Yearly Variations in Spatial Distribution of Large Mammals in a Protected Savannah Ecosystem in West Africa

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RUNNING TITLE: LARGE MAMMALS IN DRY SAVANNAHS

ABSTRACT

Tropical savannah ecosystems exhibit high biodiversity, encompassing a range of megafauna, including elephants, lions, ungulates, birds, and Insects. While substantial research has been conducted on the ecological dynamics of eastern and southern African savannahs, West African savannahs, particularly within the semi-arid Sudanian and Sahelian biomes, remain understudied. This study assesses the spatial distribution and habitat utilization of 15 large mammal species (mostly ungulates but also three primates and the elephant *Loxodonta africana*) in Comoé-Léraba National Park, southwestern Burkina Faso, over the period 2010–2018. Data collection employed line transect surveys to estimate ungulate populations, while the Minimum Convex Polygon (MCP) method quantified interannual variations in species occupancy. General Linear Models (GLM) assessed the effects of time and species identity on minimum occupied area. Results indicated no significant temporal variation in species distribution; however, species-specific effects suggested differential habitat preferences. Despite overall spatial stability, variations in poaching indices may have influenced localized species persistence. The reappearance of *Loxodonta africana* in 2018 underscores the necessity of protecting water-associated habitats and maintaining ecological connectivity. Findings emphasise the need for targeted conservation strategies to sustain biodiversity and mitigate anthropogenic pressures in West African savannahs.

Key words: Sudanian savannah; Comoé-Lérabà protected area; Mammalia; Burkina faso; Space patterns; Habitat types

1. Introduction

Tropical savannahs host a rich diversity of mammal species that fulfil essential roles as herbivores, predators, and seed dispersers (Shorrocks and Bates, 2015; Lacher et al., 2019). Understanding their spatial utilisation can illuminate complex ecological interactions and the factors influencing plant diversity, vegetation structure, and overall ecosystem health (Owen-Smith, 2002, 2014, 2015; Berthelot et al., 2021; Yeshurun et al., 2020; Lawes et al., 2000; Huntley et al., 2010). This knowledge is vital for conservationists and park managers (Fletcher and Fortin, 2019), providing insights into mammal population dynamics and informing management strategies for protected areas. Monitoring changes in wildlife distribution and abundance can reveal the impacts of environmental and human factors (Fletcher and Fortin, 2019). Additionally, studying spatial occupation is crucial for biodiversity assessments in these ecosystems (Ouédraogo et al., 2009; Hema et al., 2017a, 2017b, 2017c, 2020).

Spatial occupation studies of large mammals in savannah are essential for addressing human-wildlife conflicts by identifying areas where human activities overlap with mammal movements, facilitating the development of effective conflict reduction strategies (Frank et al., 2019). Additionally, these studies contribute to efficient conservation prioritisation by pinpointing regions vital for sustaining ecosystem functions (Lindenmayer and Franklin, 2013; Fletcher and Fortin, 2019).

Additionally, amid a changing climate, the study of mammal spatial occupation provides insights into how climate-induced shifts may affect distribution and movement patterns, aiding in predicting and managing climate change impacts on wildlife and ecosystems (Humphries, 2009).

Despite the dry savannahs of the Sahelian and Sudanian vegetation zone in West Africa supporting a remarkable community of large mammals (Hema et al., 2023), these species have received less research attention compared to their counterparts in eastern and southern Africa (e.g., Barnes and Douglas-Hamilton, 1982; Chirima et al., 2012; Schmied née Stommel et al., 2024). In contrast, a growing body of literature on Sudanian small mammals (Amori et al., 2021) highlights a significant gap in understanding the ecology and conservation needs of large mammals in this region.

This study, undertaken in the Comoé-Leraba protected area in south-western Burkina Faso (West Africa), analyses yearly variations in the areas occupied by 18 large mammal species over seven years (Hema, 2018; Hema et al., 2023). We examined yearly variations in the occupied areas of large mammals, analysed long-term trends in species distribution, and investigated potential links between these trends and poaching or anthropogenic influences.

2. Materials and Methods

2.1. Study Area

The study was conducted within the "Forêt classée et Réserve Partielle de Faune Comoé-Léraba" (FCRPF_CL) in southwestern Burkina Faso (Figure 1). Covering 124,510 hectares, this protected area features a Sudanese climate, characterised by a single rainy season from May to October (Gnoumou et al., 2011). More precisely, the study area is located in the Sudanian vegetation zone, at the transition from the North to the South Sudanian sector, already containing some floral elements of the Guineo-Congolian zone in humid areas. Habitats include wooded savannahs, tree savannahs, dry forests, semi-deciduous gallery forests, and open forests along the Comoé and Léraba rivers (Gnoumou et al., 2011). More details of the study area are available at < https://rsis.ramsar.org/fr/ris/1878?language=fr> (last accessed on 27th August 2024).More precisely, across the entire area, 20.77% was dryland crops, 0.14% lowland crops, and 4.44% fallow land. The most prominent plant species are those typical of the Sudanian savanna, with a higher prevalence of *Khaya senegalensis* and *Daniellia oliveri*. Together with *Isoberlinia doka*, these species give the landscape the appearance of a wooded savannah. Gallery and riparian forest formations can be extensive and are often mixed with Guinean species such as *Erythrophleum guineense, Anthocleista nobilis, Dialium guineense, Chlorophora excelsa, Andira inermis, Cola gigantea*, and *Anthostema senegalensis*. A localised forest stand of *Guibourtia copalifera* is observed along the banks of the Comoé River (Thiombiano and Kampmann, 2010).

2.2. Protocol

Line transects spanning the study area were surveyed from 2010 to 2018, and more precisely in 2010, 2011, 2012, 2013, 2016 (two distinct surveys), 2017 and 2018. Transects were surveyed for six consecutive days each year, with meticulous data collection on identified groups, species, sex, and age cohorts of each observed individual (Hema et al., 2023). Morphological characteristics were also utilised to distinguish between the sexes of encountered individuals whenever feasible and to differentiate in cohorts based on their relative size and morphological characteristics (Hema et al., 2023).

For this study, we used permanent transects that were walked at least once every year, according to the description provided below. Transects were distributed systematically, from a random start, and with an interval of at least 1.7 km between adjacent transects. The annual transect surveys were preceded by two days of training and re-training for the surveyors. Data collected during this training phase were not used in the study. The total lengths of the transects covered were 468.33 km in 2010, 466.91 km in 2011, 2012, 2013, and 2018, and 427.79 km in 2016. Whenever possible, the same transects were surveyed in each year to minimize observational biases (see below for more details). During the six-day annual survey, the survey teams would position themselves at the entry points of the transects by 5:40 a.m. Data collection started as soon as visibility permitted (around 6:00 a.m.), and these transects were conducted either at the end of the dry season (March–April for 2012, 2013, 2016) or at the onset of the rainy season (May–June for 2010, 2011, 2017, and 2018). Although every effort was made to consistently apply the same transect methodology, we are aware that certain biases in the estimates could theoretically arise. This is because survey season and surveyor teams were not identical across all study years due to logistical constraints. As a result, it could not be ruled out a priori that differences in factors like water availability and grazing may have influenced the distribution and visibility of the target species, potentially affecting their encounter rates (see Hema et al., 2023).

We also recorded poaching signs along transects in order to quantify poaching indices. Any illegal evidence along transects was considered as a sign of illegal human activity and poaching. These signs would include animal carcass; cartridge; rifle socket; battery; trap; poaching trail; the presence of domestic animals; hunting camp; hut; crop farm; traces of carts; bike tracks; bushmeat ovens, the foot print of domestic animals (cows); tree burning; tree cutting; cattle pens; gold panning site; human presence; human foot print; honey extraction; tree cutting. We defined the poaching index for a transect as the total count (i.e. number) of distinct poaching signs observed along transects.

2.3. Statistical Analysis

A diachronic analysis of the Minimum Convex Polygon (MCP) method was employed for 2010-2018, creating yearly maps of space occupation for various species. Space occupation by each species in each sampling year means the set of points where that species was observed in that specific year, with a MCP of sighting spots being produced on each year and for each species. Once the MCP was determined, the area included within the polygon was calculated for each species and for each study year. This area is named "minimum occupied area" in the following text. Wider minimum occupied area would indicate a higher habitat generalism/tolerance for a given species at the study area.

A General Linear Model (GLM) was used to assess the effects of the year and species on the minimum occupied areas. The GLM was run with the log link function and a Poisson distribution of error (McCullagh and Nelder, 1989). Spearman's rank correlation coefficient was used to test for the temporal patterns in the changes of the minimum occupied area by each species. Only those species with at least four years of minimum occupied area estimate were used for this analysis. All tests were carried out with Past 4.0 software (Hammer and Harper, 2001), with alpha set at 5%.

3. Results

3.1. General Distribution Patterns

The general spatial distribution of the sightings sites (all species pooled) and of the poaching/illegal human activity indices are shown in Figure 2, and the summarised species-specific key characteristics are presented in Table 1. Most observed animals concentrated around forest habitats along rivers (gallery forests), with the western Comoé River exhibiting rich mammal presence. Peripheral areas near villages showed lower sightings, likely due to human disturbances. Considering that many species occurrences are concentrated in gallery forests, which constitute only a small portion of the protected area, it is evident that a significant part of the protected territory lacks the necessary characteristics to support the diversity of mammal species in the region. Overall, wildlife distribution remained relatively consistent, while poaching indices displayed variability among years.

3.2. Minimum Occupied Area by Species and by Year

Species-by-species minimum occupied areas are given in the Online Supplementary Figures S1-S15. A GLM model indicated that there was no significant year effect ($F_{6,54}$= 0.474, P = 0.825) but a highly significant species effect ($F_{10,50}$= 5.44, P < 0.0001) on the minimum occupied area of large mammals within the protected area. Some species had a wider distribution than others within the reserve (Table 2), occurring not only in gallery forests but also in wooded savannahs and open lands. More specifically, one ungulate (*Hippotragus equinus*) and two primate species (*Erythrocebus patas* and *Chlorocebus aethiops*) were the species with occurrences in a suite of habitat types (gallery forests, wooded savannahs, open grasslands), whereas two ungulates (*Ourebia ourebi* and *Kobus ellipsiprymnus defassa*) were observed only in gallery forest (Table 2).

Minimum occupied areas declined throughout the years only in three species: *Sylvicapra grimmia* (Figure S4), *Tragelaphus scriptus* (Figure S9) and *Papio anubis* (Figure S13), whereas no detectable trend was evident for the other species.

Poaching/illegal human activity indices revealed a broad and relatively homogeneous distribution in the study area (Online Supplementary Figure S16), indicating that there is essentially no sector of the protected area that is free from illegal human activities. The central part of the protected area was particularly affected by the presence of poaching/illegal human activities, although with some differences in index intensity among years (Figure 1). Despite the strong presence of human activities in the center of the reserve, animals continue to use this area due to the presence of water supply (Figure 1).

Poaching/illegal human activity index was relatively stable from 2010 to 2016, but increased substantially between 2016 and 2018 (Figure S17).

4. Discussion

The trends observed during the study period showed strong minimum area occupancy fluctuations by species but no effect of years. As expected, some species are more habitat-generalists than others, and therefore were observed in the wider area. This would have been conditioned by the location and extent of waterbodies and rivers, favouring the sightings of those species often inhabiting gallery forests and wet areas, such as *Redunca redunca* and *Kobus kob*. It is well known but primarily anecdotal that, in African savannahs, many Afrotropical large mammals tend to use riparian and gallery forests as displacement routes (e.g. Segniagbeto et al., 2022), so in this regard, our study confirms previous anecdotal evidence. Ready access to cover and availability of suitable food plants accounted, at least partially, for the observed minimum occupied area as it implies preferences of specific vegetation types over others. Differences in the behavioural ecology and food preferences of each species will affect their distribution (Evans, 1979). Access to water is likely to have significantly impacted the movement patterns of many species in such semi-arid environments (Evans, 1979). In addition, the distribution patterns of ungulates are not only directly affected by the availability of 'suitable' habitats but also by their behavioural plasticity; competitive exclusion between certain species also needs to be considered (Averbeck et al., 2009).

The fact that many species were sighted along the main waterbodies suggests that baseline inventories of arid savannah large mammals should focus on streams, ponds, and other types of wetlands and on observing species that are not bound to these habitats. There is no doubt that transects walked close to waterbodies may have increased the chances of observing the target species, indicating that this may have influenced our results. It is conceivable that the relative scarcity of water sources in the arid savannah areas of the Sudanian vegetation zone represents a main attraction for the various ungulate species, as has been observed in East African savannahs, especially during the dry seasons (Fynn et al., 2014, 2015; Veldhuis et al., 2019).

The hypothesis that rainfall may directly influence primary productivity and therefore large mammal spatial patterns (with negative impacts of annual rainfall on primary production during particularly dry years) (e.g. Ogutu et al., 2008; Gandiwa et al., 2016) may not be tested in this study because of the relatively short field monitoring period. However, future studies should analyse the long-term correlations between yearly rainfall patterns and large mammal spatial occupations to open up new avenues of research on the dynamics of ecosystems and terrestrial mammals.

Despite a general non-effect of the single year on the minimum area occupancy, there was some reduction throughout the years in a few species, although these trends were never statistically significant due to the small number of years of survey reducing the statistical power of the correlation tests. This evidence might suggest a slightly decreasing trend of suitable habitat available for several mammal species in the reserve, accomplished with increased habitat fragmentation and, therefore, the need for adopting ecological network strategies to be adapted to the various individual species for their effective conservation (Barnes and Child, 2014; Wegmann et al., 2014; Battisti, 2024). This suitable habitat reduction might be the result of persisting poaching and other illegal human activities in the area as (1) no noticeable changes in habitat structure have been observed (Hema et al., unpublished data), and (2) signs of illegal human activity and poaching were detected in almost the whole study area. In this regard, during our field project (the "Projet D'amelioration De La Productivite Agricole Et De La Securite Alimentaire" (PAPSA) project), we observed that the number of illegal activities has experienced a constant slight reduction in poaching index (from 53 to 49) between 2010 and 2013 but a strong increase between 2016 and 2018 (66 to 172) (Hema, 2018). After the end of the PAPSA project, with the release of activities planning, monitoring and anti -breaching, there was an increase in poaching and illegal human activities in the reserve. The high poaching index values in 2016-2018 may potentially impact the minimum occupancy area of several species in the years to come, and it is therefore important to continue and intensify surveillance actions so that poaching may decrease considerably.

Our study documented the reappearance of the elephant in the area after several years (Hema, 2018). Elephant observations in 2018 were on the northwest side of the reserve, close to the Niangoloko area (about 20 km away). Therefore, these observed individuals may come from groups of elephants from the Niangoloko area (Hema et al., 2023), with the reserve possibly adequate for their sedentarisation if carefully managed.

For management purposes, we think that of particular interest is the spatial distribution of the waterbodies, which are concentrated in the central part of the reserve and which attract, despite anthropogenic disturbance, a notable concentration of the territories of the various species studied. The habitats surrounding these waterbodies should be carefully monitored and protected to maintain the populations of mammals in the reserve.

Since several species showed a wide occupancy area within the reserve (*Tragelaphus scriptus, Hippotragus equinus, Phacochoerus africanus, Chlorocebus aethiops* and *Erythrocebus patas* to cite a few), it can be anticipated that their populations can be positively influenced if there will be a strengthening of the connectivity between the reserve and adjacent conservation areas (Battisti, 2024), such as the classified forests of Boulon and Koflandé and the classified forest of Warigué and the Comoé National Park in Cote d'Ivoire. Therefore, the management of cross-border resources with Côte d'Ivoire to allow the realisation of connectivity projects and the signing of an anti-poaching control agreement to make them more efficient monitoring is strongly needed.

4.1. Limitations of the study

The results presented may have been affected by various factors that are difficult to evaluate. To begin with, the effectiveness of the census teams. To minimise this potential issue, we employed all throughout the years of study the same trackers, who were used as observers during the surveys and participated in all the data collection phases. Unfortunately, this was not the case for forestry personnel (team leaders of each survey) who changed for logistical reasons year by year. The fact that the same actors did not collect all the data used to assess the temporal trends in mammal sightings may introduce a bias in the estimates. Another potential bias may come from the data collection period year-by-year. The data collection period extended from February to May during the whole assessment period, but given that the season (availability of water, grazing, visibility) can influence the distribution and/or visibility profile of wildlife and therefore the encounter rate (Bukombe et al., 2016), the fact that the data could not be not collected under the rigorously identical conditions of rainfall and temperatures (as these fluctuated yearly) may have affected the data quality and therefore introduced a bias in the estimates.

5. Conclusions

While species-specific minimum occupied area fluctuated, no significant year effect was observed. Some minimum occupancy area reduction occurred over time in a few species, suggesting potential habitat reduction due to persistent poaching. The reappearance of elephants in 2018 and their concentration near water bodies highlight the importance of protecting habitats around these areas. Strengthening connectivity between the reserve and adjacent conservation areas is crucial for positively influencing wide-ranging species (Battisti, 2024).

This study provides valuable insights into the spatial distribution of large mammals in the Comoé-Leraba protected area. Understanding spatial dynamics aids conservation efforts, and our findings have implications for habitat protection, cross-border cooperation, and ongoing monitoring to combat poaching and other illegal human activities. This research contributes to the broader understanding of ecological science and supports the conservation of vital landscapes and their diverse species.

CRediT authorship contribution statement

Emmanuel M. Hema: Conceptualization, Methodology, Software, Data curation, Writing – original draft, Writing – original draft. Yaya Ouattara: Field, Investigation. Urbain Belemsobgo: Conceptualization, Methodology, Software, Data curation, Writing – original draft, Writing – original draft, Field, Investigation. Ismael M. Tou: Field, Investigation. Youssouf Sanou: Field, Investigation. Mamadou Karama: Field, Investigation. Giovanni Amori: Writing – review & editing. Julia E. Fa: Writing – review & editing. Luca Luiselli: Formal analysis, Writing – original draft.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper. Data availability Data will be made available on request.

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Table 1. Synopsis of the species-specific patterns of spatial occupation of the Comoé-Lèraba National Park by the 18 mammal species throughout the study period

Species	Description
Alcelaphus busephalus	Our data reveal extensive use of the reserve from 2010 to 2018. Throughout this period, there was a slight decrease in the log-transformed minimum area occupancy, with the species consistently observed on the right bank of the Comoé River (Figure 3).
Syncerus caffer	This species was observed only six times, each instance near the Comoé River or water points (Figure 4). The limited number of records prevented us from calculating a minimum area occupancy for this species in the study area.
Cephalophus rufilatus	Occasional sightings occurred near water points, and a single estimate for minimum annual distribution area was possible for this species in 2011, spanning 6,933 hectares.
Sylvicapra grimmia	Frequently observed in each survey year, this species was most often sighted near permanent water points (Figure 6). The minimum occupied area showed a significant decrease, from 33,699 hectares in 2010 to 1,589 hectares in 2016, although the reduction in log-transformed minimum area occupancy wasn't statistically significant due to the small sample size.
Kobus kob	Observed each year, this species consistently inhabited areas near the Comoé and Léraba rivers. The minimum occupied areas displayed significant fluctuations over the study period, ranging from 365 hectares to 28,395 hectares (Figure 7), with no evident temporal trend.
Kobus ellipsiprymnus defassa	This species was mainly observed in plains near ponds and along the Comoé and Léraba rivers, with notable variations in minimum occupied area across the years (Figure 8). A non-significant negative temporal trend was detected.
Redunca redunca	Similar to Kobus ellipsiprymnus, this species concentrated around ponds in the center of the reserve (Figure 9).
Hippotragus equinus	This species occupies a wide range of habitats, with notable variations in spatial occupation from year to year (Figure 10). Overall, there was a slight non-significant increase in the log-transformed minimum area occupancy ($r = 0.414$, $P = 0.356$).
Tragelaphus scriptus	Despite relatively low numbers, this species was widespread throughout the reserve during the survey years (Figure 11). The minimum occupied area decreased marginally from 48,392 hectares in 2010 to 12,174 hectares in 2018 ($r = -0.872$, $P = 0.051$).
Ourebia ourebi	This species had a distribution similar to *Tragelaphus scriptus* but with a concentration around central ponds (Figure 12). The minimum occupied area varied across the years, suggesting a non-significant decrease in log-transformed minimum area occupancy ($r = -0.493$, $P = 0.320$).
Phacochoerus africanus	Widely distributed throughout the reserve (Figure 13), this species exhibited an increase in the minimum area occupied between 2010 and 2018, with intermittent decreases (Figure 13). No apparent temporal trend was detected ($r = 0.045$, $P = 0.923$).
Loxodonta africana	Observed only twice during all seven inventories, the species occurred near water points in 2011 and 2018 (Figure 14). The sample size was too small for statistical analysis.
Papio anubis	This species was observed five times in seven inventories, with all sightings concentrated in the central part of the reserve around water bridges (Figure 15). The minimum area occupied showed a decrease between 2010 and 2018 (Figure 15), but a non-significant negative temporal trend was observed ($r = -0.871$, $P = 0.327$).

Erythrocebus patas	Patas were present along the reserve rivers, with higher densities in the central and northern parts of the reserve (Figure 16). The minimum area occupied displayed fluctuations from 2010 to 2018 (Figure 16). Although no significant temporal trend was detected, there was a non-significant slight increase in the log-transformed minimum area occupancy ($r = 0.468$, $P = 0.291$).
Chlorocebus aethiops	This species was found throughout the reserve, with higher densities in the center and north, including a remarkable presence on the left bank of the Comoé River (Figure 17). The minimum area occupied varied significantly from 2010 to 2018 (Figure 17). Statistical analyses indicated no significant temporal trend in minimum area occupancy ($r = 0.493$, $P = 0.916$).

Table 2. Descriptive statistics of the minimum occupied area (km^2) by mammal species for which at least four years of analyses were available

	Min	Max	Mean	Stand. dev	Median
Phacocoerus africanus	11172	43221	29385.57	13060.00	33768.00
Chlorocebus aethiops	22012	67447	37986.29	17053.66	33377.00
Erythrocebus patas	26176	70234	45718.43	17119.96	50767.00
Papio anubis	7595	26639	13981.67	10961.73	7711.00
Ourebia ourebi	1770	25013	8757.33	8233.19	6122.00
Tragelaphus scriptus	8661	48392	25640.81	15984.06	27897.00
Hippotragus equinus	22017	68730	42306.71	17297.83	42267.00
Kobus ellipsiprymnus	1004	12504	6800.00	4869.81	6846.00
Kobus kob	365	28395	13649.25	12860.91	12918.51
Sylvicapra grimmia	773	33699	12773.25	15406.52	8310.52
Alcelaphus busephalus	1005	28863	19014.43	12367.79	26743.00

Figure 1. Map of Burkina Faso, showing the study area with the vegetation characteristics and the land use within the protected area

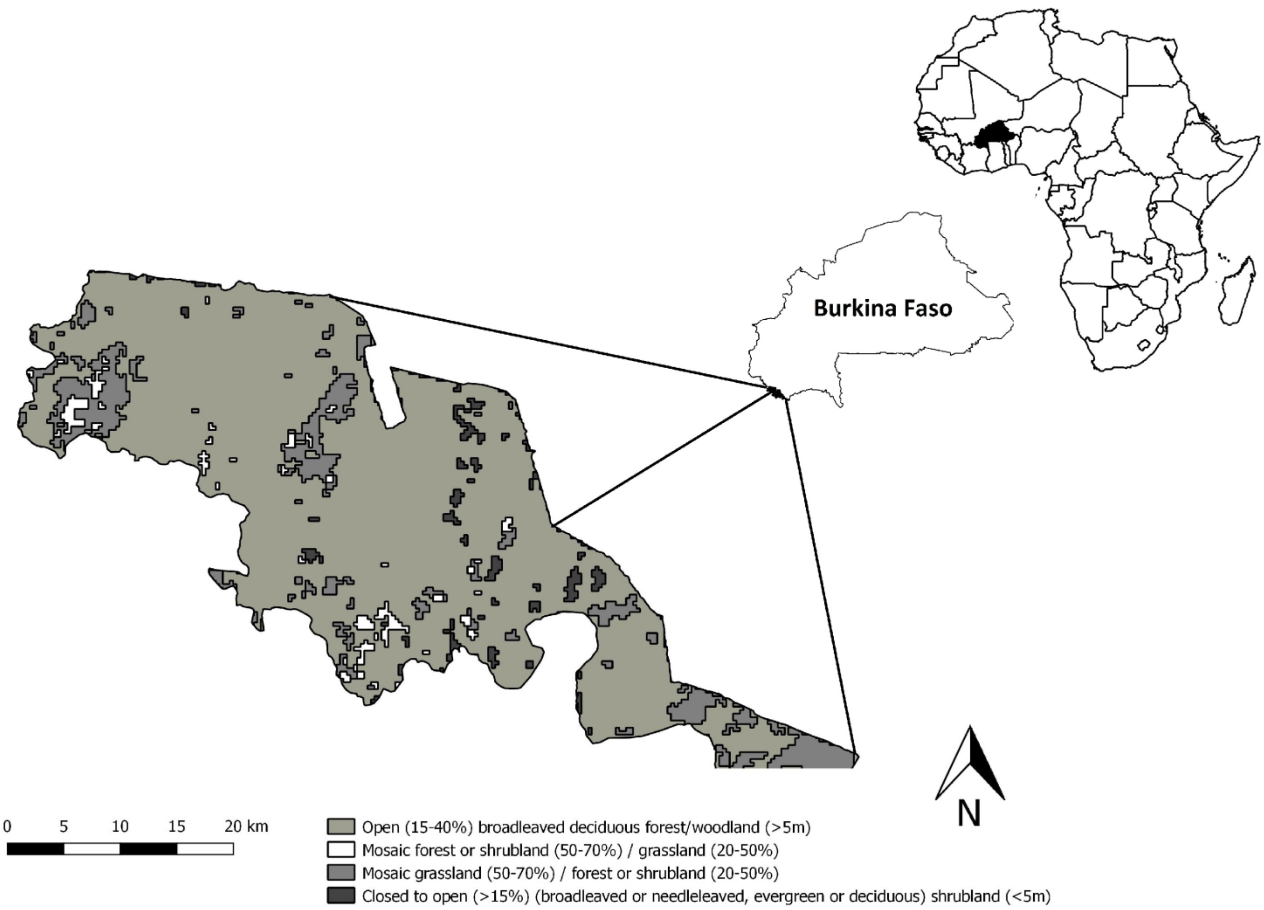
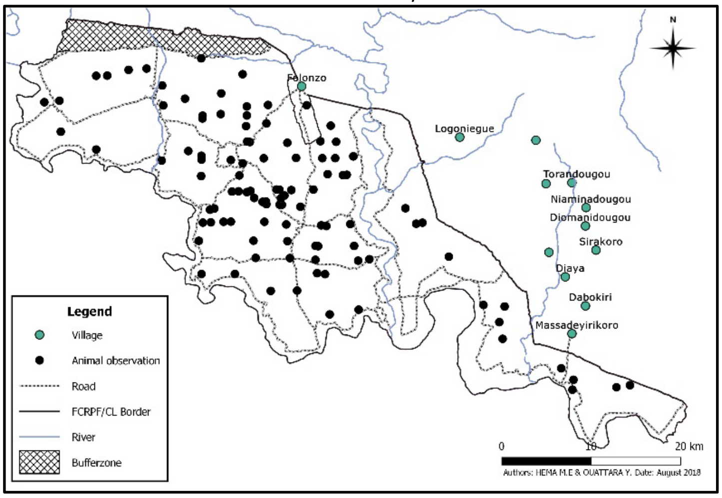
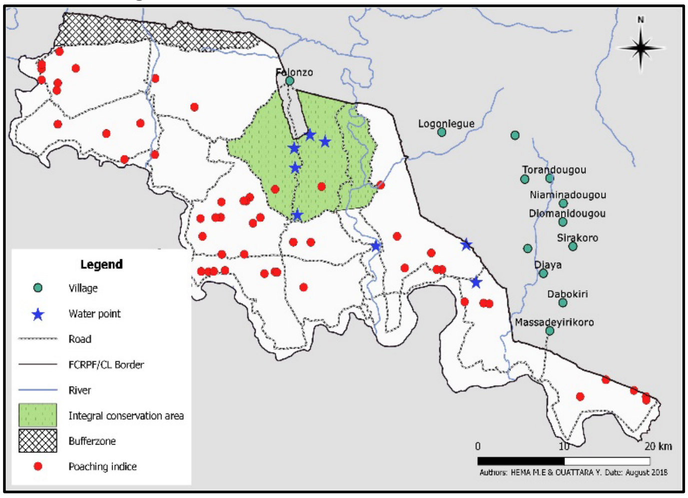


Figure 2. Comparative figures of wildlife distribution (in terms of sightings) and poaching indices in the study area between 2010 and 2018

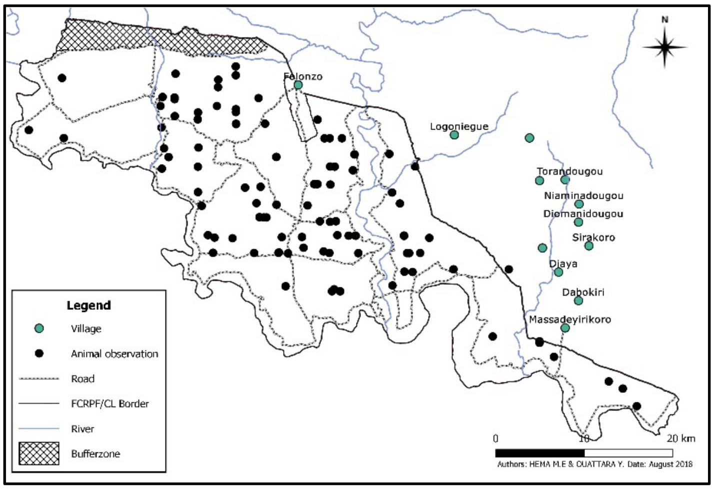
Animal distribution in the FCRPF/CL 2010



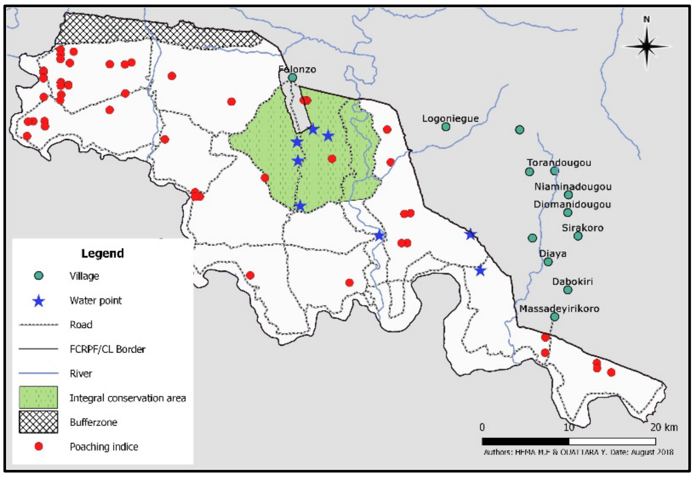
Poaching indices distribution in the FCRPF/CL 2010



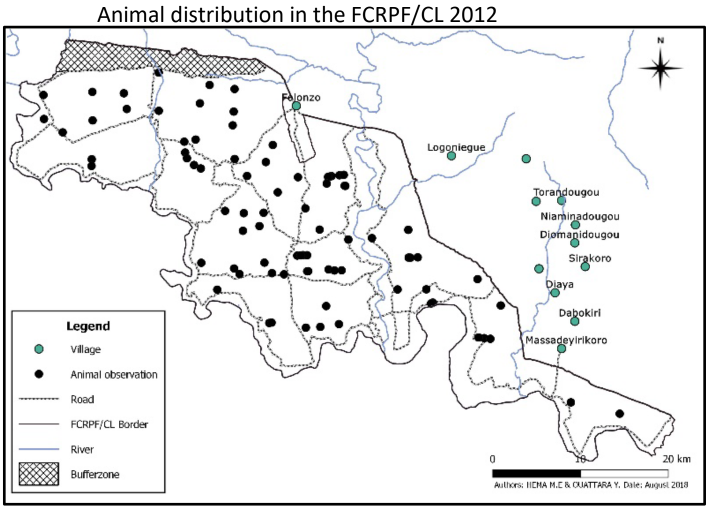
Animal distribution in the FCRPF/CL 2011



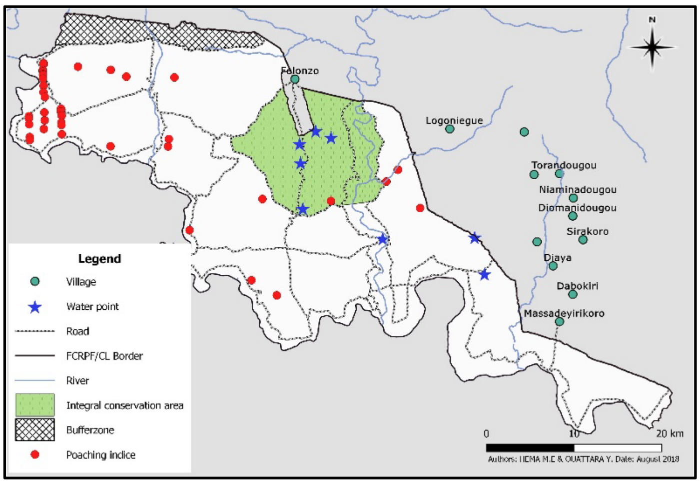
Poaching indices distribution in the FCRPF/CL 2011



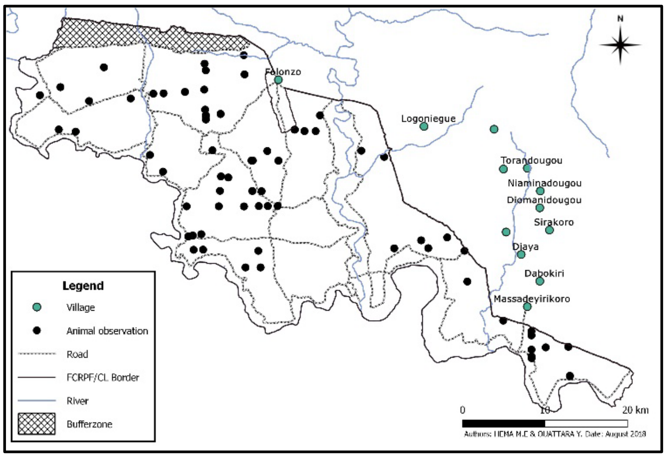
Animal distribution in the FCRPF/CL 2012



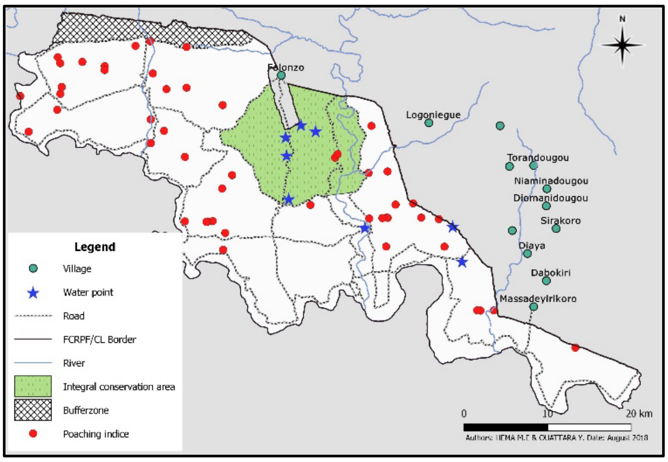
Poaching indices distribution in the FCRPF/CL 2012



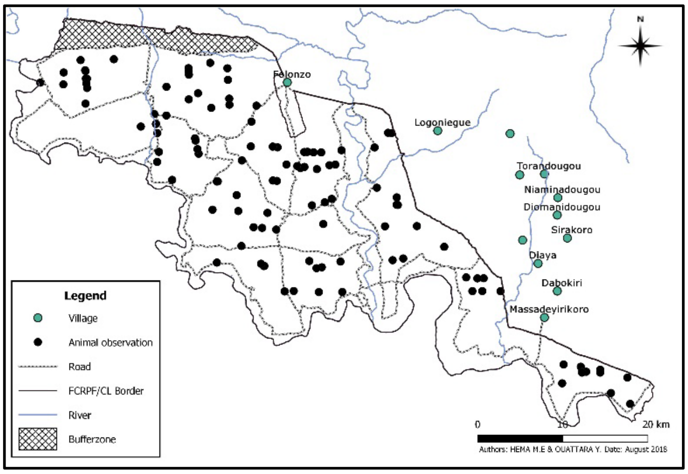
Animal distribution in the FCRPF/CL 2013



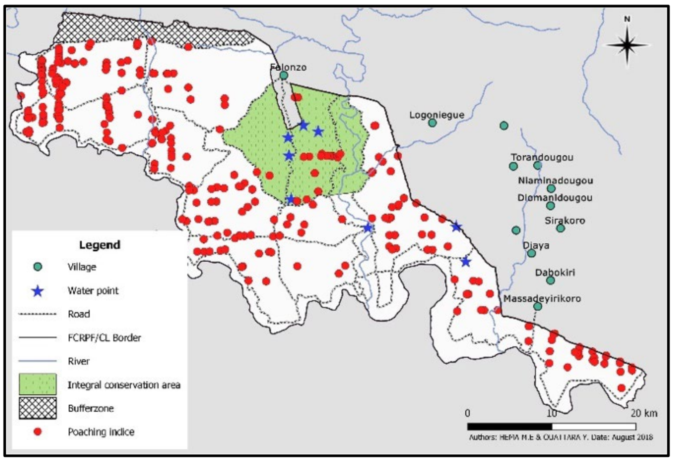
Poaching indices distribution in the FCRPF/CL 2013



Animal distribution in the FCRPF/CL 2018



Poaching indices distribution in the FCRPF/CL 2018



ONLINE SUPPLEMENTARY MATERIALS

Figure S1. Spatial distribution of *Alcephalus busephalus* in the FCRPF_CL between 2010 and 2018. In the inset, the yearly used area of the reserve by the species (minimum convex polygon method)

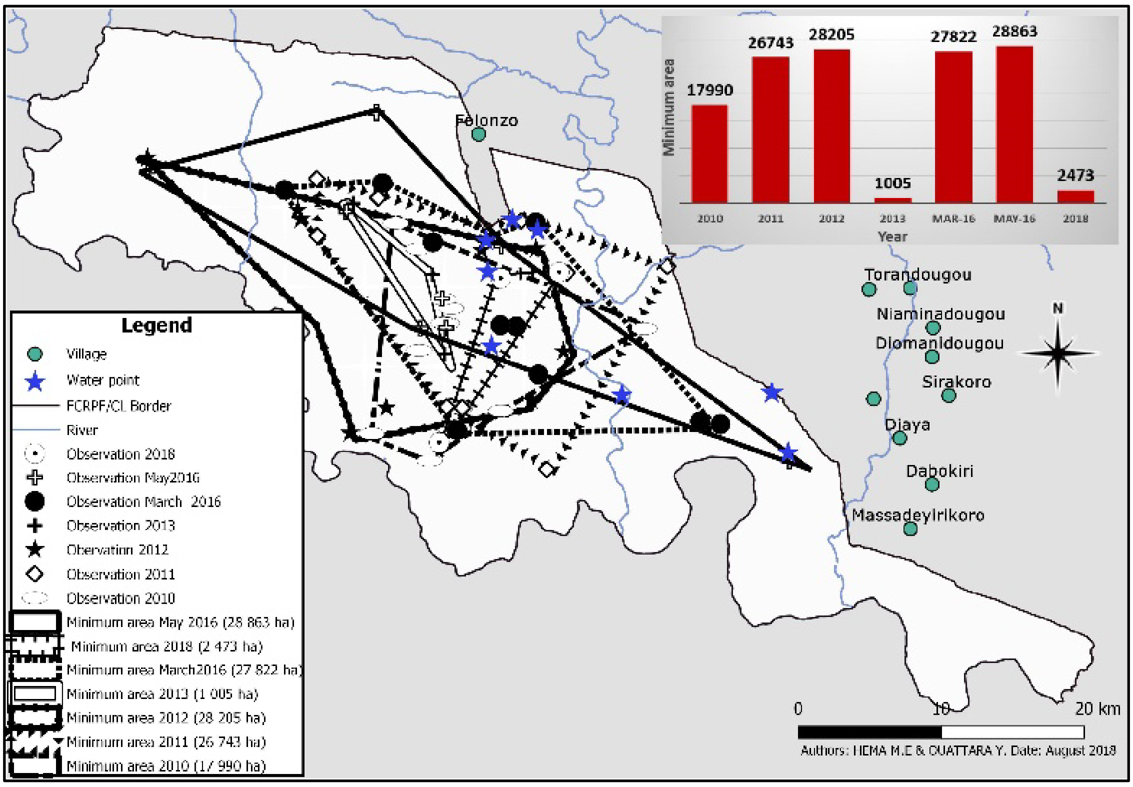


Figure S2. Spatial distribution of *Syncerus caffer* in the FCRPF_CL between 2010 and 2018

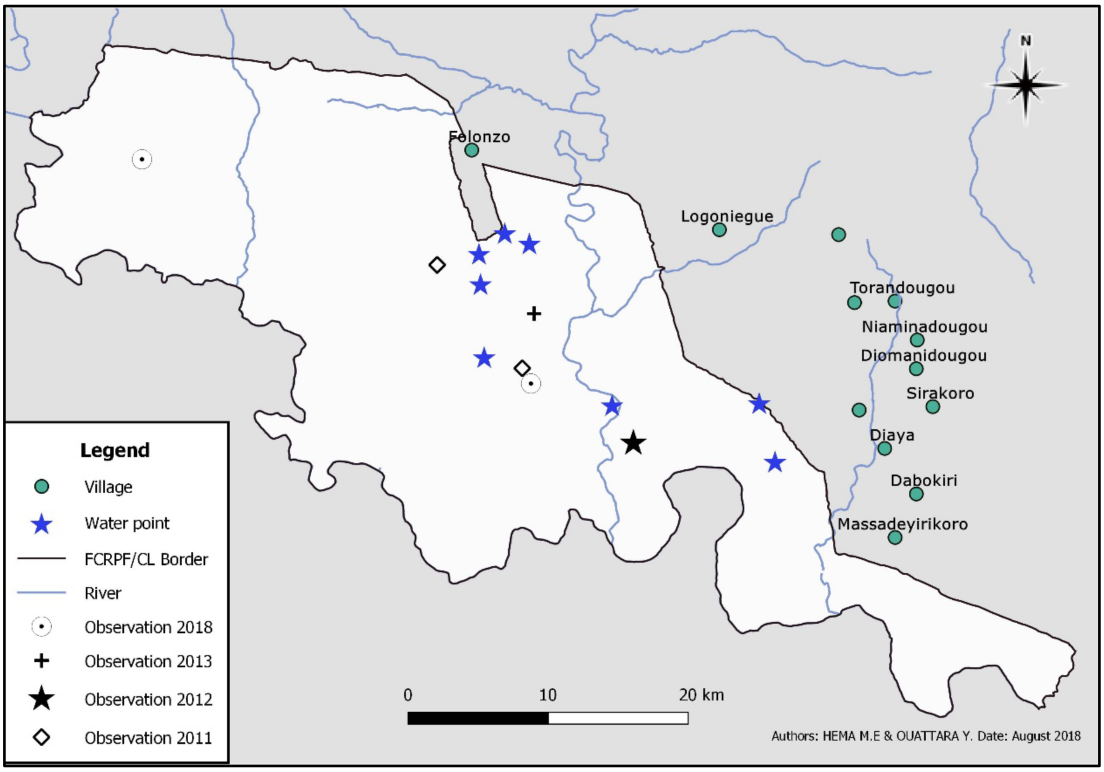


Figure S3. Spatial distribution of *Cephalophus rufilatus* in the FCRPF_CL between 2010 and 2018. In the inset, the yearly used area of the reserve by the species (minimum convex polygon method)

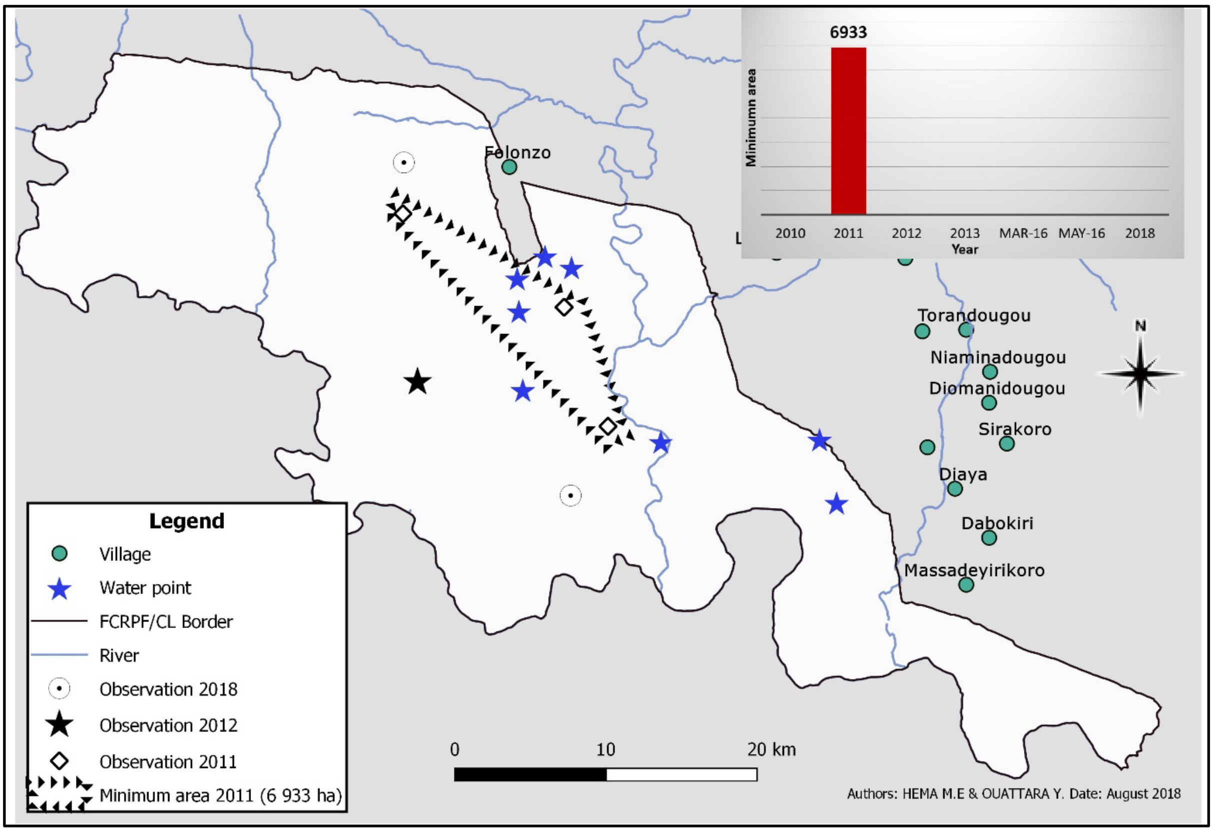


Figure S4. Spatial distribution of *Sylvicapra grimmia* in the FCRPF_CL between 2010 and 2018.

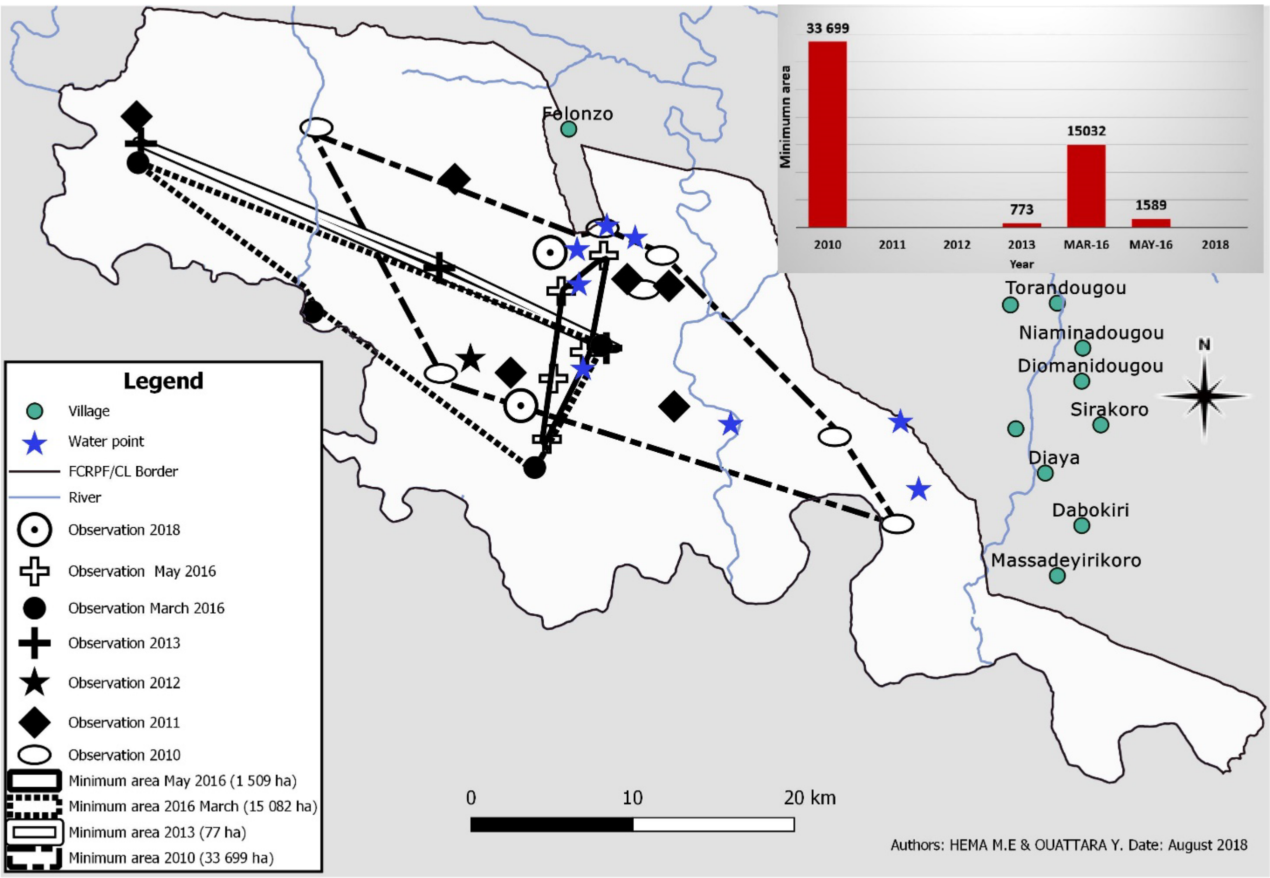


Figure S5. Spatial distribution of *Kobus kob* in the FCRPF_CL between 2010 and 2018.

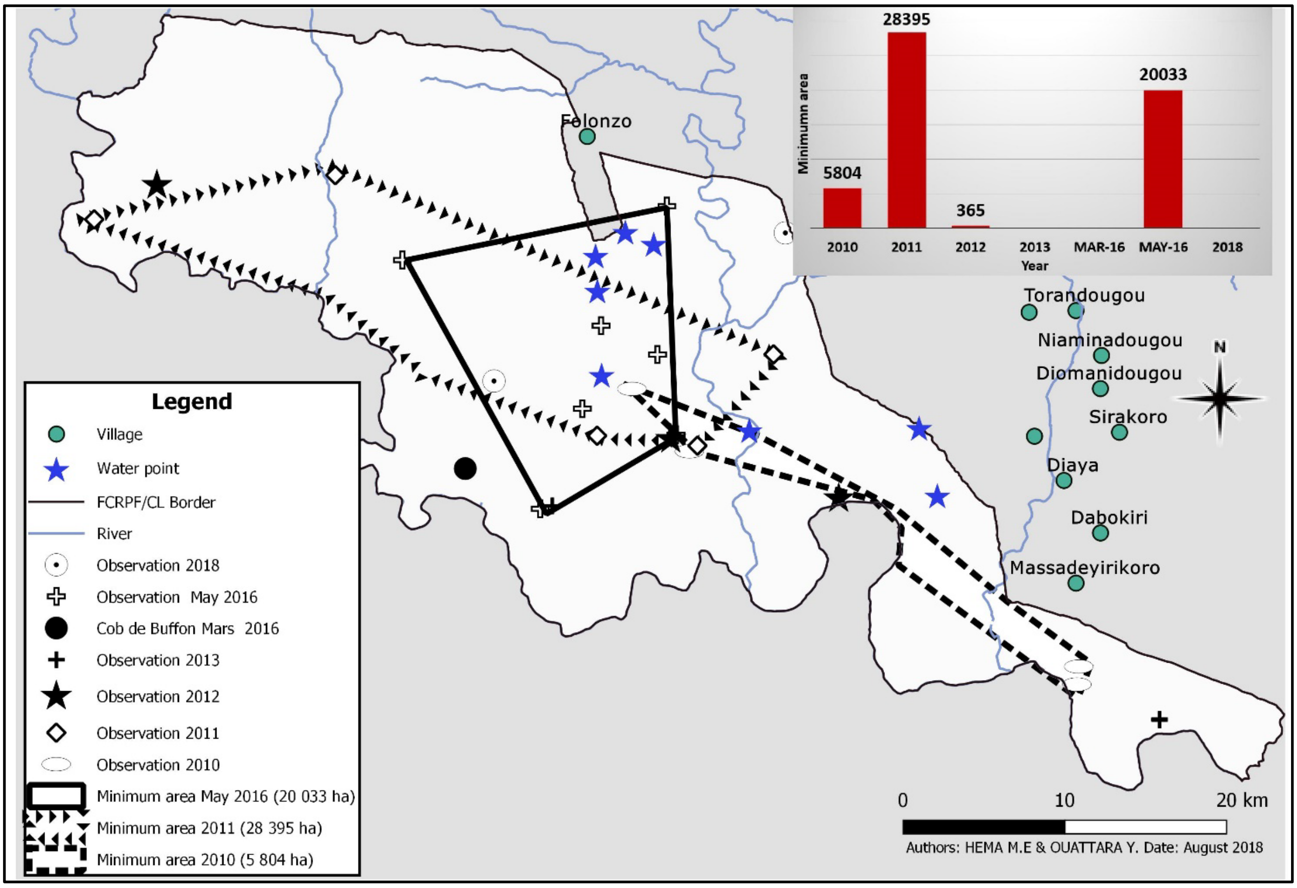


Figure S6. Spatial distribution of *Kobus ellipsiprymnus defassa* in the FCRPF_CL between 2010 and 2018. In the inset, the yearly used area of the reserve by the species (minimum convex polygon method)

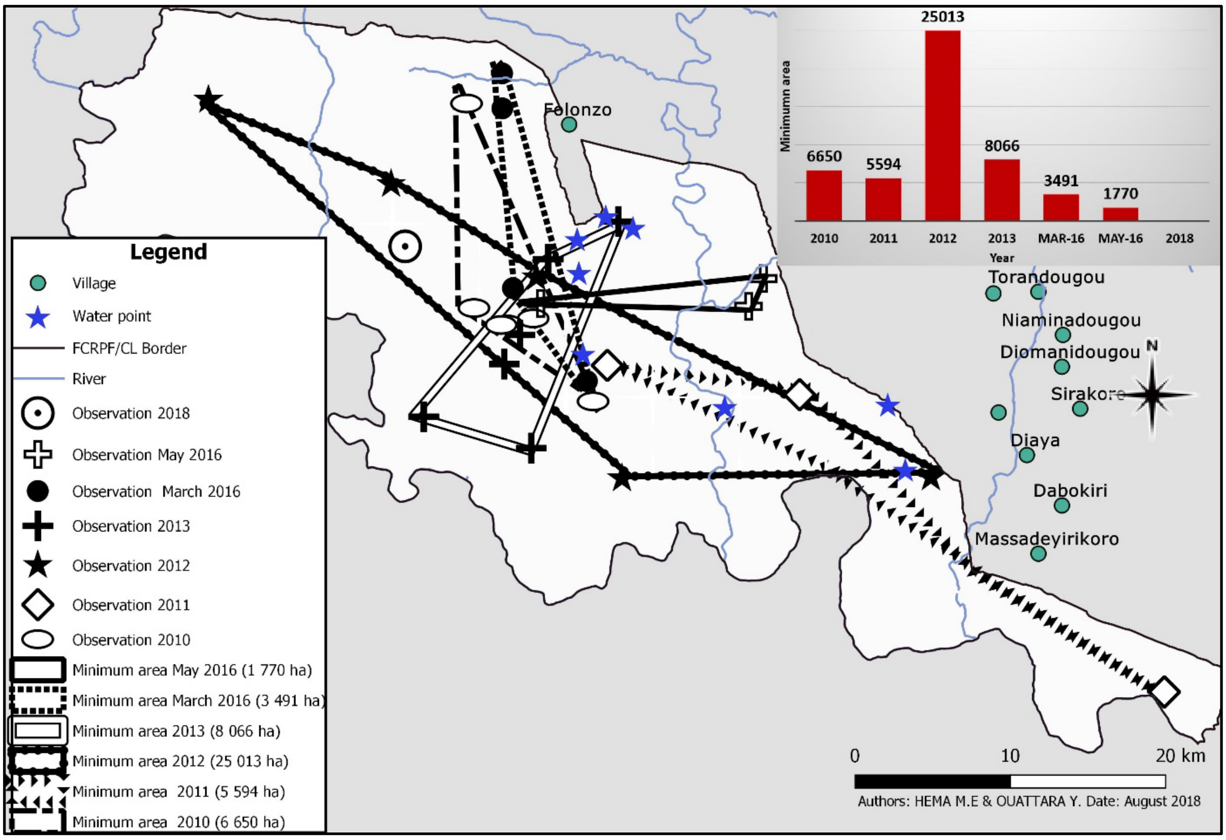


Figure S7. Spatial distribution of *Redunca redunca* in the FCRPF_CL between 2010 and 2018

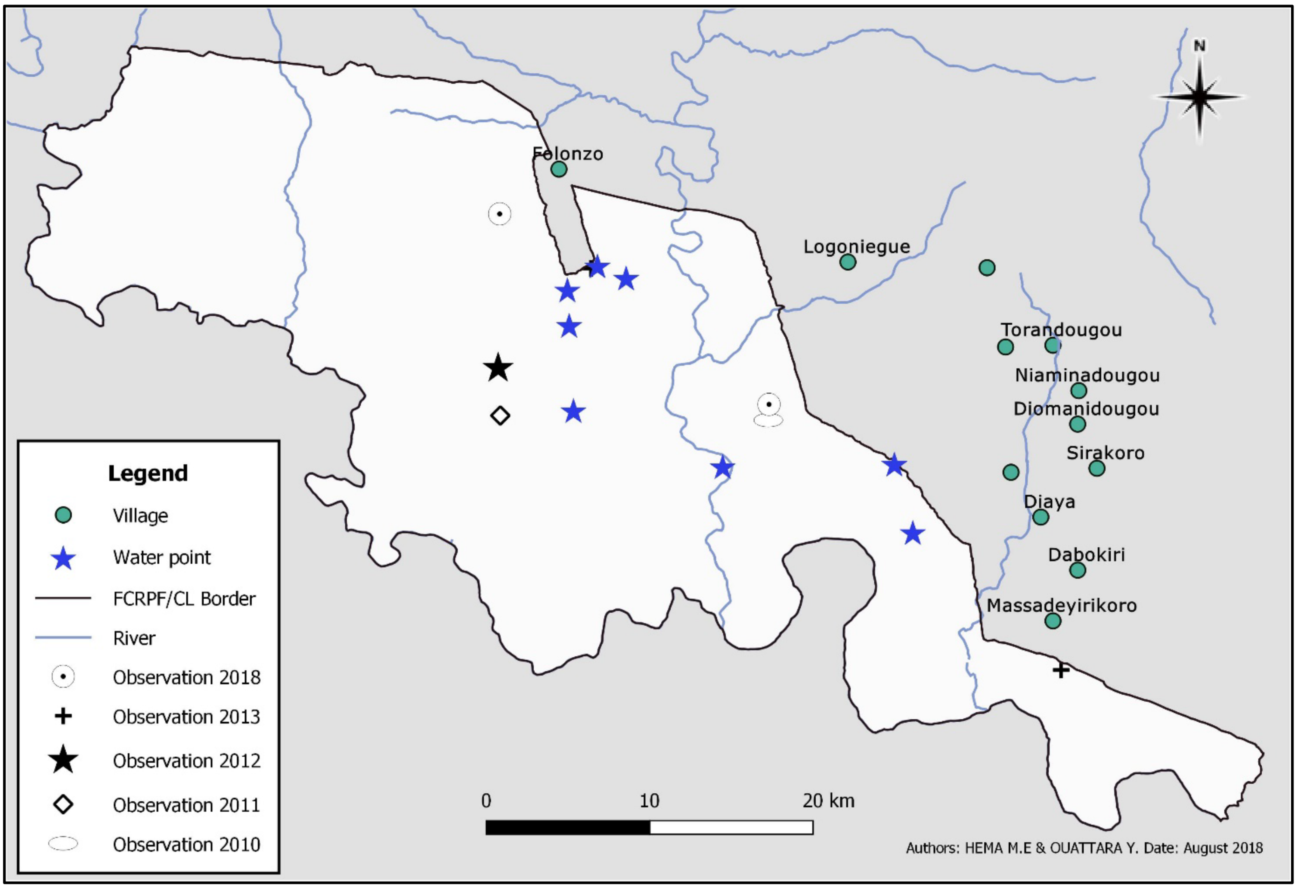


Figure S8. Spatial distribution of *Hippotragus equinus* in the FCRPF_CL between 2010 and 2018. . In the inset, the yearly used area of the reserve by the species (minimum convex polygon method)

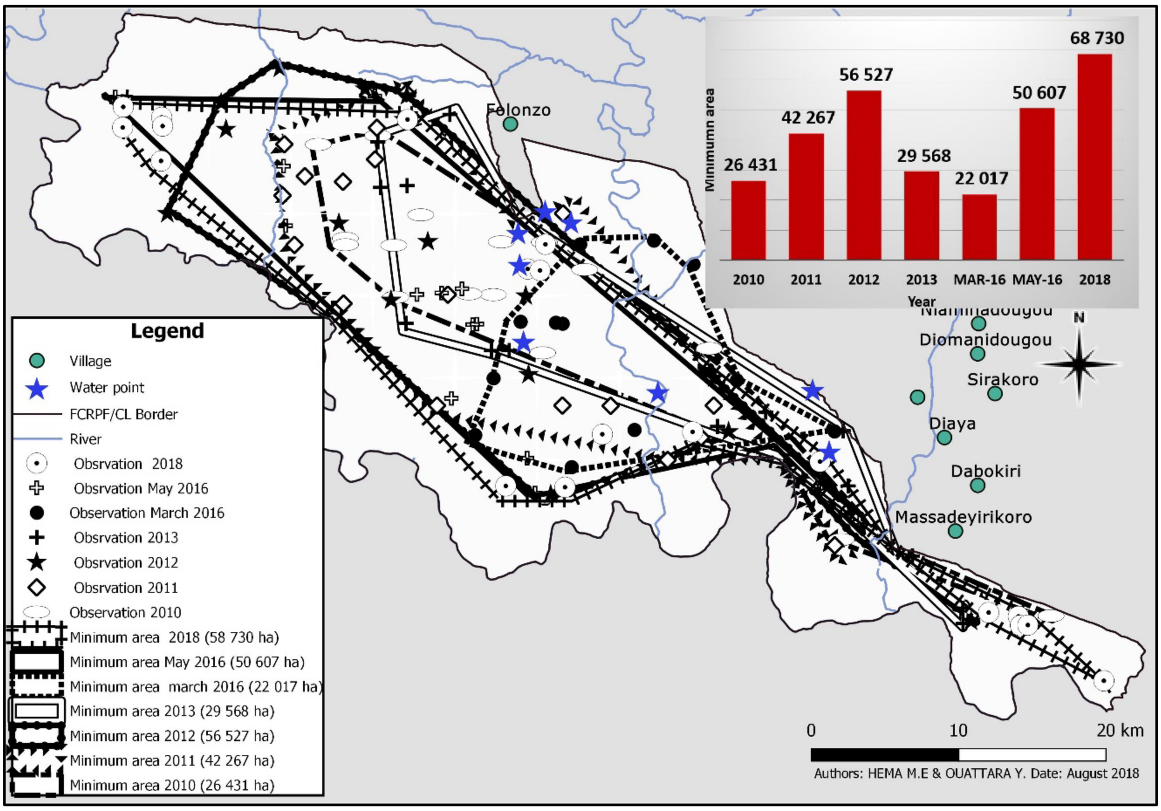


Figure S9. Spatial distribution of *Tragelaphus scriptus* in the FCRPF_CL between 2010 and 2018. In the inset, the yearly used area of the reserve by the species (minimum convex polygon method)

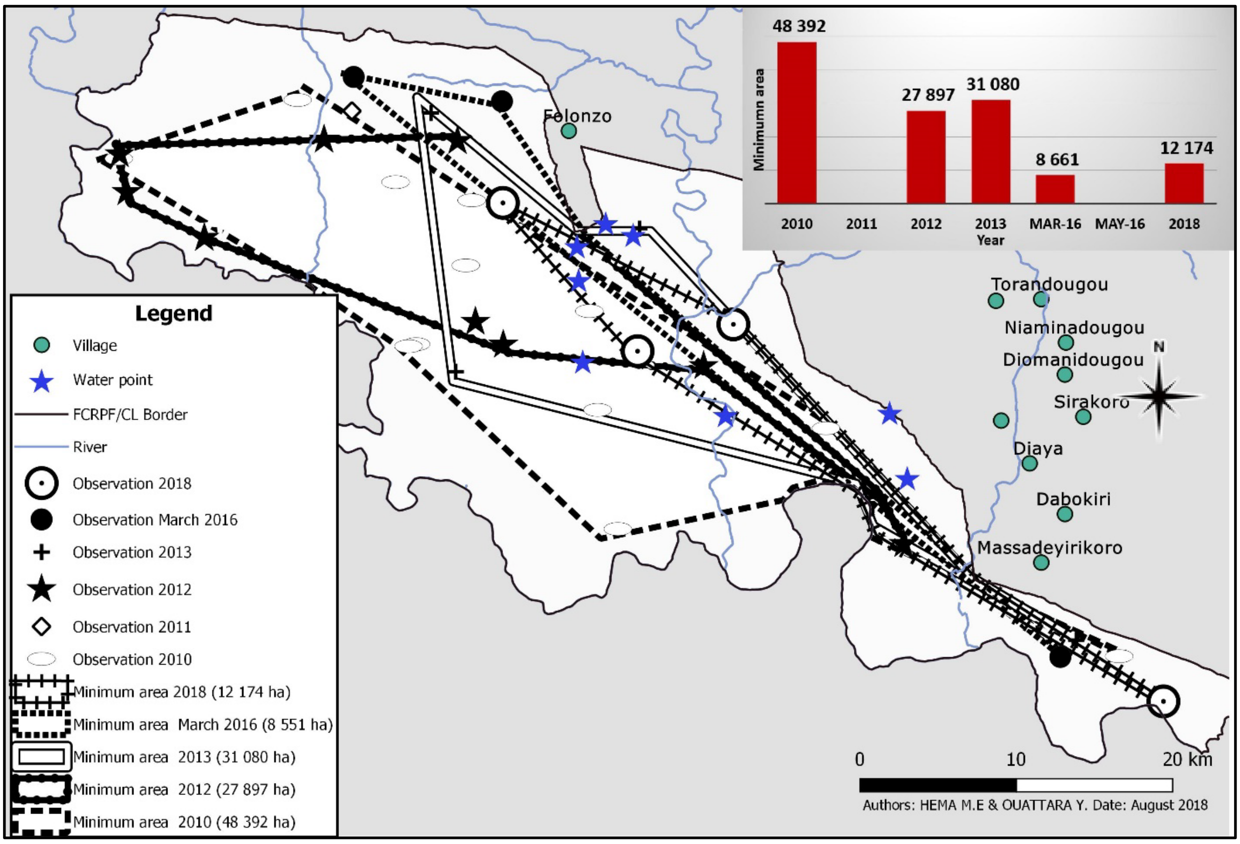


Figure S10. Spatial distribution of *Ourebia ourebi* in the FCRPF_CL between 2010 and 2018. In the inset, the yearly used area of the reserve by the species (minimum convex polygon method)

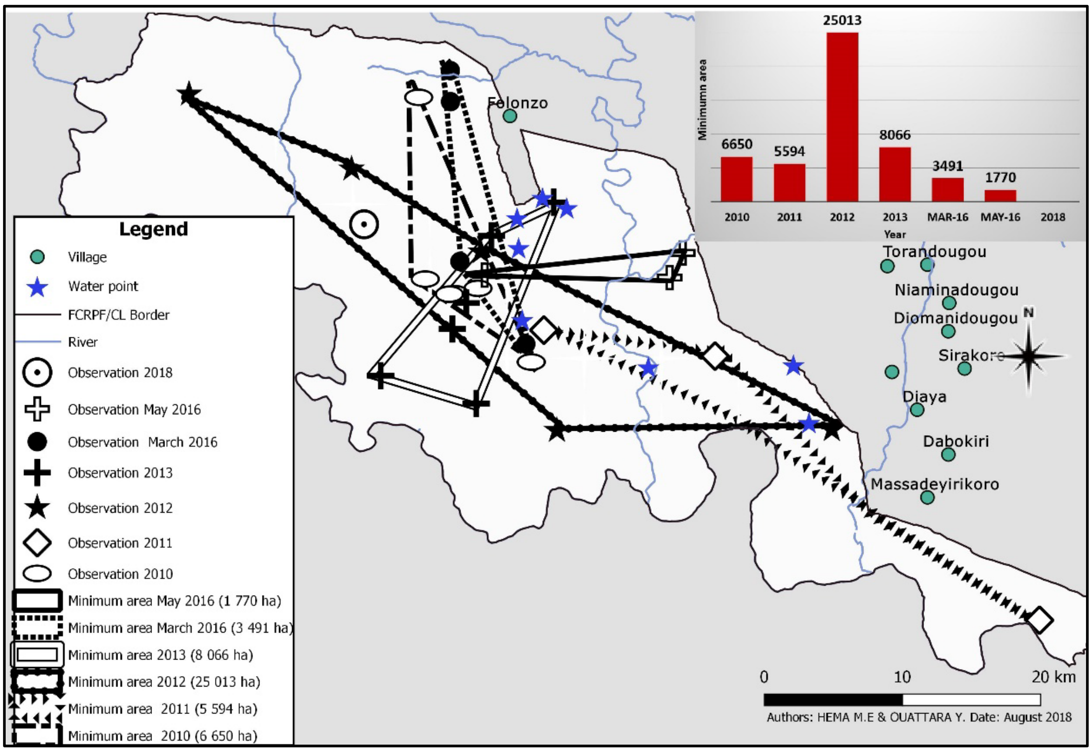


Figure S11. Spatial distribution of *Phacochoerus africanus* in the FCRPF_CL between 2010 and 2018. In the inset, the yearly used area of the reserve by the species (minimum convex polygon method)

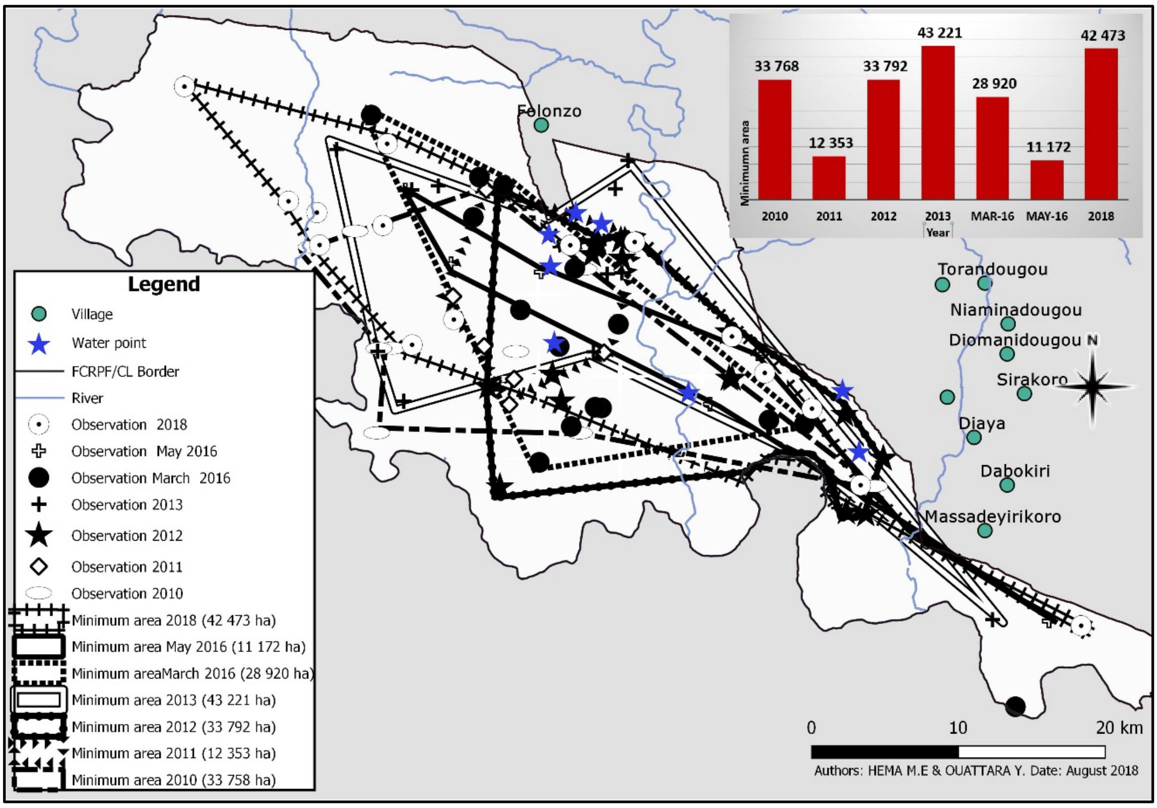


Figure S12. Spatial distribution of *Loxodonta africana* in the FCRPF_CL between 2010 and 2018

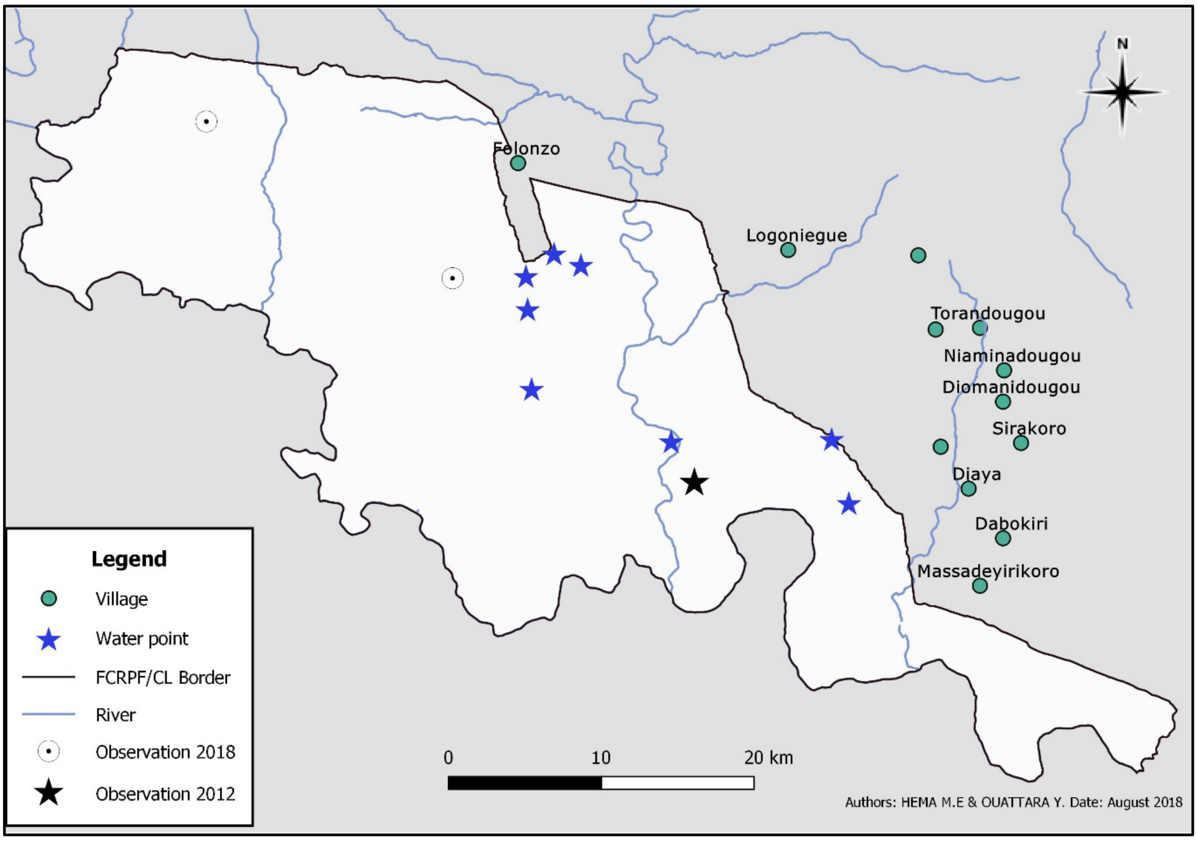


Figure S13. Spatial distribution of *Papio anubis* in the FCRPF_CL between 2010 and 2018. In the inset, the yearly used area of the reserve by the species (minimum convex polygon method)

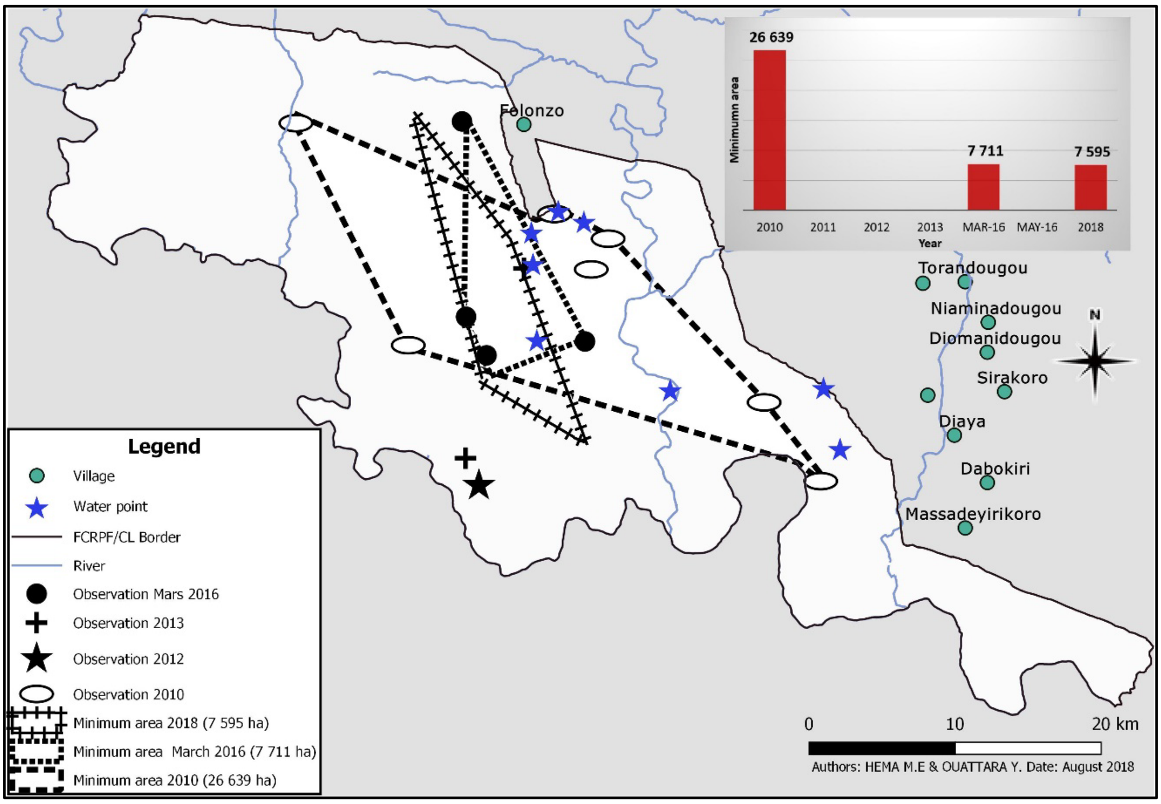


Figure S14. Spatial distribution of *Erythrocebus patas* in the FCRPF_CL between 2010 and 2018. . In the inset, the yearly used area of the reserve by the species (minimum convex polygon method)

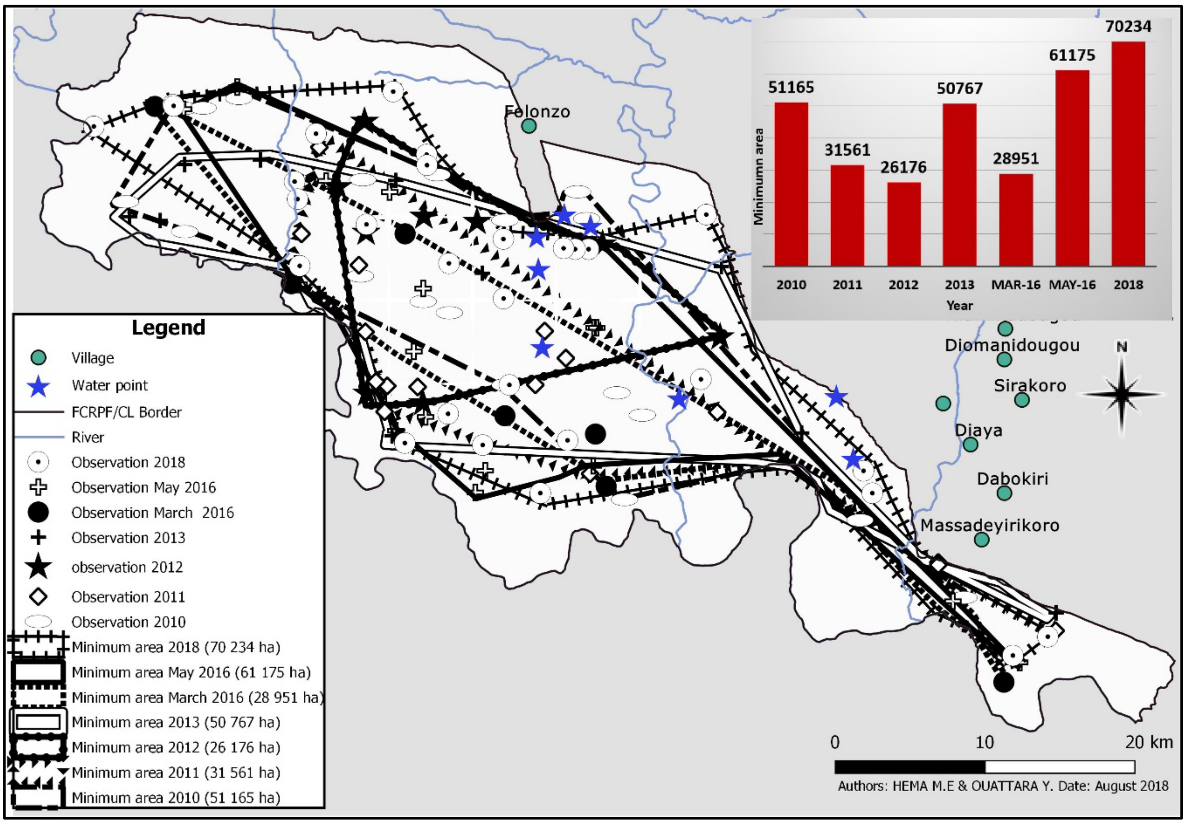


Figure S15. Spatial distribution of *Chlorocebus aethiops* in the FCRPF_CL between 2010 and 2018. In the inset, the yearly used area of the reserve by the species (minimum convex polygon method)

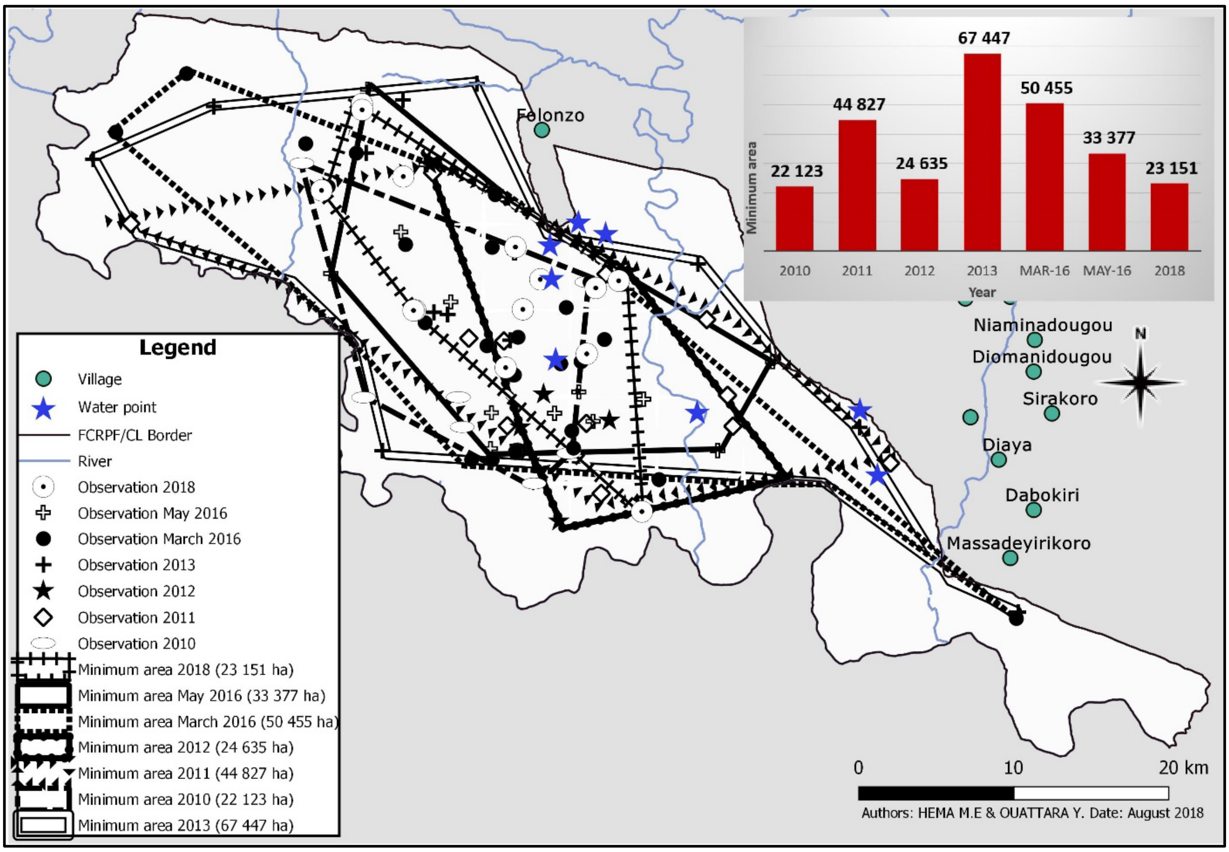


Figure S16. Cumulative distribution of poaching indices between 2010 and 2018 in the study area (FCRPF/CL)

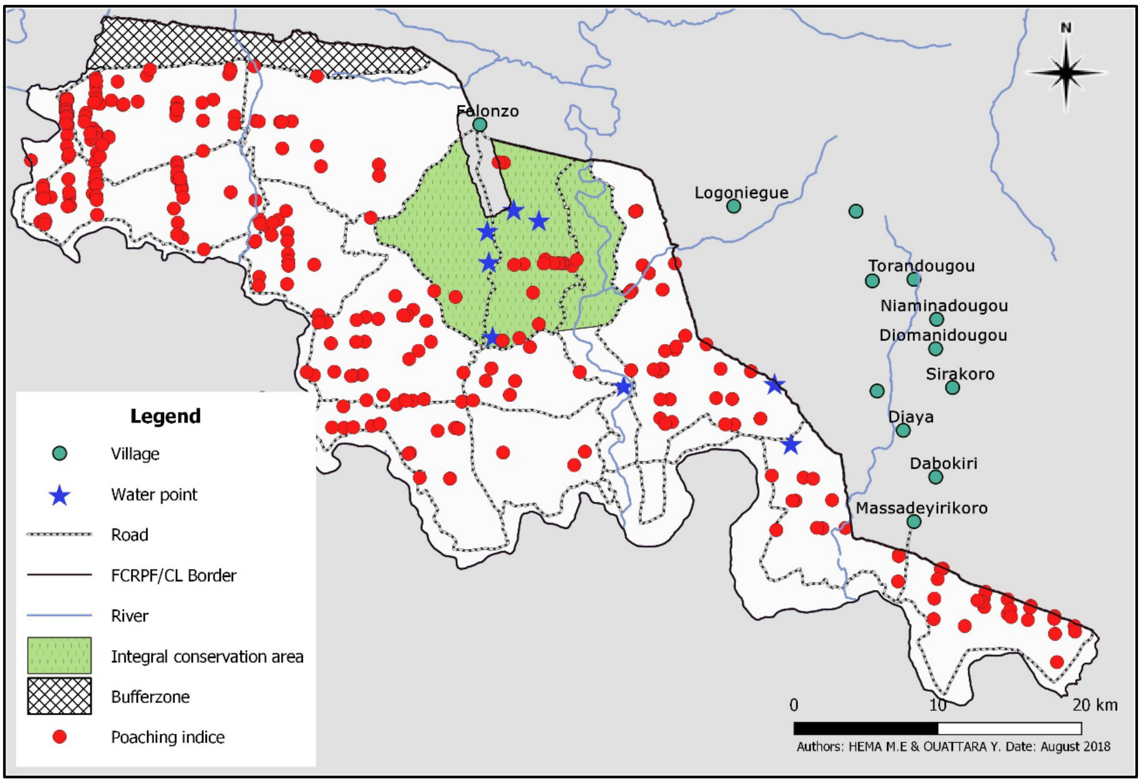


Figure S17. Yearly trend of the poaching index, at the study area between 2010 and 2018