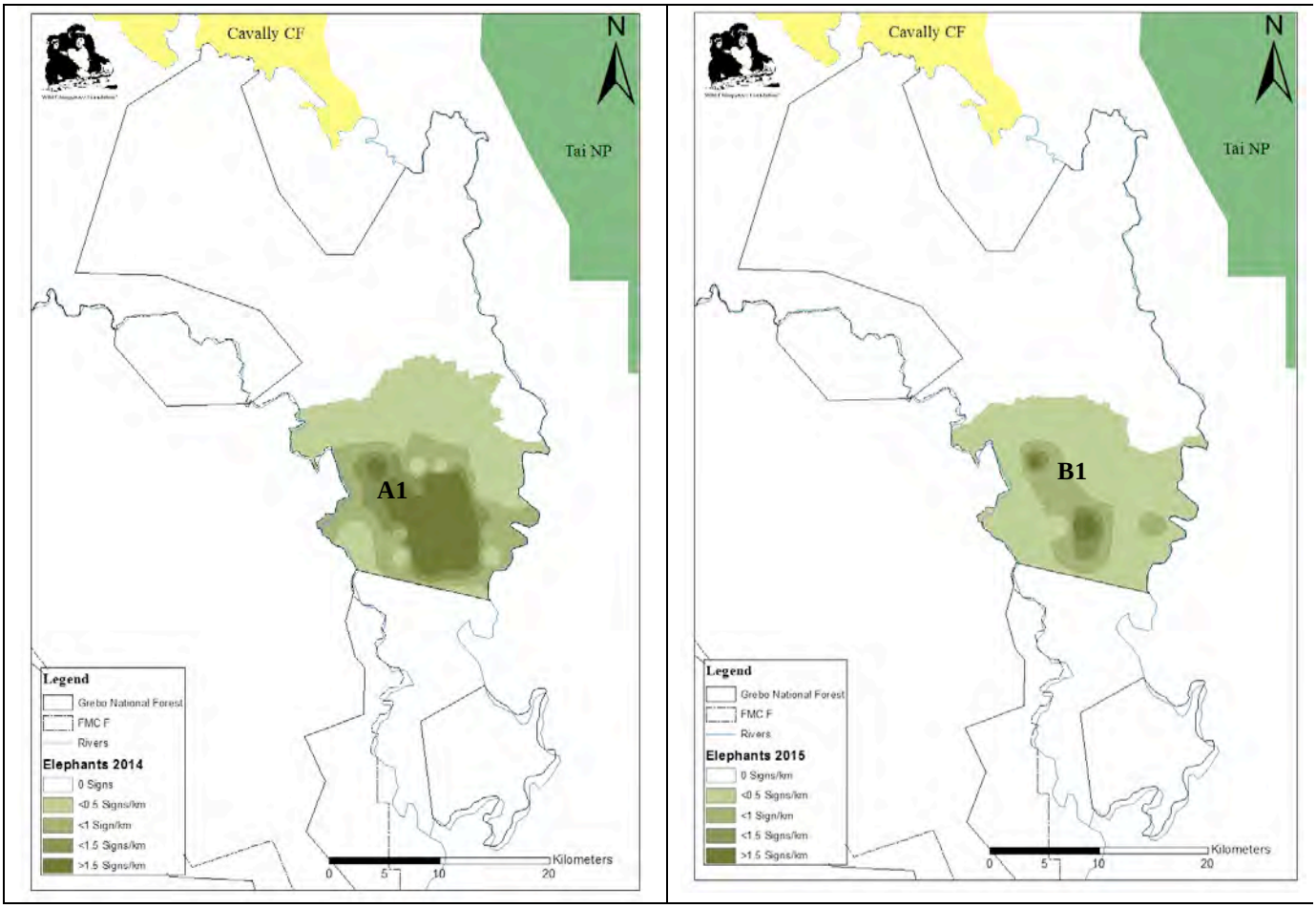

Figure 10: Spatial distribution maps of elephants observed in 2014 (left) and 2015 (right) in Grebo-Krahn NP. Area A1 indicates an area of high abundance in phase 1 and area B2 indicates an area of high abundance during phase 2 of biomonitoring.

As for pygmy hippopotamuses, they are found throughout the park in both stages of biomonitoring (Figure 11). In the north of the park, there are still small areas showing signs of pygmy hippopotamuses of more than one sign/km, but the area of high signs has now moved to just south of Tempo during phase two (Figure 11-A1 and B1). In the centre of the park, there are still patchy areas where more signs of pygmy hippopotamuses are found and there seem to be an increase of signs along the Cavalla River during the second phase of data collection (Figure 11-A2 and B2). Signs of pygmy hippopotamuses in the southern area of the park seemed to have reduced between phase 1 and phase 2, with fewer signs being found in the isolated patch (Figure 11-A3 and B3). All of these variations in distribution seem to be natural and do not suggest any increase or decrease in the population.

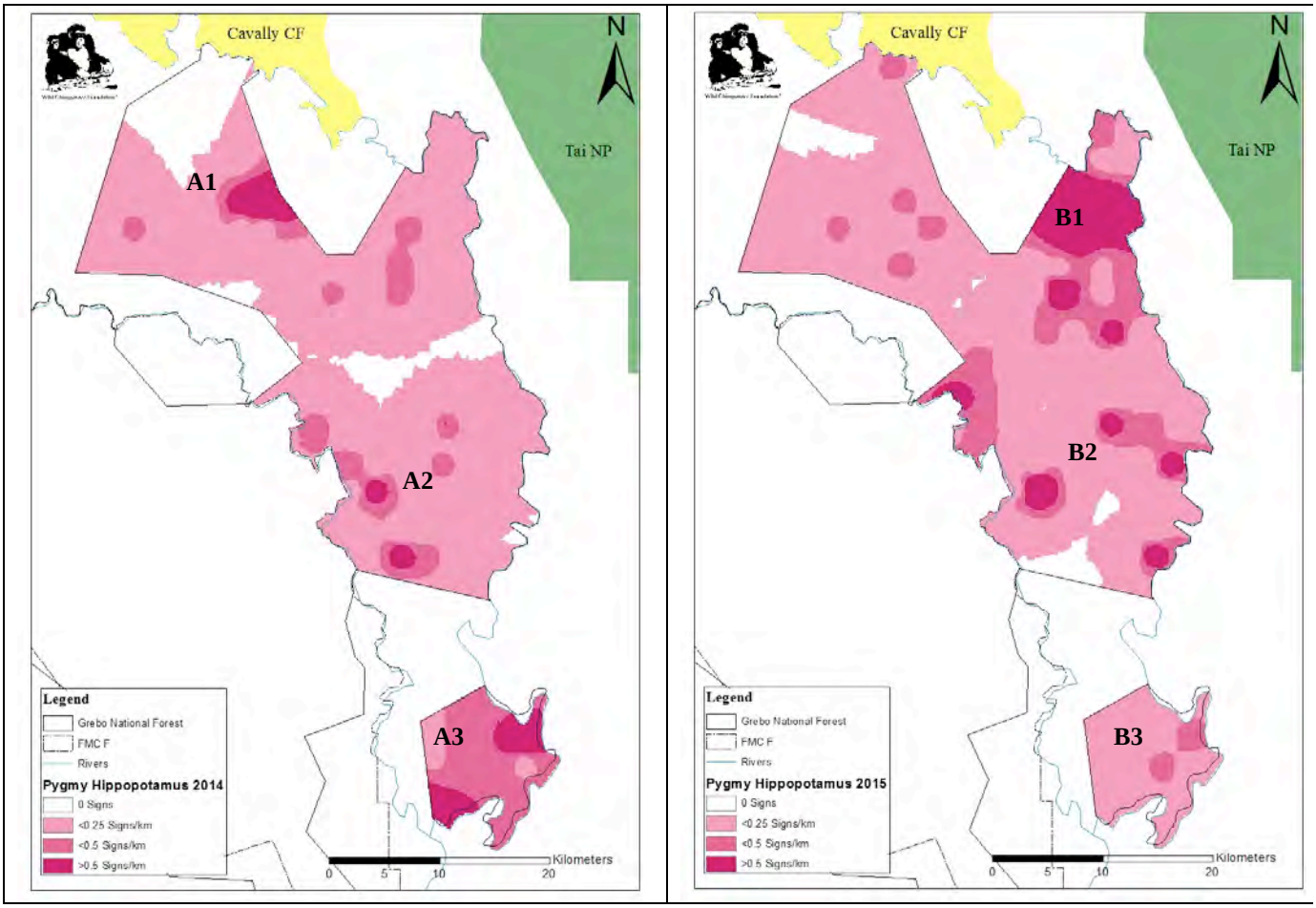

Figure 11: Spatial distribution maps of pygmy hippopotamuses observed in 2014 (left) and 2015 (right) in Grebo-Krahn NP. Areas A1, A2 and A3 indicate areas of high abundance during phase 1. Areas B1 and B2 indicate areas of high abundance and area B3 highlights a region of relatively low abundance during phase 2 of biomonitoring.

3.5. Threats or factors influencing the distribution and density of chimpanzees and other large mammals in the new PGKNP

We observed threats to wildlife across the entire Grebo-Krahn NP through signs of aggression on fauna and flora. Evidence of fauna aggression (hunting) was indicated by direct and indirect observations, including poachers heard, gun shots heard, poacher trails, snares, and used cartridges. Observations of signs of aggression on flora (habitat disturbance) included farming, logging and chewing stick harvesting (Table 6). The encounter rates of signs of aggression on fauna are greater than those on flora. Poacher trails were the most abundant signs encountered with 1.42 signs per kilometer walked. Survey team members regularly heard gun shots during the survey period, though only five shots were heard (three of which were heard in areas of forest in close proximity to Bilibo) along transects and therefore included in our analysis. When comparing encounter rates with the biomonitoring survey 2014, we observed some variations also longer term studies should be developed to be able to say if it shows a decrease in hunting signs from 4.07 signs/km in 2014 to 2.39 signs/km in 2015. Encounter rates of aggression against flora only decreased slightly between the two phases with an encounter rate of 1.88 signs/km in 2014 and 1.52 signs/km in 2015.

Of the signs of habitat disturbance collected in the 2015 phase, 61% of these observations were related to the chewing stick trade.

Table 6 Human activities or illegal signs encountered on transects in the new Grebo-Krahn NP in 2015

Type of human activity	Observation	Number of observations 2015	Encounter rate 2015 (N/km)	Encounter Rate 2014 (N/km)
Aggression against fauna (hunting)	Direct Observations of people	5	0.02	0.01
	Cartridges	96	0.39	0.51
	Trails	111	0.45	0.54
	Object (items left by poachers)	14	0.06	0.06
	Hunting Tent	2	0.01	0.02
	Poacher Trail	355	1.42	2.87
	Gunshot heard	5	0.02	0.04
	Traps	9	0.04	0.03
	TOTAL	**597**	**2.39**	**4.07**
Aggression against flora (habitat disturbance)	Chewing Stick Roots*	83	0.33	1.28
	Chewing Sticks*	52	0.21	
	Chewing Stick Stump*	95	0.38	
	Settlements	3	0.01	0.00
	Honey Extraction	0	0	0.01
	Observation of people (miners/farmers)	8	0.03	0.08
	Farm	20	0.08	0.05
	Human Clearing	1	0.00	
	Human path (leading to mine/logging/chewing stick activity)	7	0.03	0.00
	Objects left behind (mining/logging equipment)	2	0.01	0.00
	Cut down trees*	14	0.06	0.42
	Logging road	81	0.32	
	Prospection hole (mining)	3	0.01	0.05
	Mine/gold washing site	10	0.04	
	TOTAL	**379**	**1.52**	**1.88**

** Chewing stick roots refer to the roots of Garcinia sp. which have been dug up to sell, chewing sticks are piles of logs which have been harvested and chewing stick stump refers to a stump of a tree remaining after a log has been cut. Cut down trees refer to logs of all other species.*

Hunting signs were found throughout the park in both phase 1 and phase 2 of biomonitoring in Grebo-Krahn NP (Figure 12). Although, in phase 2 of biomonitoring, there seems to be a reduction of areas in the forest that show more than 10 signs/km of hunting activity. In phase 1 there were three areas in the park that showed high signs of hunting activity (Figure 12-A1, A2 and A3). In phase two, some reductions in the amount of hunting signs seemed to be

visible in the centre and southern areas of the park (Figure 12-B2 and B3). Hunting signs could also have been reduced along the Cavalla River during phase two of biomonitoring in Grebo-Krahn NP, but this needs to be confirmed in the future biomonitoring.

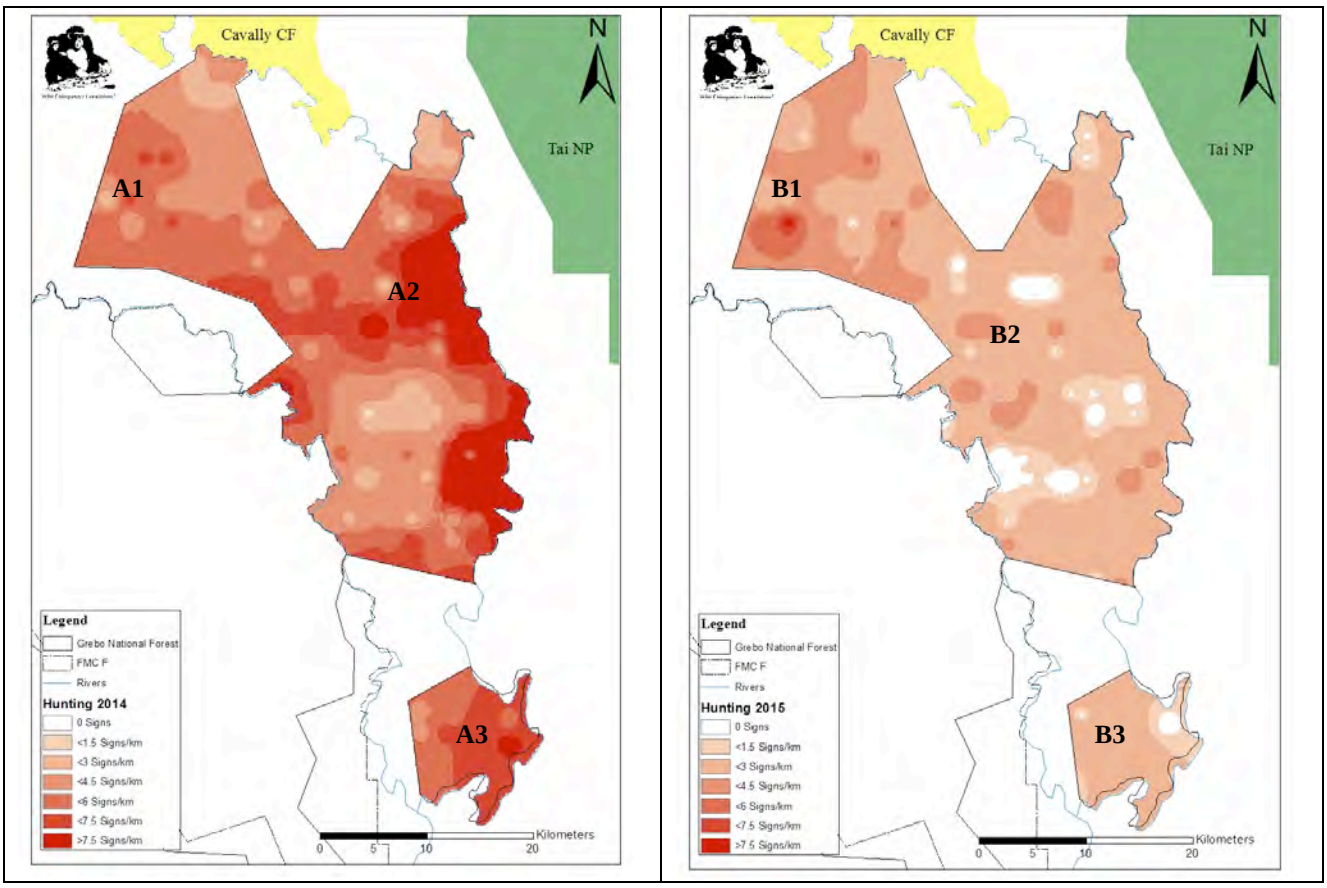

Figure 12: Spatial distribution maps of hunting signs observed in 2014 (left) and 2015 (right) in Grebo-Krahn NP. A1, A2 and A3 indicate areas of high abundance in phase 1. B1 indicates an area of high abundance and B2 and B3 highlight areas of lower abundance during phase 2 of biomonitoring.

Figure 13 displays threats to flora in the park, such as mining sites, farms and chewing stick activity. When farming is taken into consideration you can see that the two affected areas are maintained between the two phases, with farms being present around Bilibo in Grand Gedeh and Sala in River Gee. Mining activity has increased within the park and is centered around the area between Bilibo (a well-known mining community) and Garleo, three new mines were discovered during the second phase of biomonitoring in Grebo-*Krahn* NP suggesting that this might be an increasing threat to flora in the park. Regarding chewing stick activities within the park, in 2014, chewing stick activity had been mostly confined to the area next to Cavalla River where Ghanaians would travel from Côte d'Ivoire to collect chewing sticks in Grebo-*Krahn* NP. Worryingly, in 2015 the spread of chewing stick activity now covers almost the entirety of the central area of Grebo-*Krahn* NP, suggesting an intensification of chewing stick harvesting within PGKNP.

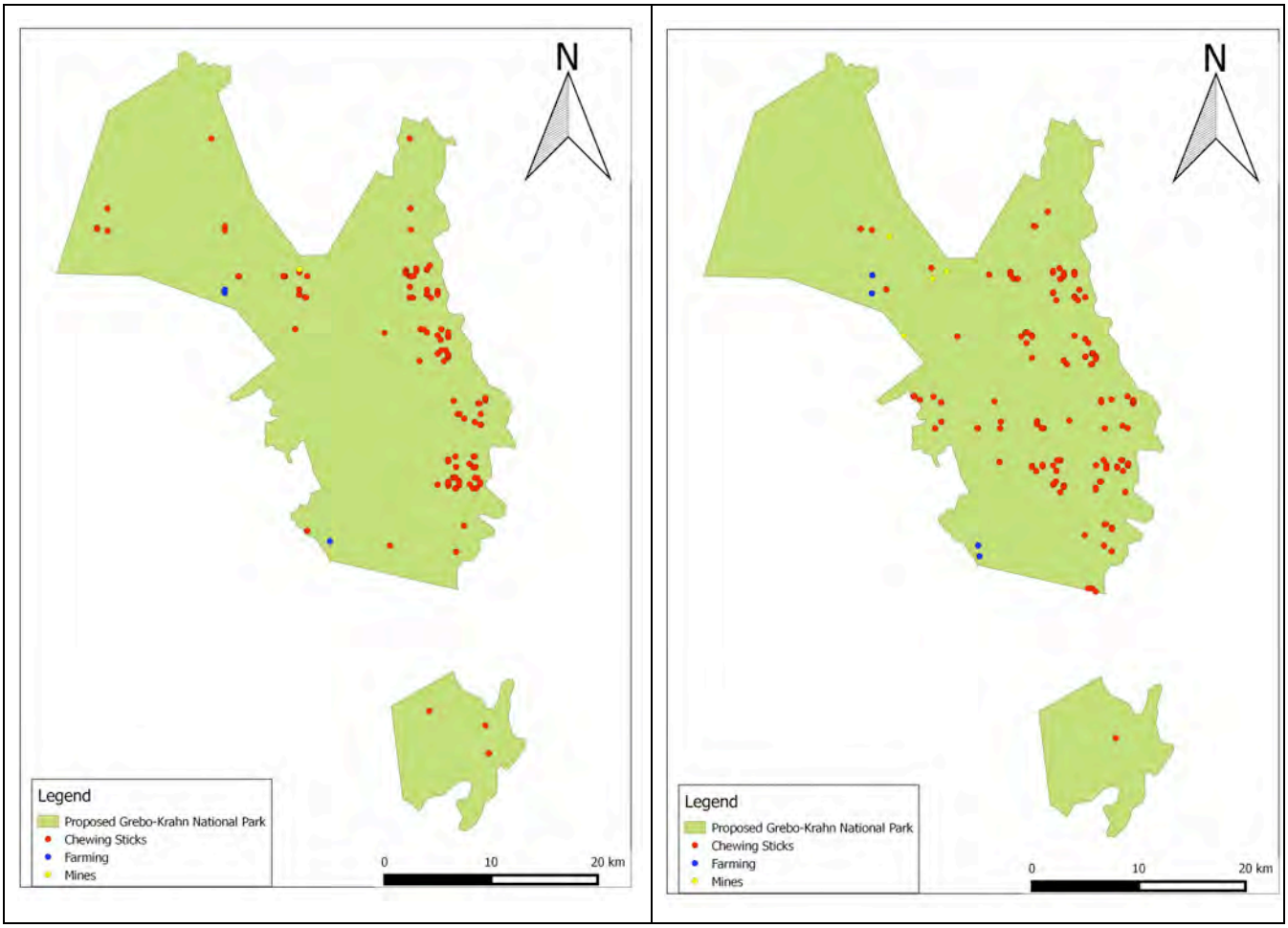

Figure 13: Locations of farms, mines and chewing-stick harvesting sites in Grebo-Krahn NP in 2014 (left) and 2015 (right).

4. DISCUSSION

The 2015 phase of biomonitoring provides important results for the management of Grebo-Krahn NP. The 2015 phase is the first time that the same methodology has been repeated in Grebo-Krahn NP allowing direct comparisons with the data from the 2014 phase of biomonitoring. These comparisons allow an insight into the evolution of mammal populations and their distribution within Grebo-Krahn NP. Even so, the relatively high survey effort has not attained the required sample size (n > 60 or at least 40) for reliable density estimates of bovids and monkeys (Buckland et al. 2001). This suggests that low densities of large and medium size mammals are present in Grebo-Krahn NP, and they are performing extreme elusive behaviour to escape human observers and therefore limit direct detections.

Regarding chimpanzees in Grebo-Krahn NP, the abundance estimates possess a precision of CV = 22.60% (mean estimate was 246 weaned individuals) which is reliable enough, and the population size of weaned individuals suggest a possible increase by 17% from 204 individuals in 2014. Although this estimate seems like a fairly large increase, this figure falls within the 95% coefficient of variation from the 2014 results (128-327) suggesting no significant change and that the population of chimpanzees has remained stable between the two phases of biomonitoring in 2014 and 2015. Also, when looking at the spatial distribution of chimpanzees within Grebo-Krahn NP, the general pattern has remained the same over the two phases. Signs of chimpanzees have increased dramatically in the isolated patch between the two phases.

The diversity of large mammal species within Grebo-Krahn NP has been confirmed with the presence of 29 species during the second phase of biomonitoring in 2015. This is an increase from the first phase of biomonitoring which yielded 21 species of large mammal. This increase may be due to the improved skills of field team members in identifying the indirect signs of large mammal species. The 29 species discovered is also a higher figure than that attained by Hoke *et al.* (2007) which yielded a total number of large mammal species of 27. There were several species which were present in this phase that were not reported in the aforementioned study, such as: African clawless otter (*Aonyx capensis*), crested porcupine (*Hystrix cristata*), flying squirrel (*Anomalurus peli*), giant pouched rat (*Cricetomys emini*) and marsh cane rat (*Thryonomys swinderianus*).

The distribution of large mammal species seems to have remained largely stable within Grebo-Krahn NP, with a slight constricting of areas of high presence in the north of the park, which may be due to the farming and hunting activities taking place in the illegal settlement of Boley Village. One interesting fact to note is that along the Cavalla River (the border with Côte d'Ivoire), more signs of large mammal presence were observed. This possible increase in signs may be due to the closure of the Ivorian-Liberian border due to the Ebola outbreak and the fact that many Ivorian hunters admitted to stopping hunting during the Ebola outbreak and the fact that many Ivorian community members stopped eating bushmeat during this time (Normand, Pers. Comm). This border remains closed and has been for over 12 months now, meaning that cross-border hunting activity has been drastically reduced. This reduction may have led to a recolonization of the border area by large mammal species, explaining the increase of their presence in that area.

The diversity of large mammals of conservation importance in the Grebo-Krahn NP is confirmed with the presence of ten primate species including the Western chimpanzee, the African forest elephant, the pygmy hippopotamus, and the leopard. This diversity reaffirms

the importance of the creation of the national park and its role within the Taï-Grebo-Sapo Forest Complex.

When considering the spatial distribution of large mammals, endangered species, vulnerable species, bovids, monkeys and chimpanzees, there was a common factor in all cases when the data was compared to phase 1 of biomonitoring. In the north of the park areas of high signs of the aforementioned groups seemed to be reducing. Some areas, such as the area of forest contiguous with Cavally Classified Forest still harbour areas with many signs, but the general pattern was a constriction of areas with high signs of wildlife. The main reason for this could be due to the presence of Boley Village in the heart of the horn of Grebo-Krahn NP. Boley Village has an ever expanding area of cleared land that is now used for cultivating crops and is also well known as a hunting village which provides much of the illegally hunted bushmeat to the mining camp CVI, in the neighbouring logging concession FMC F. Due to the village continually expanding, its impact is now having an effect on the surrounding wildlife.

In stark contrast, the distribution of the same groups of animal species yielded much more positive results in the isolated patch in the south of the park, in Glaro District. The number of observed signs increased for large mammals, endangered species, vulnerable species, bovids, monkeys and chimpanzees in this area of Grebo-Krahn NP. If confirmed, the reason for this increase may be that the Glaro Native Reserve is now clearing areas of forest for cocoa production at a much faster rate and much of the forest land has now been cleared. This may have led to some of the aforementioned species migrating into the relative protection of the isolated patch. These results demonstrate how important it is to keep this isolated patch included in PGKNP as it holds key populations of vulnerable, endangered and protected species.

One other positive result is the possible reduction in hunting levels within Grebo-Krahn NP between phase 1 and phase 2 of biomonitoring. This should not be expected to continue as there is still a high dependency on bushmeat in the areas surrounding Grebo-Krahn NP. This reduction may be due to increased awareness of populations on the dangers of bushmeat consumption due to the Ebola outbreak. The first phase of biomonitoring also demonstrated that a lot of hunting was taking place on the border with Côte d'Ivoire, a border which is still officially closed due to the Ebola outbreak. These two factors may have had an impact on the levels of hunting in the park, but it is important to remain vigilant to the possibility that hunting rates may increase again in the near future.

Globally, our continued understanding of the population dynamics of large mammals and threats from human activities within the new Grebo-Krahn NP is well clarified from this study. Most importantly, it confirms the high potential of the new Grebo-Krahn NP for the biodiversity of Taï-Grebo-Sapo and it requires immediate recommendations (see next section) for both the Liberian government through the Forestry Development Authority and international donors to improve its management and conservation.

5. CONCLUSION AND RECOMMENDATIONS

The second official phase of biomonitoring reported here has confirmed the continuing rich diversity of large mammal species, including endangered, endemic and vulnerable species, inhabiting the Proposed Grebo-Krahn National Park. The presence of ten primate species has been confirmed, among which the population estimates of the Western chimpanzee is known

with a total mean abundance of 289 individuals (range 186-449; CV=22.60%). Attention and immediate action is, however, needed from the Liberian government, conservation NGO's and international donors to significantly reduce the threats faced by this area so rich in biodiversity.

The creation of Grebo-Krahn National Park is vital to ensure integrity of the Taï-Grebo-Sapo Forest Complex. Recommendations on local, national, and international scales are provided below:

I. FDA should continue law enforcement patrols within the park. These patrols may have had an impact on levels of hunting within the park and can only serve to improve the park's protection. These patrols also send out a clear message to communities that the park is well protected and that illegal activities will not be tolerated.
II. FDA should continue community awareness, annual biomonitoring and the ecoguard program within PGKNP. These programs are vital for providing data which will orient management decisions/strategies for the park. The ecoguard program also provides employment for community members and allows for communities to be informed about the park and interact with FDA staff on a regular basis.
III. The eviction process for Boley Village should be implemented as soon as possible. This village is having a detrimental effect on the surrounding forest through hunting and habitat degradation and Boley Village is also continually expanding. Any mission to evict Mr Boley and his family should be followed up with a mission to remove all dwellings in the village and all plantations in order to prevent anybody returning to live in the village.
IV. Ranger posts along the border, in the park, and on the eastern side of the park should be built. A permanent presence of rangers is needed to stop hunting inside the park, as well as other illegal activities. Ranger posts should also be placed at known crossing points to stop the trade of bush meat and chewing sticks.
V. Flagging of the southern area of the park should be a priority. The flagging of the northern area of the park has been completed, but until the southern portion has been completed the continuation of the gazettement process is stalled. It is vital for the process not to be delayed any further.
VI. Once flagging is completed a final round of community consultations need to take place for all communities to verify the boundary lines.
VII. Completion and submission of the gazettement package in 2016 is of the utmost importance for the creation of Grebo-Krahn National Park. With elections in Liberia being held in 2017, it is vital that the package is presented to the Government of Liberia before the election to prevent further delays in the gazettement of the park.

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APPENDICES

Appendix 1 List of field team members including experts

NAME	POSITION
Zoro Berenger	WCF Supervisor
Jimmy Parker	WCF Supervisor
Clement Tweh	FDA/WCF Supervisor
Fredrick Wonday	FDA Biomonitoring Team A member
Stephen Teah	FDA Biomonitoring Team A member
Lindsey Rue	FDA Biomonitoring Team A member
Sunnyboy Bando	FDA Biomonitoring Team A member
John Miaplay	FDA Biomonitoring Team A Volunteer
Lewis Monu	FDA Biomonitoring Team A Volunteer
Christopher Doe	FDA Biomonitoring Team B member
Junny George	FDA Biomonitoring Team B member
Williams Wonday	FDA Biomonitoring Team B member
Anthony Farley	FDA Biomonitoring Team B member
Tulay Padeah	FDA Biomonitoring Team B Volunteer
Milton Kuloe	FDA Biomonitoring Team B Volunteer
Charles N. Teah	FDA Biomonitoring Team C member
Isaiah Zoway	FDA Biomonitoring Team C member
Samuel Sayndee	FDA Biomonitoring Team C member
Amstrong J. Saylee	FDA Biomonitoring Team C member
John Z. Kaso	FDA Biomonitoring Team C Volunteer
Amos Wenjor	FDA Biomonitoring Team C Volunteer

Appendix 2 Map of locations of elephant carcasses found during field activities in Grebo-Krahn NP in 2015