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I hope the study may have a positive influence on the Boé, for all its people and biodiversity.

Abstract

Title: Relative abundance of *Pan troglodytes verus* in the forested habitats of the Boé region, Guinea-Bissau

Abstract Background: The West African chimpanzee has a serious risk in becoming extinct in GuineaBissau. Although the occurrence of chimpanzees has been confirmed in different parts of the country, baseline data on their exact distribution and habitat use are still missing. In recent years the national government of Guinea-Bissau has become increasingly aware of the importance of legally protected areas, with the consequence of two National parks being established in the Boé, a dry and extremely poor region of Guinea-Bissau, consisting mainly of savannah vegetation intersected by gallery and dry forests. However, according to Foundation Chimbo, a NGO involved in chimpanzee conservation, the protected areas are not large enough to safeguard the chimpanzee in the Boé. This created the need to identify key areas for chimpanzee conservation.

Aim: Identify key sites for chimpanzee conservation and complement the established legally protected areas in the Boé to safeguard the survival of the chimpanzee in the region.

Organism: West African chimpanzee *(Pan troglodytes verus)* Place of research: Boé region, Gabú province, south east of Guinea-Bissau.

Methodology: Reconnaissance (Recce) walks have been used to assess chimpanzee presence and relative abundance, and water resource availability in sacred and non-sacred forests, and forests with and without water resources in the dry and wet season. Additionally, they were used to collect data on human and large carnivore presence.

Principal findings: The occurrence of the Western chimpanzee in the Boé does no differ between sacred and non-sacred forests, and forests with and without water resources. Also, it was observed that chimpanzee presence in the sacred forests of the Boé does not differ between the dry and wet season. Additionally, it was found that chimpanzee relative abundance in the forests increases with larger distance to human settlements.

Conclusion: The findings indicate that the presence of the Western chimpanzee is not determined by the availability of sacred forests and water resources in the different forests of the Boé. Additionally, it can be concluded that seasonality does no elicit a change in chimpanzee presence in the sacred forests of the Boé. To adapt and survive in the Boé region chimpanzees might depend on both sacred and non-sacred forests, with and without water resources to get enough access to resources. Considering the establishment of protected areas, it is in particular important to protect forests with relative higher scores of chimpanzee relative abundance and forests with larger distance to villages.

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1. Introduction

In the last decennia, chimpanzees *(Pan troglodytes)* are declining in numbers and, according to the IUCN Primate Specialist Group, the West African chimpanzee (*Pan troglodytes verus*) is declining even faster and has a serious risk in becoming extinct in Guinea-Bissau (IUCN, 2016; Kormos & Boesch, 2003). As a matter of fact, this species already has become extinct in Benin, Burkina Faso and Togo (Kormos & Boesch, 2003).

Although the occurrence of chimpanzees has been confirmed in different parts of Guinea-Bissau, baseline data on their exact distribution and habitat use are still missing and existing data are in general incomplete as these data are mainly derived from rough wildlife surveys (Brugiere, Badjinca, Silva, & Serra, 2009). Also in the Boé, an extremely poor region in the south-east of Guinea-Bissau, consisting mainly of savannah vegetation intersected by gallery- and dry forests, chimpanzee populations are poorly documented. The total chimpanzee population in the Boé is estimated at around 700 animals. However, this estimation is unreliable since it is based on interviews with local villagers (Sá et al., 2013), making further surveys necessary. A better understanding of the status, habitat use and protection possibilities of the Boé chimpanzee is urgently needed. Especially as threats in the Boé are increasing due to rural development and increased population growth (Chimbo, 2017b; IBAP, 2016). According to research of IBAP, the National Institute for Biodiversity and Protected areas in Guinea-Bissau, the Boé has a rich abundancy of different fauna species. In earlier studies of the National Government it was even found that the Boé is one of the most important areas of the country for mammal species. However, due to high pressure of the local population on the existing habitats a part of its fauna already disappeared (IBAP, 2016).

In recent years, the national government of Guinea-Bissau has become increasingly aware of the importance of the establishment of legally protected areas (Costa, 2010). As a consequence it has started with the development of two legally protected areas and three ecological corridors in the Eastern part of the country (IBAP, 2016). This is done with support of Foundation Chimbo, a Dutch NGO involved in chimpanzee conservation (Chimbo, 2015). Although the protected areas cover all together an area of 406.556 ha (IBAP, 2016) the area is, according to Foundation Chimbo, not large enough to safeguard the chimpanzee population in the Boé.

However, the management plan of the Boé (IBAP, 2016) mentions that areas in the ecological corridors as well outside the National Parks can be included in the legally protected areas, if new scientific evidence for its importance has been found. Based on this, further research may offer possibilities for the safeguarding of the Western Chimpanzee and other species in the Boé. Above all, it reinforces the importance of a serious investment in the identification of important chimpanzee conservation areas to establish effective legally protected areas which can help to preserve the chimpanzee in the Boé.

This study, in collaboration with Foundation Chimbo, has been developed with the aim to expand the knowledge on chimpanzee occurrence and habitat use in the Boé region. The objective is to identify key sites for conservation and to contribute to the establishment of effectively legally protected areas.

In the research a distinction has been made between sacred and non-sacred forests, whereas chimpanzee relative abundance has been compared between these forests. Sacred grooves are old growth forests, with a near-natural state of vegetation (Malhotra, Gokhale, Chatterjee, & Srivastava, 2001) and often rich in biodiversity (Bhagwat & Rutte, 2006). In the Boé, they are primary forests located at the origins of streams and rivers (Hoogveld, 2013), creating forests patches with permanent water availability. For these reasons, the expectation is that sacred forests would offer important habitats for chimpanzees in the Boé.

Sacred grooves are devoted to ancestral spirits or deities, preserved by the maintenance of traditional spiritual beliefs and practices by the people inhabiting the surrounding area (Bhagwat & Rutte, 2006; Klepeis et al., 2016). However, in recent years these sacred spaces and its elements have been threatened by poor governance, population growth and an increase in the exploitation of natural resources. But also the westernization of urban cultures has led to the weakening of cultural habits and practices among the younger generations (Klepeis et al., 2016). This seems also be the case in the Boé, in particular in the forests around Belí (Ramachandra, 2017; Wabeke, 2017), a larger and more accessible village in the Boé (Chimbo, 2015) with approximately 1200 inhabitants (Wabeke, 2017). By developing new evidence with regard to the importance of sacred grooves for chimpanzee conservation, the establishment of well-defined protected areas in the Boé may contribute to the protection of primary forests with its respective biodiversity, as well to the preservation of cultural heritage, traditional knowledge and ecosystem services in the region (IBAP, 2016).

The study also compared forest fragments with water resources with forest fragments without water resources to evaluate the effect of water availability in the different forests (sacred as well as non-sacred) on the relative abundance of chimpanzees. This, since chimpanzee presence is according to Wenceslau (2014) related to water availability.

A third and final aspect of this study is the distinction between the dry and wet season. This in order to investigate if seasonality causes differences in chimpanzee relative abundance between the (sacred) forests throughout the year. According to earlier studies, during the dry season chimpanzees seem to be more restricted in their habitat use to forests harboring water resources (Pruetz & Bertoniani, 2009; Wenceslau, 2014). As the sacred grooves could be the only places in the Boé with water availability during the dry season, due to the presence of water sources, high chimpanzee activity was expected in these forests compared to the wet season. Besides permanent sources of water, these gallery forests may also form important areas for chimpanzee activity as these old growth forests provide cooler habitats than other areas in the savannah-woodland landscape. This was also suggested in a study of Wenceslau (2014) on gallery forests in Fongoli, a similar savannah-woodland landscape in Senegal.

Other factors such as food and nesting resources, may also affect chimpanzee occurrence. However, this study only focused on the effect of water availability, seasonality and forest status (sacred and non-sacred) on the occurrence and relative abundance of chimpanzees in the forests of the Boé.

To investigate relative abundance of chimpanzees in the different forests and to determine the importance of sacred and non-sacred forests, with and without water for chimpanzee conservation, two research questions have been formulated:

1. Is the presence of the Western Chimpanzee (*Pan troglodytes verus*) in the forests of the Boé region during the dry season determined by the availability of sacred grooves and water resources in these forests?
2. Is there a difference in chimpanzee presence in the forests of the Boé region between the late dry and early wet season?

To answer these research questions reconnaissance walks have been carried out in the forests of the central and south-east part of the Boé region, during the late dry and early wet season. A widely-used method to determine key sites for conservation of a single species by counting direct and indirect great ape signs (H. Kühl, Maisels, Ancrenaz, & Williamson, 2008; Max Planck Institute for Evolutionary Anthropology, 2012).

In summary, this study invested in the understanding of the importance of the different forests during the year, to define effectively protected areas in the Boé to conserve chimpanzees and their habitats, in harmony with humans and their customs. Collecting data on chimpanzee relative abundance in sacred and non-sacred forests, with differences in water availability in both seasons, can contribute to the identification of key sites for conservation, and the types of habitats within these areas that are important for chimpanzee survival throughout the year. Additionally, by including sacred grooves in the study on chimpanzee relative abundance in the forested habitats of the Boé region, the study has sought to develop new evidence with regard to the importance of sacred grooves for chimpanzee conservation.

2. Area description

Guinea-Bissau

The field work in Guinea- Bissau was carried out in the period from the beginning of April till the end of July 2017, in the sacred and non-sacred forests in the surroundings of the villages of Belí, Uncire and Capebonde of the Boé region. Guinea-Bissau is located on the Atlantic coast of West Africa, where the Boé sector in the south east of Guinea Bissau, is the area of focus of this study.

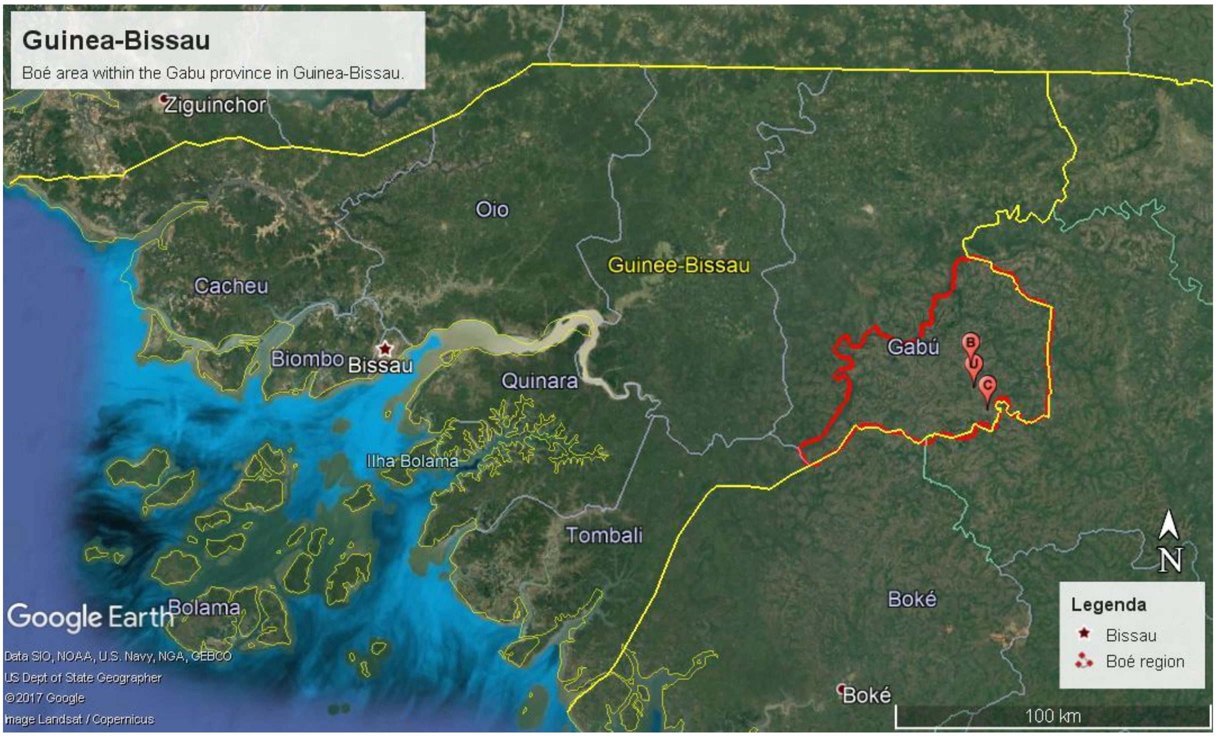

Figure 1 Boé region, circled red, in the Gabú sector of Guinea-Bissau. Location of the three villages are illustrated with symbol (B): Belí; (U): Uncire and (C): Capebonde.

Geography

The Boé sector is located in the Gabú region, where the northern border of the sector is marked by the Corubal river, and in the south- east by its neighboring country Guinee (Sá et al., 2013). In the west of the region a larger lake, Vendu Tcham, is located (Guilherme, 2014). The Boé covers an area of 3.289 km^2 and is situated between 11°30' and 12°05' northern latitude and between 13°45 ' and 14°30 ' western longitude (Wit & Reintjes, 1989).

The sector is covered mainly by a laterite cap with savannah vegetation intersected by narrow riverine valleys with in general steep shorelines (Breider M. J., 2016). Higher parts of the Boé can reach up to 300 m of altitude, where hills are often incised by permanent and temporal rivers. Besides temporal and permanent rivers, the hydrology is characterized by the interception of rainwater in parts of the landscape creating temporal and permanent lakes (IBAP, 2016).

The soils have often low fertility and on the lateritic cap overlaying the Boé, are usually less than 10 cm deep, making the soil unsuitable for agriculture and limiting the establishment of forested habitats in the area (Silva, 2007). Only in regions where the soil is deep enough to root, dry and tropical forests can be detected (Wit & Reintjes, 1989). In the surroundings of river valleys, where more fertile loamy soil has built up, agricultural areas and evergreen forests are located (Kühnert, 2016). The common tree species in these areas include *Afzelia africana, Ceiba pentandra, Sterculia tragacantha,* and *Pterocarpus spp*., whereas in the savanna the most frequently occurring tree species are *Crossopteryx febrifuga, Parkia biglobosa, Pterocarpus erinaceus,* and *Terminalia albida* (Catarino & Diniz, 2008; Wit & Reintjes, 1989). At the source of rivers or streams sacred forests can be found, representing small areas of unlogged forest (Hoogveld, 2013; Kühnert, 2016). As gallery and sacred forests are situated in the same areas (river valleys) they are often exposed to the same soil type (Hoogveld, 2013).

Climate

The climate of the region is tropical with two clearly defined seasons, wet and dry season, of which the dry season is of longer duration (IBAP, 2016). The average temperature is 28°C and the measured maximum is 42.7°C in April (van Steenis, 2017). The Boé has an annual rainfall between 1600 and 2100 mm, which is restricted to the rain season and is relatively high compared to other parts of Guinea-Bissau (Catarino & Diniz, 2008). Starting at the mid of May and lasting till the beginning of November, whereas the other months (November till the mid of May) correspond to the distinct dry season (Wit & Reintjes, 1989). During the dry season access to drinking water becomes more limited, with the consequence in some parts of the Boé drinking water competition occurs between human and animals (IBAP, 2016).

3. Context

Chimpanzees

In Guinea- Bissau 600- 1000 chimpanzees *(Pan troglodytes)* are estimated (Sá et al., 2013; Torres et al., 2010). Chimpanzees are robust apes with black hair, a bare face and abdomen, which display large variability in space and time in their behavior and movement patterns. Their responses are related to seasonality, resource abundance, group patterns, changes in activity patterns and/or habitat change (H. Kühl et al., 2008; Oates, 2011).

There are four subspecies of chimpanzees; the West African chimpanzee *(Pan troglodytes verus)*, which occurs in Guinea-Bissau, the Eastern chimpanzee *(Pan troglodytes schweinfurthi)*, the Central African chimpanzee *(Pan troglodytes troglodytes)* and the Nigeria- Cameroon chimpanzee *(Pan troglodytes ellioti).* These four subspecies vary in geographical range through the African continent, and are all IUCN rated as endangered (Bowden et al., 2012; IUCN, 2016; Kormos & Boesch, 2003; H. Kühl et al., 2008; Oates, 2011). The West African chimpanzee and the Nigeria- Cameroon chimpanzee are the most threatened and have even already become extinct in Benin, Togo and Burkina Faso (Kormos & Boesch, 2003). Also the remaining population in Guinea-Bissau is extremely threatened (Garriga, 2013).

Habitat

Chimpanzees are mainly found in forests and forest galleries extending into savanna woodlands where they depend on tree resources for nesting and food availability (Bogart, 2009; Oates, 2011). In environments dominated by savanna like the Boé, gallery- and dry forests form important habitats for chimpanzees where highest nest densities occur in these two habitats (Sousa, Casanova, Barata, & Sousa, 2014). Nests are in general most often observed in trees with greater diameters and a significant higher height than trees not used for nesting (Hakizimana, Hambuckers, Brotcorne, & Huynen, 2015). The habitat in the Boé comprises also agricultural areas, where sometimes chimpanzees use areas close to villages (Brugiere et al., 2009; Hoogveld, 2013; Wenceslau, 2014). When sufficient large trees are available, Boé chimpanzees can, according to Wenceslau (2014), tolerate some anthropogenic impact in their environment.

Evidence for more chimpanzee presence in gallery forests has been suggested to be related to food availability since gallery forests have higher tree species diversity compared to other habitat types in a savanna dominated landscape. In addition, it has been hypothesized that gallery forests are more often used due to better water availability and shelter possibilities (Sousa et al., 2014). In Fongoli, a similar area in Senegal, it was found that chimpanzees during the dry season prefer to use forested habitats with close canopy, using gallery forests more often compared to other habitats. This may be since gallery forests at Fongoli are the only places with permanent sources of water during the dry season, but also as these habitats provide in contrast to other areas in the savannah-woodland landscape shade making them cooler habitats (Pruetz & Bertoniani, 2009). In the Boé, a change in chimpanzee distribution has also been observed between the two seasons, where during the wet season apes were less restricted to gallery forests and occurred more frequently in forests positioned at hills. This was explained by an increase in water availability outside riverine valleys after half May (Wenceslau, 2014).

Sacred forests

Sacred forests are old growth forests that are devoted to ancestral spirits or deities, preserved by the maintenance of traditional spiritual beliefs and practices by the people inhabiting the surrounding area

(Bhagwat & Rutte, 2006; Klepeis et al., 2016). The sacred places cover different types of habitat and are often biodiversity rich areas (Bhagwat & Rutte, 2006). The religious based traditions (Klepeis et al., 2016) can lead to the prevalence of biological diversity and ecosystem services (Bhagwat & Rutte, 2006), even when the values of protection may not be related with a concern about biodiversity, land degradation of water management.

Also in the Boé sacred forests are found. In general they are last remnants of primary forests (Kühnert, 2016), around the origins of streams or rivers in gallery forests, isolated in savannah vegetation and designating an area with limited or no human activity (Hoogveld, 2013; Koops, McGrew, de Vries, & Matsuzawa, 2012; Meer, 2014; Silva, 2007). The gallery forests are characterized by dense canopy cover with a vegetation structure and composition that differs from non-sacred forests (Wabeke, 2017). In a study of Wabeke (2017) it was found that sacred forests in the surroundings of Belí and Capebonde have more forest regeneration, higher species richness and stem density than non-sacred forests. According to Wabeke (2017) difference between these forests can be described to the sacred designation of these forests, limiting access and disturbance as access to these forests is restricted to site keepers or avoided due to the presence of a bad spirit in the forest. For these reasons, sacred forests are expected to be important chimpanzee areas. Evidence for this was also found in a study of Hoogveld (2013) in Quebube, a small area in the centrum of the Boé, were more chimpanzee nests were observed in sacred areas near river and streams. However, in recent years sacred forests have been threatened by poor governance, population growth and an increase in exploitation of natural resources. At the same time an increase in population growth but also the westernization of urban cultures has led to the weakening of the importance of cultural habits and practices among the younger generations (Klepeis et al., 2016). This may also be the case in the Boé region, as results from Wabeke (2017) show no signs of recent ceremonial activities in the forests. Also a decrease in traditional customs in relation to sacred forests was detected in a study of Ramachandra (2017)

Figure 2 Satellite image of a sacred forest at the origin of a stream (white circle, radius= 150 m) in the Boé, Guinea-Bissau. Adapted from Kühnert (2016).

Social & development context

Guinea-Bissau achieved after an independence war in 1975 its independence from Portugal. In 2003 a military coup took place which created more poverty in the country and brought damage to its economy and infrastructure. Today, it is one of the poorest countries in the world, where the majority of the inhabitants live below the poverty line. The largest part of the population lives in rural areas, far from medical support and relies on farming and fishing activities (Costa, 2010). This is also the case in the Boé, an extremely poor region that is sparsely inhabited (Chimbo, 2017b; Guilherme, 2014). In the region live approximately 12.000 inhabitants (Sá et al., 2013) who depend for their living mainly on gathering, hunting and slash and burn to allow agricultural practices (Catarino & Diniz, 2008; IBAP, 2016). The major part of the population is Islamic, belonging to the Fulani ethnicity, and lives in the western part of the region (IBAP, 2016; Sá et al., 2013). The population has a strong spiritual connections with nature, which can be observed in the utilization and preservation of sacred forests in the Boé (IBAP, 2016). However, in recent years the population has increased rapidly resulting in the disappearance of old traditions and taboos, but also leading to an increase in hunting and poaching activities in the area (Chimbo, 2017a). New villages have been established in previously uninhabited areas in the central part of the Boé, and more land has been converted into agricultural fields to cultivate rain-fed rice, the main crop in the Boé, and cashew plantations which have contributed to a progressive deforestation in the area (Costa, 2010), offering a serious threat to the ecosystems and natural resources of the region (IBAP, 2016). In particular river valleys are intensively exploited (Silva, 2007), consequently affecting the survival of the Western chimpanzee and its habitat (Costa, 2010).

The regional development has also led to governmental plans for the construction of a paved road intersecting the center of the region. This may pose a risk to the natural resources of the Boé, since it will make the area more accessible for the exploitation of natural resources. At the same time, an Angolan company started to show interest in the bauxite resources of the Boé. This situation might become even more serious when the infrastructures in the region will improve. In particular bauxite mining may constitute a threat to chimpanzees, as the bauxite locations in the Boé are located in chimpanzee habitats (Chimbo, 2017a).

The lack of interest in conservation issues by the country's government, has led to the development of other economic activities that affect Guinea-Bissau's wildlife and habitats (Costa, 2010). Only recently the government has started to show interest in the establishment of legally protected areas (Costa, 2010), whereby the government designated parts of the Boé the status of National parks (Chimbo, 2015). One of the consequences of this still recent interest in and recognition of the importance and benefits of protected areas for the development of local communities, is that only one of the six legally protected areas has a conservation plan, and it indicates the great importance in establishing new protected areas as well as the development of effective management plans (Costa, 2010).

National Park

The designated legally protected area is located between 12° 14.236' N and 11° 52.971' N latitude and 13° 43.185 - 14° 19.889 longitude. The National park, is divided in two areas, the Dulombi National Park in the west and the Boé National Park in the north-east which extend to areas outside the Boé region in the north of the Corubal river. These areas are connected by the ecological corridor Tchetche. Together with the ecological corridor, it covers an area of 155.925 ha, of which 49.922 ha correspond to the ecological corridor Tchetche and 105.767 ha to the National Park of the Boé. By creating National Parks and by reinforcing the connection between these areas the national government has the objective to preserve the biodiversity in the area and to improve migration of terrestrial species between Senegal, Guinee and Guinea-Bissau. Moreover, the legally protected areas have the goal to preserve cultural history, such as sacred forests and natural monuments, and to prevent loss of traditional knowledge and culture by new generations (IBAP, 2016). However, the development of protected areas may be a challenge for Guinea-Bissau since it is a small country with little human and financial resources (IBAP, 2016). For this reason, and given the fact that the local population of the Boé has a lot of traditional knowledge on the preservation and protection of the natural resources of the region, it is, according to IBAP (2016), of great importance to collaborate in the development of the National parks with the local population of the Boé.

Biodiversity & Threats

Thanks to the isolated position of the Boé, the sector has conserved its biodiversity (Breider M. J., 2016; Chimbo, 2015; IBAP, 2016) which includes 374 bird species, 39 reptile and 65 mammal species (IBAP, 2016), such as the Western chimpanzee *(Pan troglodytes verus)* and king kolobus *(colobus polykomos)*, large mammals like the common hippopotamus *(Hippopotamus amphibious)*, leopard *(Panthera pardus)*, spotted hyena *(Crocuta crocuta)* (Sá et al., 2013), and lion *(Panthera leo)* (Breider M. J., 2016; IBAP, 2016). However, as mentioned before, the Boé's social and development context constitutes a threat to its biodiversity. Human activities like illegal logging, (uncontrolled) bushfires, and the conversion of forests into agricultural land have led to the decline of forests by 50 % over the last 17 years. The occurrence of economically interesting tree species like *Afzelia africana, Prosopis africana* and *Pterocarpus erinaceus* has encouraged the illegal timber exploitation in the area and may have led to a reduction of certain tree species (Guilherme, 2014).

Most conversion of land is around settlements but also more outlying areas have been affected (Guilherme, 2014) such as the gallery forests (Wenceslau, 2014). In the gallery forests, where the oil palm *(Elaies guineensis)* is restricted to, no chimpanzee nests have been found in this tree species. This in contrast to the legally protected Cantanhez National Park, Guinea-Bissau, where this palm species harbors 92% of the chimpanzee nests. This may be due to the extreme anthropogenic exploitation of this species in the Boé for the production of oil palm, chasing consequently chimpanzees away from these trees and affecting the occurrence of chimpanzees in the gallery forests (Wenceslau, 2014).

In the Boé chimpanzee and other wildlife also may be threatened by poaching since this occurs in different parts of West Africa (Brugiere et al., 2009; Kormos & Boesch, 2003; Sá et al., 2013), but also due to the frequent visit of poachers in the region to hunt illegally and export bushmeat to its neighboring country Guinea (Guilherme, 2014). Due to illegal hunt in the Boé, Forest Buffalo *(Syncerus caffer nanus)* has declined in numbers and its appearance is now restricted to gallery forest along the river Fefine, a permanent river that crosses the region from north to south (Guilherme, 2014). However, due to the similarity of chimpanzees to humans, meat consumption of chimpanzees in Guinea-Bissau is taboo (Costa, 2010) which might limit their hunt.

Foundation Chimbo

The above-mentioned findings indicate the urge for the establishment of protected areas in the Boé region and effective conservation programs. Therefore, Chimbo Foundation, a Dutch NGO, established in 2007 with the aim to protect the West African Chimpanzee, has implemented community based conservation programs in the area to protect the chimpanzee population and their habitat in the Boé (Chimbo, 2015). It has a/o established 28 village vigilance committees that regularly patrol forests in the surroundings of their villages and report illegal activities, presence of Chimpanzees, etc.. The conservation strategy of Chimbo includes not only to conserve the biodiversity in the Boé in general, but also to secure food, cultural values and to use nature conservation as a potential to generate income through the development of ecotourism (Chimbo, 2015).

The activities of the organization support the work of IBAP, the National Institute for Biodiversity and Protected areas in Guinea-Bissau, responsible for the protected areas in Guinea-Bissau. Additionally, the organization collaborates with DGFF, the Directorate General Flora and Fauna which is responsible for areas outside legally protected areas, and with traditional local authorities in the Boé to develop sustainable development of local communities to conserve chimpanzee habitats outside the future National Parks (Chimbo, 2015).

For the identification of protected areas and the contribution to conservation programs Chimbo invests in the collaboration with several international research organizations and universities (Chimbo, 2015) and offers students and researchers a campsite and field station facilities in the largest village of the Boé, Belí.

This study, carried out in collaboration with Foundation Chimbo, has as its goal to contribute to the identification of chimpanzee key habitats and the selection of conservation areas. This to determine which additional areas need to be included in the two National Parks in the Boé. In this way this study tries to contribute to the safeguarding of the Western chimpanzee and their habitats.

4. Material and methods

Research Area

The field study was carried out in the surroundings of three villages, Belí and Uncire, located in the central part of the Boé, and in the surroundings of Capebonde, a village located in the south east of the region. The surveys have been conducted during two periods of the year: the late dry season from April till May and the early wet season from June till July. The villages were selected on the basis of their accessibility, remoteness, an even coverage of the Boé sector and to complement previous research, done in the same area.

Table 1 Villages were research has been conducted and their coordinates.

Village	Latitude	Longitude	Distance to Belí (km)
Belí	11°50'29.34"N	13°56'4.63"W	0.00
Uncire	11°46'56.37"N	13°55'38.76"W	7.24
Capebonde	11°43'18.15"N	13°53'9.42"W	14.99

Forest selection

In the dry season 20 forests have been sampled, 10 sacred and 10 non-sacred, and 10 forests with water resources and 10 without water resources (Figure 2). During the wet season, the 10 selected sacred forests of the dry season were sampled again. Table 2 shows the distribution of the sacred and non-sacred forests, and forests with and without water resources during the dry and wet season for each village. During the selection of forests, attention was paid to have as much as possible an equal cover of sacred and non-sacred forests, with and without water across the research area.

Table 2 Number of sampled forests during the dry and wet season, where in each season the number of sacred forests and number of forests with water resources is indicated.

		Dry season				**Wet season**		
		Sacred		**Non-sacred**		**Sacred**		**Non-sacred**
Village	**Forests (N)**	With water res.	With-out water res.	With water res.	With-out water res.	With water res.	With-out water res.	
Belí	13	2	3	4	4	2	3	-
Uncire	1	1		-	-	1	-	-
Capebonde	6	2	2	1	1	2	2	-
Total	**20**	**5**	**5**	**5**	**5**	**5**	**5**	**-**

For the selection of the sacred and non-sacred forests, with and without water, in the surroundings of the villages semi-structured/informal interviews were hold with the local assistants of Foundation Chimbo, children and elders of the villages, and the research coordinator Katharina Kühnert of Chimbo who was present in Belí during the first month of data collection in the Boé.

In the selection of forests with local villagers and assistant's, drawings were used to gain insight in the distance between the village and the different forests, the distance between forests, forest size, presence of water resources and sacred forests in the forested habitats in the surroundings of the specific village. During the meetings the need was explained to select both non-sacred as well sacred forests, and within in each of these groups forests with and without water resources. Furthermore, it was specified the different forests needed to be even distributed around the village, where forests in each group needed to have a range of 1-7.5 km distance to the nearest village. A list of the sampled forests and its coordinates can be found in Annex I.

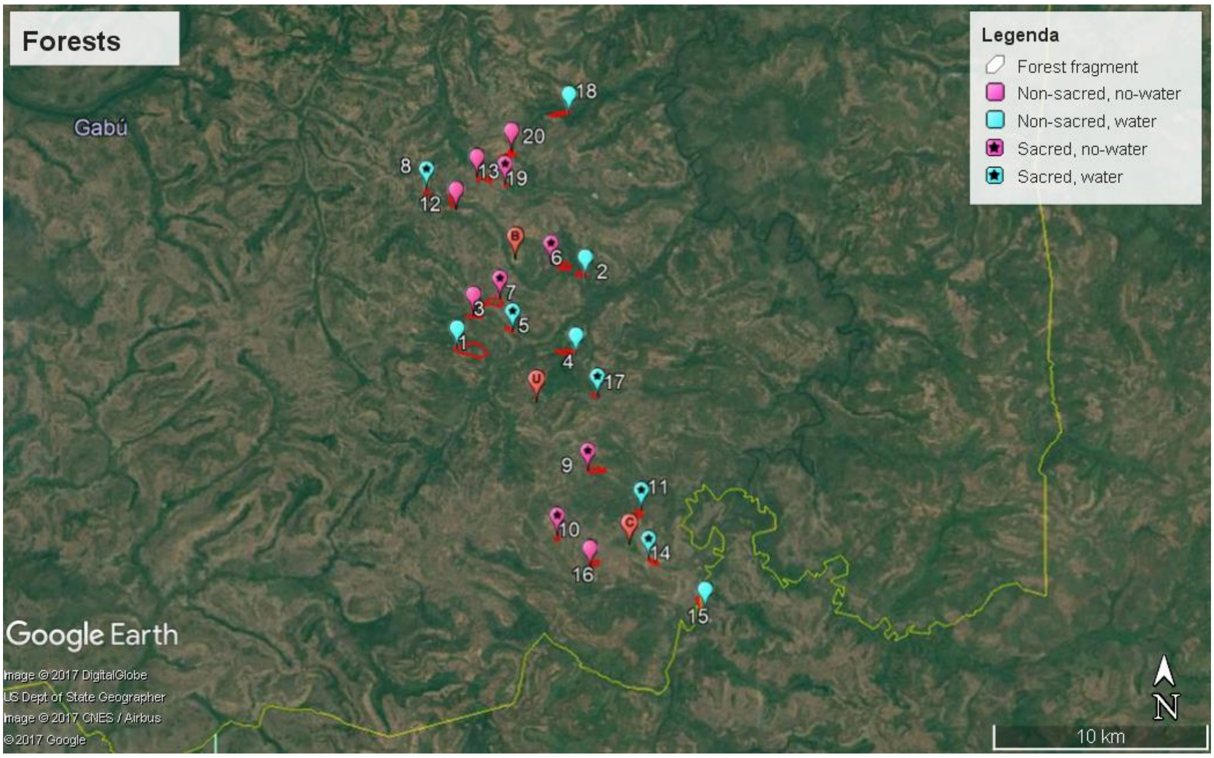

Figure 3 Sampled sacred and non-sacred forests, with and without water, in the surroundings of the villages (B): Belí, (U): Uncire and (C) Capebonde in the Gabú province of Guinea-Bissau. Red line spots illustrate the sampled size of each forest. The yellow line indicates the border of Guinea-Bissau with Guinee.

Table 3 Name of sampled sacred and non-sacred forests during the dry and wet season, with and without water.

Village	Forest	Forest name	Sacred/Non-sacred	Water resource	Season	
Belí	1	Quebube	Non-Sacred	River	Dry	
Belí	2	Bundujuri	Non-Sacred	River	Dry	
Belí	3	Beli Um	Non-Sacred		Dry	
Belí	4	Kineke	Non-Sacred	River	Dry	
Belí	5	Bundu Quebube	Sacred	River	Dry	Wet
Belí	6	Bundu Njuri Noku	Sacred		Dry	Wet
Belí	7	Gadda Beli Um	Sacred		Dry	Wet
Belí	8	Bartanjan	Sacred	Source	Dry	Wet
Capebonde	9	Vendu Queiwi	Sacred		Dry	Wet
Capebonde	10	Barqueda da Um	Sacred		Dry	Wet
Capebonde	11	Guenjari	Sacred	Source	Dry	Wet
Belí	12	Near Bartanjan	Non-Sacred		Dry	
Belí	13	Pataque	Non-Sacred		Dry	
Capebonde	14	Hore Capebonde Um	Sacred	Pools	Dry	Wet
Capebonde	15	Fefine	Non-Sacred	River	Dry	
Capebonde	16	Barqueda da Um	Non-Sacred		Dry	
Uncire	17	Babal 2	Sacred	Source	Dry	Wet
Belí	18	Tuntedje 1	Non-Sacred	River	Dry	
Belí	19	Hore Pete Kekum	Sacred		Dry	Wet
Belí	20	Tuntedje 2	Non-Sacred		Dry	

Data collection

The main method in the research has been the Occupancy method, which uses Reconnaissance walks to make inferences about a species occurrence, abundance and habitat choice in order to identify key sites for the conservation of a single species (H. Kühl et al., 2008; Max Planck Institute for Evolutionary Anthropology, 2012). Additionally, informal interviews with the staff of Foundation Chimbo, and local residents, were applied. This all together to provide a pilot study on chimpanzee occurrence and relative abundance in the sacred and non-sacred forests in the Boé region during the late dry- and early wet season, and the influence of water resources on chimpanzee occurrence within the forests. Non-sacred forests were surveyed during the late dry season, and sacred forests during the late dry season from April-May and June-July which corresponds to the early wet season. Additional, the survey collected also specific information on the distribution of water resources in the two types of forests.

Before data was collected in the surroundings of each village semi-structured/informal interviews were hold to obtain insight and information in the occurrence of the chimpanzee in the larger area and to use as a guideline for the selection of the sacred and non-sacred forests, and forests with and without water resources. But also, to obtain information to supplement the field surveys. Additionally, to the interviews and reconnaissance walks, a lot of time was invested in the observation of local people and their traditions and in participation in daily life activities. This was done to build trust in relationships with local people of the different villages, to become familiar with the local languages and to get more access to information. A camera and notebook were used to note observations.

Table 4 Survey methods.

Method	Objective
Reconnaissance walks	Presence/ absence chimpanzees Presence/ absence water resources Relative chimpanzee abundance (direct and indirect signs)
Interviews	Provide verbal information based on local knowledge with respect to: Presence/ absence chimpanzees - Chimpanzee occurrence over large area and forests - Identification of sacred and non-sacred forests - Identification of water resources in the different forests and periods of the year

Reconnaissance walks

Reconnaissance (Recce) walks have been used to assess chimpanzee presence and relative abundance, and water resource availability in the different forests. Additionally, they were used to collect specific geographical information on habitat preferences and data on human and large carnivore presence.

Sampling Approach

In this study the recce method was used, based on the IUCN Best Practice Guidelines for Surveys and Monitoring of Great Ape populations of Kühl et al (2008) and the Data Collection Protocol of Max Planck Institute for Evolutionary Anthropology (2012). The recce walk is a method where the observer(s) walks a straight line of determined length, which is placed randomly across the survey area, and notes all signs of the object to be detected. This in order to determine key sites for the conservation of the species of interest (H. Kühl et al., 2008; Max Planck Institute for Evolutionary Anthropology, 2012).

In this study recces of 1 to 3.5 kilometers, depending on the forest size, were walked back and forth and placed randomly in the forests in the surroundings of the selected villages. Since surveys in the wet season required more time, time was too limited to survey non-sacred forests a second time.

Along the recces chimpanzee vocalisations and all direct ape signs at any distance were recorded, nests and group of nets were noted down when located within 10 m distance, whereas all other indirect signs were recorded if situated within 2 m of the recce line. In case a forest, with an identified water source or pool was surveyed, at the end of the recce the size of the waterhole was quantified. This was done by walking the contour of the waterhole with the tracklog function of the GPS. The recces took 1 day for each forest. Attention was paid to maintain a recce speed of 0.65 km/hour, however recce speed could vary per forest depending on the structure, size of the forest, weather conditions and travel distance to the selected forest.

Variables sampled: all signs of chimpanzee presence with direct & indirect surveys.

Direct survey

1. Chimpanzee individuals
2. Group of chimpanzees
3. Number of animals in a group

Indirect survey

Nests

1. Number of nests
2. Nest state (new/ recent/ old/ decayed)
3. Group of nests
4. Number of nests in a group

Other signs

1. Excreta (dung and urine)
2. Footprints
3. Feeding remains
4. Tools (stone throwing tools)
5. Unnatural modifications in the environment (tool marks, travel paths, accumulated objects)
6. Carcasses
7. Vocalizations
8. Opportunistic data on predator occurrence (footprints, feces, vocalizations, of leopard *(Panthera pardus)*, lion *(Panthera leo)*, spotted hyena *(Crocuta crocuta).*

Human signs

1. Opportunistic data on presence of human activity (individuals, objects, vocalizations, pets, cattle, cattle dung or carcasses, logging remains).

Area characteristics

1. Forest type (gallery forest/ dry forest)
2. Canopy (open/ closed)
3. Topography (valley/ slope/ hill top)
4. Water resource (water source/ pool/ river/ stream)
5. Size of water source or pool

Weather conditions

1. Sunny/ light cloudy/ cloudy/ rain

Classification & Definitions

- Chimpanzee observation

Individual/ Group

Observation of individual animals or groups of chimpanzees. When encountering a group of apes, all individuals in the group are counted. (Max Planck Institute for Evolutionary Anthropology, 2012).

- Nests

Nest State

Nests classified as 'new' have green leaves, and urine and feces can be found beneath them. These nests are expected to be one day old. 'Recent' nests are nests older than one day, 1-3 days, dominating in green leaves but also consisting of dry leaves. No dung and urine can be found beneath them. 'Old' nests are nests that consist of brown leaves and 'Decayed' nests are nests with holes where leaves have fallen out leaving a nest which only consists of branches. Old and decayed nests are considered to have been constructed during the current year or in the same season (Hakizimana et al., 2015; Maisels, 2008; Max Planck Institute for Evolutionary Anthropology, 2012).

Figure 4 New ground nest (red circle) in a forest of the Boé, Guinea- Bissau.

Group of nets

A collection of nests is considered a group when nests of the same state are in a distance ≤ 20 m from each other (Furuichi, Hashimoto, & Tashiro, 2001; H. Kühl et al., 2008). When a nest exceeds 20 m from the nearest nest the nest is assigned separated of the group (Hakizimana et al., 2015). In this order, nest of the same age class, found within 10 m from the recce line, and with a distance ≤ 20 m between them, are counted as a nest group.

Figure 5 Group of old nests in a tree in a forest of the Boé, Guinea- Bissau. Group nests consisting of three nests, indicated by each red circle.

- Feeding remains

Fruits

Fruit remains caused by chimpanzees consist of fruit skins, wedges, fruit kernels or the accumulation of thin branches under trees. Wastes of fruits skin are defined as fruit skin in more or less in a pile, and caused by the apes before feeding on large fruits. Wedges are defined as fleshy fruit parts containing imprint of mouth and teeth and are caused after chimpanzees have extracted juice with their mouth without eating the pulp. Fruit kernels are characterized by the presence of the hard part of the fruit, whereas the soft fleshy part has been removed. Thin branches stand for the accumulation of thin branches with most fruits eaten under trees after chimpanzees have feed on small fruits in trees (Max Planck Institute for Evolutionary Anthropology, 2012). If it was not possible to count al the individual wastes due to a high number of fruit remains (more than 10 objects) to maintain a constant walking speed, the minimum number of food waste was noted down and described in the data as '10+'. Later, the value is replaced by a scale variable, which represents the average of noted numbers of food wastes higher than 10 among the different sampled forests.

Figure 6 Fruit kernels in the forests of the Boé, Guinea- Bissau.

- *Tools*

In this study chimpanzee tools were described and identified according to the data collection protocol of Max Planck Institute for Evolutionary Anthropology (2012). Tools in this study are heavy and hard objects to bump hard shell of fruits or nuts open, but also used to hit or throw against trees. Stones used as tools present signs of wear from hitting hard objects on at least one part of the surface and do not break after hitting it to a tree trunk or stepping on it. The objects have a weight of min. 100 grams and max 20 kg and consist of lateritic, granite or quartz material (Max Planck Institute for Evolutionary Anthropology, 2012). When touching a tool gloves were used to prevent disease transmission. Tools or tool marks were recorded and photographed from different angles, with a ruler a side.

Figure 7 Stone tool near base of tree in a forest of the Boé, Guinea- Bissau. Red marks on stone represent wear marks, indicated by the red circle.

- Unnatural modifications in the environment

Signals like modifications on trees, travel routes and accumulation of stones or instruments due to chimpanzee behaviour (Max Planck Institute for Evolutionary Anthropology, 2012). These events were recorded and photos of these indirect signals were taken.

Tool marks

Clear hitting marks on root, rock and base of trees where stones have been bumped in (for example due to stone throwing behaviour). Stones, nuts and other objects can be found lying around (H. S. Kühl et al., 2016; Max Planck Institute for Evolutionary Anthropology, 2012).

Figure 8 Base of tree with hitting marks, indicated by the red circles, in a forest of the Boé, Guinea-Bissau.

Travel paths

Chimpanzees travel routes are open paths, which contain chimpanzee dung or other ape signs (Max Planck Institute for Evolutionary Anthropology, 2012).

Accumulation of natural objects

Accumulated objects, are in this study defined as stones at the base of trees or fresh leaves accumulated in forested habitats. Accumulated green leaves are circular platforms of leaves or/and bushes located on the ground and are considered to be one day old. According to local villagers of the Boé these platforms are used by chimpanzees during feeding or resting behavior.

- Area characteristics

Forest type

Gallery forest: Linear forest fragment along a stream or river. Forest within a large forest area or isolated in savanna.

Dry Forest: Forest with well-drained soil, on hills and isolated in woodland or in savanna.

(Max Planck Institute for Evolutionary Anthropology, 2012)

Canopy

Forested parts along the survey trail of each forest fragment were classified in closed canopy forest (coverage > 60% coverage) and open canopy forest (60 to 10/20%) (FAO, 2017). Closed canopy forests are forests with a dense canopy, whereas open canopy forests are fragments with sparse and irregular canopy consisting of large gaps, with more dense undergrowth of shrubs, climbers and small trees than closed canopy habitats (Sousa et al., 2014).

Closed: Tree crowns are touching each other and the canopy is closed for approximately 78%. The lower limit of a closed canopy is 60%.
Open: Trees are standing together, however crowns are not interlocking.
Based on the Classification system of the FAO (2017).

Water resources
Permanent and non-permanent water resources. Permanent resources are present in both the dry and wet season, non-permanent resources are only available in the wet season.
Permanent: sources/ waterholes.
Non-permanent: streams, pools.
Based on the Classification system of the FAO (2017) and Protocol of Max Planck Institute for Evolutionary Anthropology (2012).

- Weather conditions

Sunny: blues sky with sun; light cloud: some blue sky as well clouds visible; cloudy: complete cloud cover; rain: raining (Maisels, 2008; Max Planck Institute for Evolutionary Anthropology, 2012).

Protocol Reconnaissance walks
Data on recces were collected between 6:45 and 13:00 due to visibility reasons (light availability) and to avoid work during the hottest part of the day. Before the start of a recce a waypoint was taken. This in order to mark the forest location and to be able to revisit forest fragments for a new recce during the wet season. The GPS used for the collection of spatial data was the Garmin eTrex® with the coordinate system WGS 1984. Before moving forward in a straight line following a compass bearing in a North-South direction, the tracklog on the GPS was activated. Observations started at 0 m, and when moving along the line the field team scanned constantly both sides, as well above and under the line. Indirect signs within 2 m of distance of the recce line were noted, with exception for nests, group of nests and human and chimpanzee vocalisations/ sounds. Nests or group of nets were noted when visible within a 10 m band at each site of the recce. Vocalisations and all direct ape signs were recorded at any distance from the line. The widths of 10 m and 2 m were fixed in order to minimize variation in visibility between the different forest types. When a direct or indirect sign was detected, the team stopped and came together to record the necessary findings. Each sign or water resource observation was written against a GPS coordinate, distance along the line and time of the day, together with its classification characteristics and forest type, canopy and topography characteristics. After recording the data, the team members returned to each original position on the recce line. If the team needed to deviate from the line due to rocks, treefalls or other features, the team returned to the line after deviation. In addition, opportunistic data on the presence of large carnivores was noted. At the end of the recce, the point when the last observer had reached the end of the line, a way point was taken and noted on the field sheet as end of the recce. The end of the recce was indicated by the GPS after 3.5 km had been walked or when a whole forest fragment had been walked within 1- 3.5 km recce. If possible, at the end of a recce the tracklog and GPS coordinates were downloaded to a PC and two backups were made.

Additional protocol wet season

The additional protocol for the wet season follows the same Reconnaissance walk protocol as on page 18, with exception for the following aspects:

- Start time

If a recce could not be started in the early morning due to tropical rainfall, the survey was started between 9:30 and 11:00 hour when the chance on heavy rainfall and thunderstorm was smaller.

- Tropical rainfall

When encountering tropical rainfall during a recce walk, work was stopped and continued on the same line site after the heaviest rain/ thunderstorm had passed away. This, as well the physical features of the areas during rainfall affected the observation capabilities of the team. According to the IUCN Best practice guidelines for the surveys and monitoring of great ape populations (2008) data collection in the rain of the rain season cannot be reliable as it is very difficult to spot tree nets with falling water in the eyes, and the darkness that falls during the tropical rainfall limiting visibility considerably. For instance, heavy thunderstorms limit the detection of animal and human vocalisations/ sounds.

In Figure 9 and 10, the recce design in series of parallel lines is shown.

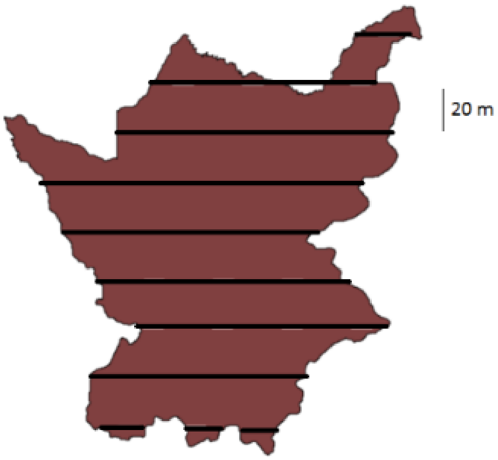

Figure 9 Recce design for sacred and non-sacred forests. Adapted from Kühl et al. (2008).

Figure 10 Tracklog of a recce walked in a forest with a water resource in the Boé region. The short winding lines in the recce represent areas where the field team needed to deviate or encountered more of more resistance due to vegetation or topographic features, whereas the straight parts of the recce line represent a path of less resistance through the survey area.

Survey team

The survey team was most of the time composed of two people, consisting of me and a local villager from Belí who had contributed on a more or less regular basis to research activities of Foundation Chimbo and with previous experience in assisting animal and plant ecology studies. To diminish the observers bias, caution was to carry out field surveys often as possible with the same local guide. During fieldwork in sacred forests of Uncire and Capebonde, a local villager assisted the recce survey. This as it was not allowed to work in the forests without the responsible site keeper since sacred forests in the surroundings of the village are property of specific families in the village.

The survey team consisted of a forward team or person, who navigated and cut vegetation (only if necessary) on a recce line. Behind followed the team leader, who recorded the data in data sheets, carried the GPS and called halt when the end of the recce approached in non-sacred forests. In sacred forests this was the task of the forward team or person. Together with an assistant, the team leader measured the distances between the recce line and the nests, and if necessary this was also done for the other type signs. During the field surveys, name of the observers were noted and all persons had the function of observer.

Recce line opener

The recce line opener walked with a machete, and when the team consisted of three persons, the line opener listened to the instructions of the compass bearer. When the line opener deviated from the line, he was guided back to it by the compass bearer. Before the survey started it was carefully explained the necessity for minimum of vegetation damage.

Compass bearer

The compass bearer concentrated on the line, and ensured the correction of errors, as they happened, of the line opener. If the team consisted of two persons, the front person had the task of line opener and compass bearing and the team leader the task to correct the line of the front person.

Observers

The observer team consisted most of the times of one person who was familiar with wildlife vocalisations as well with observation, since according to the IUCN guidelines for the surveys and monitoring of great ape populations (2008) many observations (in particular primates) are confirmed by species-specific calls. The observers concentrated on signs on the ground (ground nests, food wastes, dung, human signs etc.) and scanned trees for tree nests and primates. All the team members needed to agree on the sign and communication was done as silently as possible.

Interviews

Variables to be sampled: distribution of sacred and non-sacred forests in the surroundings of Belí, Uncire and Capebonde; additional verbal information on chimpanzee and water resource occurrence, and their distribution in the different forests (sacred and non-sacred).

Sampling approach: Face-to-face questionnaire

Interviews have been held with the local employees of Foundation Chimbo and the present research coordinator of Chimbo to obtain information before the start of the field surveys. Additionally, interviews have been conducted with local villagers of different ages and local collaborators of Foundation Chimbo, chiefs and senior counsellors of the three selected villages.

These semi structured interviews were held with the aim to create more insight in the occurrence of the chimpanzee in the large area and to use as a guideline for the selection of the sacred and non-sacred forests, with and without water resources, and their reconnaissance walks. But also, to obtain information to supplement the field surveys.

Sampling approach

The interviews consisted mainly of open-end questions, where after an initial answer was provided specific items of the answer could be discussed. Before starting, verbal permission was obtained from the participants and is was clearly stated that no identifying information would be collected about the interviewee. The questions were related to chimpanzee occurrence, chimpanzee resources, chimpanzee habitats, the location of sacred forests and water resources in sacred and non-sacred forests. To prevent the questionnaire from contamination of the research expectations, no previous signs were given to the topics of the interview. Informal interviews were held in group of people, varying between 3 to 10 persons. This format allowed interviewees to correct one another, and produced an informal setting that allowed interviewees to feel comfortable and to discuss and share information openly.

The interview was started with 7 questions related to forests and sacred places:

1. Are there sacred forests in the vicinity of the village? And if so, in which directions of the village?
2. Which of these sacred forests contain water resources?
3. Are these resources all year round or seasonal?

4. Are there also other forests with water resources?
5. And are these seasonal or all year round?
6. Which of the sacred forests are larger in size?
7. And which of the sacred and non-sacred forests are the most distant from the village?

After questions related to forests and sacred places were discussed, questions related to the West African chimpanzees were asked:
1. In which areas are chimpanzees more common?
2. Can you tell me if there is a particular reason why there are more chimpanzees in that area?
3. Can chimpanzees be found in the sacred forests and non-sacred forests? And if so, in which forests?
4. Do they occur in the sacred and non-sacred forests seasonal or throughout the year?

Reliability of the data

During the interviews precautions needed to be taken with local inhabitants to avoid mistakes in the interpretation of the results. To treat the interview with caution and to get reliable responses on sacred and non-sacred forests occurrence interviews were performed in the local language with the assistance of the field assistant and with supporting drawings, and adapted to schedules of the respondents. In addition, the men-woman relation was tried to be kept balanced as possible. However, this was in general not possible as women were almost the whole day working in the cashew plantations and occupied with household activities like cooking and fire wood collection, in contrast to men. During the wet season, both genders were during the daytime in the fields, cultivating rice. Additionally, when women were around and encouraged to participate, they were shy and seemed to feel uncomfortable in contributing to the informal questionnaire. This may be caused by the very distinct social roles between men and women in the Boé. Women are responsible to raise the children and do the housekeeping, activities that are performed in the direct surroundings of the villages, while men are expected to engage in agricultural, hunting, trade and decision-making activities. But also since gender differences are high in Guinea-Bissau and women are not expected to have opinions. Nevertheless, the responses in general helped to give a global idea of the sacred and non-sacred forest distribution and chimpanzee occurrence in the area around the villages as the responses gave an indication where the animals were encountered more frequently.

Materials

Table 5 Survey equipment.

Item	Model	Total Units
Extern hard disk	70 TB	2
Cutting tools	Knife, scissor, machete	1
GPS	Garmin eTrex®	1
GPS batteries	NiMH or Lithium 2 AA batteries	4
Plasticized maps	Plasticized maps of the survey area	2
Measuring tape	10 m	1
Rope	10 m	2
Water Filter	MSR Mini Works EX Waterfilter	1
Compass		2
Medical kit	Including antiseptic, anti-malarials, antibiotics, needles etc.	1
Bicycle		2
Bicycle repair kit	Bicycle tire	1
Bicycle pump		1
Telephone		1

Notebooks	150-page book	2
Pencils	10 pack	1
Ruler	30 cm	2
Plastic gloves		2
Digital Camera		1
Digital camera batteries		2
Waterproofed pack	30 L, 20 L	2
Mosquito net		1
Silica gel bags		2
SD card Digital camera	16 GB	2

Logistics

Field facilities during the data collection period such as accommodation at the first night of arrival in Bissau, and the night before departure back to Netherlands, transport between Bissau and Belí, accommodation, interpreter assistance and workplace in Belí, and field assistants in the different forests were provided by Chimbo Foundation. Local transport in the Boé was made possible by the utilization of a bicycle provided by Chimbo Foundation.

Transport in and between the villages in around Belí and to the forests were done by bicycle and a few times on foot. The condition of the roads was poor, and in general travels were a challenge since most of the times cycling was over sandy and rocky parts of the landscape. Travel in particular got difficult during the rainy season, when sand paths and lower parts in the landscape got inundated by rain water. At the end of July, due to long periods of heavy rainfall, access by bicycle to some forests and villages got limited since temporal rivers and deep pools had established in lower parts of the roads and rocky sandy parts of the savannah.

Figure 11 Inundated parts due to heavy rainfall on the travel to Capebonde during the wet season.

Organization of fieldwork in the villages

When fieldwork had to be conducted in areas more than 7.5 km away from the campsite in Belí, an arrangement was made with a village in the area, concerning the execution of fieldwork in the surroundings of the village, guidance by the person responsible for the sacred forests in the area, and a place to stay with a local family.

In general, 2-3 forests were sampled around the villages, spread over a short period of time, but with a maximum of 5 days, due to the fact that food in the villages was limited and drinking water became scarce in Uncire and Capebonde at the end of the dry season and beginning of the rain season.

On arrival in a village, the research team was welcomed by local villagers, by giving the team a place to sit and something to eat. When the Djarga, the local village chief, was available, the team was brought to the chief and elders of the village, where the meeting would start with an introduction of the research team and the research objectives and gifts were handed over to the chief.

Communication

In Belí the main languages were Fulah and Creolo based on Pidgin Portuguese, whereas in the more remote and less accessible villages, Uncire and Capebonde, the only spoken language was Fulah.
In Belí some people were able to speak some basic English and Portuguese. A few people, related to Foundation Chimbo, had a professional working proficiency of English, French and/or Portuguese.

Field work was in general conducted with an employee of Chimbo, who was not familiar with other languages besides Fulah and Creolo. Since it was necessary to travel, collaborate and stay for longer periods in other villages, it was important to become familiar with the local languages. This was done by involvement in everyday routines and activities of the local villagers, but also by, whenever possible, asking the Portuguese or English speaking Chimbo employees for translation. After two months a basic vocabulary of Creolo and in particular Fulah, related to the field surveys, travel and stay in other villages was developed. Although limited, this understanding showed very useful during the research period both in the establishment of a relation of trust with local people as well as having access to information and during field work. In addition, speaking a bit of Fulah facilitated the adjustment to the routines and rituals of the different villages. In some occasions, in particular during the first period after arriving in Belí, an English-speaking employee of Chimbo, served as a translator to introduce me to the villagers of Belí and to ask permission for stay in Belí to the Djarga, the local village chief. During these meetings, a gift was brought for the Djarga and elders of the village. Also in a second meeting with Belí's Djarga a translator was used. In this meeting permission was asked to conduct research in the sacred forests of Belí. In the other villages, Samba, the research assistant of Chimbo, was responsible for the communication with the village chief. In these cases, before travel, the message and questions for the Djarga were carefully discussed with Samba and the translator of Belí.

Conducting fieldwork in a foreign language posed some particular challenges as communication required more time and patience. On the other hand, communication could be facilitated by the use of drawings and sketches. Drawings were used in particular during meetings in Uncire and Capebonde. After arriving in one of the villages, an afternoon was spent with children, women, men and elders to have semi-structured interviews and discussions about the selection of forests in the surroundings of the village. During these meetings drawings were used to indicate the location, distances and size of forests, availability of water resources. Additionally, drawings were used to explain the research method or, during fieldwork, to identify a walking direction or animal species.

Drawings also were used at the start and the end of the fieldwork to explain the local population in the different villages the objectives of the survey and its potential benefits for their livelihoods such as the conservation of forested habitats.

Data analysis

Mapping

For mapping the spatial data of the chimpanzee survey, including chimpanzee, large carnivore and human direct and indirect signs, habitat characteristics, and the locational data the geographical program Google Earth Pro 2017 was used, with the coordinate system WGS 1984 Web Mercator (Auxiliary Sphere) and map date of 18-8-2017.

- Signs & forest characteristics

GPS data was recorded for each chimpanzee sign including both direct and indirect signs together with the area characteristics where it was observed. In addition, water resources in the different forests were georeferenced in order to map the location of the water sources and their sizes in Google Earth Pro.

- Forest fragment and water source size

Besides mapping of georeferenced ape and water source signs, the size of forest fragments and water holes was determined by downloading the GPS tracklogs in a satellite image of the Boé in Google Earth Pro. After plotting the water resources tracklogs, a polygon was made over the cluster of points of the water sources and pools and the area measured in m^2. Additionally, a polygon was created for the determination of the size of the different forest fragments. The size of forests was calculated in hectares and was done by creating a polygon in Google Earth covering the data collection zone of each forest. Data collection zones corresponds to the tracklog of the walked recce in each forest, varying between 1-3.5 km. The total area of sacred forests was measured by determining the area by plotting the sampling units, which covered globally the whole forest, on a satellite image of the region for better reference of the forest borders. For non-sacred forests a minimum size of the forest area was calculated. For the reason data collection in these forests did not cover the whole forest. This, due to its larger size compared to sacred forests and since it was not possible to determine in Google Earth accurately the borders of these forests as vegetation, such as forest and cashew plantation, in non-sampled parts could not be distinguished. Therefore, the minimum size was measured by creating a polygon over the cluster of tracklog points in the forest.

With the mapped locations of the different forest and villages, in the program Google Earth, the distance in km between each forest and their nearest village was determined to explore at a later moment through statistical analysis the influence of distance size between forests and the nearest village, and other characteristics such as forest size and waterhole size in the Boé region, on the variance in chimpanzee relative abundance.

Statistics

Statistics were calculated with SPSS 24, using an alpha-level of 0.05. Before a statistical method was applied, chimpanzee relative abundance was calculated in order to make comparisons in statistics.

- Scale variable

Before calculating chimpanzee relative abundance, values in the data noted for food wastes during the recce with a score of '10+' were replaced by a scale variable. If it was not possible to count al the individual wastes due to a high number of fruit remains (more than 10 objects) the minimum number of food waste was noted down and described in the field datasheets as '10+'. The scale variable represents the average of noted numbers of food wastes higher than 10 among the different sampled forests within the same season.

- Rescaling chimpanzee signs

Relative abundance of chimpanzee signs (chimpanzee signs/km^2) in forests was calculated first by standardizing the value of each chimpanzee sign for each recce. The variables were rescaled to compare values of the different signs within and between the different forests. But also, to made it possible to sum up the values of the different signs related to chimpanzee presence in order to calculate chimpanzee relative abundance. Standardization was done by mean subtraction and division by standard deviation.

- Chimpanzee Relative Abundance

After rescaling the values, the sum of each chimpanzee sign in each forest was divided by the area in km^2 surveyed. Area in km^2 was calculated by multiplying the total km recce walked by its width wherein signs are detected. This is done for the different type of signs separately (nests 10 m, other signs 2 m), where after chimpanzee relative abundance in each forest is calculated by summing the different scores/km^2 of each sign up together.

Comparisons between forest fragments

First, with statistical analysis it was checked whether the chimpanzee relative abundance (signs/ km^2) in sacred and non-sacred forests, and forests with and without water resource followed a normal distribution. Therefore, a histogram was made for ape relative abundance in each season and forest. Additionally, normality tests and Q-Q plots were plotted. Since the residuals on chimpanzee relative abundance, after a Ln (+3) transformation, were normally distributed and the Levene's test showed equal variances a Two-Way Anova test was conducted. With a Two-Way Anova test differences in chimpanzee relative abundance between the sacred and non-sacred forests, forests with and without water resource, and interaction effect of these groups were investigated.

Secondly, it was determined if there were statistically significant differences in score of different signs related to chimpanzee presence between the sacred and non-sacred forests, and forests with and without water resources. Since data of the different chimpanzee signs did not assume normality and was sensitive to outliers, but did meet homogeneity of variances in the non-parametric equivalent of the Levene's test, a Kruskal Wallis test was conducted.

To compare scores of human disturbances by the different forests a Two-Way Anova was conducted. Prior to conducting the analysis, residuals of human disturbance, after a Ln (+3) transformation, were found to be normally distributed and homogeneity of variances was assumed based upon results of Levene's tests.

Comparison of forest fragments during the late dry and early wet season

After making sure the distribution of the differences in chimpanzee relative abundance between the sacred forests in the dry and wet season were normally distributed a Paired Samples T- test was run. The test was used to compare dry versus wet season on ape relative abundance as in both season chimpanzee signs in sacred forests were recorded. The test was followed by the construction of a box plot to illustrate significances.

To compare if the score of different chimpanzee signals varies between the dry and wet season in the sacred forests a Wilcoxon signed rank test was conducted. In preliminary analysis, it was found data on the relative abundance of the different chimpanzee signals did not assume normality. Since data did meet the assumption of equal distribution it was chosen for the non-parametric equivalent of the Paired T-test.

Additionally, a Paired Samples T-test was conducted to compare scores of human disturbances by the dry and wet season. Prior to conducting the analysis, the assumption of normally distributed differences in human disturbance scores was examined and ensured.

Explorative analysis with multiple linear regression
Finally, to analyse if there might be a relationship between chimpanzee relative abundance and different variables related to the sampled forests such as forest size, human disturbance in forest, distance of forest to nearest village (km), waterhole size, sacred forest availability and presence of water resources an explorative analysis was performed to investigate which of these variables might predict significant variance in chimpanzee relative abundance.

A Multiple Linear Regression Analysis was used to determine which predictors may explain variance in chimpanzee relative abundance and it was investigate how much of the variation in chimpanzee relative abundance might be explained by the different independent variables. Before data was analysed with multiple regression, it was made sure the data could be analysed using multiple linear regression. To avoid over fitting the stepwise method was selected as the method of the multiple linear regression. The criteria for the stepwise inclusion was inclusion of variables that increase F by at least 0.05 and exclude them again if they increase F by less than 0.1. The collinearity diagnostics were included and the Durbin- Watson test for auto-correlation. To test the assumption of homoscedasticity and normality of residuals in the dialog Plots, the standardized residual plot (ZPRED on x-axis and ZRESID on y-axis) was included. Additionally, a Pearson correlation was carried out to have a general idea on which other variables may indicate a relationship on variability of chimpanzee relative abundance.

Table 6 Variables associated with test choice. Showing data for testing, data type, and test.

Test	**Variables**		**Data type**	**Based on**
Two-Way Anova test	Dependent variable	- Chimpanzee Relative Abundance	Scale	Signs/km2
	Independent variable	- Sacred and Non-sacred forests - Forest with and without water	Nominal Nominal	1 Sacred 2 Non-sacred 0 Absent 1 Present
Kruskal Wallis test	Dependent variable	- Relative abundance of different sign types (related to chimpanzee presence)	Scale	Signs/km2
	Independent variable	- Sacred and Non-sacred forests - Forest with and without water	Nominal Nominal	1 Sacred 2 Non-sacred 0 Absent 1 Present
Two-Way Anova test	Dependent variable	- Relative abundance of human disturbance in forest	Scale	Signs/km2
	Independent variable	- Sacred and Non-sacred forests - Forest with and without water	Nominal Nominal	1 Sacred 2 Non-sacred 0 Absent 1 Present
Paired Samples T-test	Dependent variable	- Chimpanzee relative abundance in the dry and wet season	Scale	Signs/km^2 in the dry season Signs/km^2 in wet season
	Independent variable	- Sacred forests	Nominal	1 Sacred
Wilcoxon signed-rank test	Dependent variable	- Relative abundance of chimpanzee sign types in the dry and wet season	Scale	Signs/km2 in the dry season Signs/km2 in wet season
	Independent variable	- Sacred forests	Nominal	1 Sacred
Paired Samples T-test	Dependent variable	- Relative abundance of human disturbance in forest	Scale	Signs/km2 in the dry season Signs/km2 in wet season
	Independent variable	- Sacred forests	Nominal	1 Sacred
Multiple linear regression	Dependent variable	- Chimpanzee relative abundance	Scale	Signs/ km2
	Independent variable	- Forest size - Human disturbance in forest - Distance of forest to nearest village - Waterhole size - Sacred forests - Water resource	Scale Scale Scale Scale Nominal Nominal	Size in ha Disturbance in forest/ km^2 Distance in km Size in m^2 1 Sacred, 0 Non-sacred 1 Present, 0 Absent

5. Results

In this chapter first, the results will be presented on differences between sacred and non-sacred forests, forests with and without water and interaction between these groups on chimpanzee relative abundance. This is followed by the results of a Paired Samples T-test to depict influence of seasonality on chimpanzee relative abundance. Additional, results on comparisons on relative abundance of different chimpanzee signs and human disturbance scores between the different forests and seasons will be shown. Signs related to chimpanzee presence consist of excreta (dung and urine), nests (tree and ground nests), feed remnants and marks such as stone throwing behaviour marks, travel paths or accumulated tools.

Lastly, results of an explorative analysis on the relationship between chimpanzee relative abundance and different variables is presented to create insight by which other variables variation in chimpanzee relative abundance in the Boé area may be explained. To supplement the findings on the qualitative data on chimpanzee occurrence in the different forests and seasons, the last section of the chapter offers an overview of the opportunistic data related to chimpanzee and large carnivore occurrence.

Differences between forest fragments

Chimpanzee relative abundance

To analyse if sacred forests and non-sacred forests, and forests with and without water resources, differ in chimpanzee relative abundance a Two-Way Anova was performed. In the Two-Way Anova (Table 8) no significant difference was detected between sacred and non- sacred forests ($F(1,20)= 0.02$, $p= 0.88$), and forests with and without water resources ($F(1,20)= 0.07$, $p= 0.79$). The combination of sacred forest availability and presence of water resource shows also no significance ($F(1,20)= 1.18$, $p= 0.29$). Table 7 shows the Descriptive Statistics of the Two-Way Anova with the mean and standard deviation of each group, non-sacred forests (M= 0.81, SD= 0.81), sacred forests (M= 0.76, SD= 0.79), forest with water resources (M= 0.83, SD= 0.91) and forests without water resources (M= 0.73, SD= 0.68). Distribution of data for sacred and non-sacred forests, and forests with and without water resources are illustrated by boxplots in Figure 12 and 13.

Table 7 Descriptive Statistics of the Two-Way Anova. Chimpanzee relative abundance as the dependent variable, and sacred/ non-sacred forests and forests with and without water resources as the independent variables.

Descriptive Statistics				
Dependent Variable: Ln (Chimpanzee relative abundance +3)				
Forests	Water resource	Mean	Std. Deviation	N
Non-Sacred	Absent	0.56	0.67	5
	Present	1.06	0.94	5
	Total	0.81	0.81	10
Sacred	Absent	0.91	0.71	5
	Present	0.61	0.92	5
	Total	0.76	0.79	10
Total	Absent	0.73	0.68	10
	Present	0.83	0.91	10
	Total	0.78	0.78	20

Table 8 Results of the statistical test Two-Way Anova.

Tests of Between-Subjects Effects						
Dependent Variable: Ln (Chimpanzee relative abundance+3)						
Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	0.86[a]	3	0.29	0.43	0.74	0.07
Intercept	12.30	1	12.30	18.23	0.00	0.53
Forest_S	0.02	1	0.02	0.02	0.88	0.00
Water_resource	0.05	1	0.05	0.07	0.79	0.01
Forest_S * Water_resource	0.80	1	0.80	1.18	0.29	0.07
Error	10.80	16	0.68			
Total	23.96	20				
Corrected Total	11.66	19				

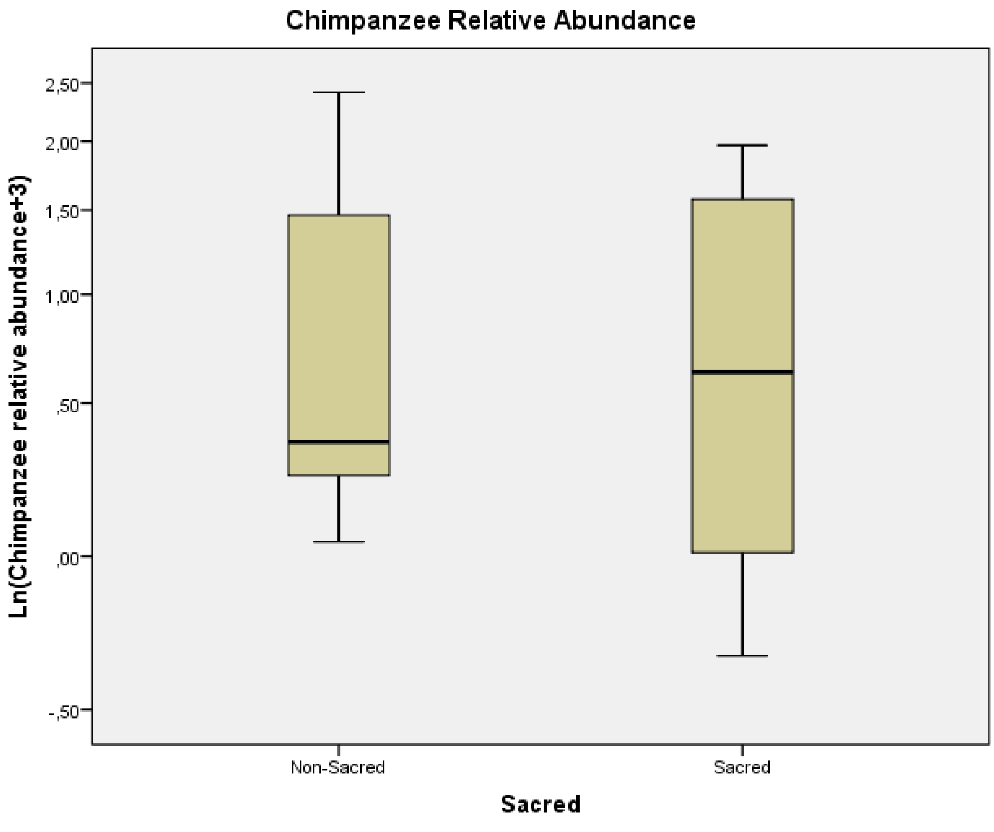

Figure 12 Box plot for Chimpanzee Relative Abundance in the group: sacred and non-sacred forests. Low negative values of chimpanzee signs/ km² mean low scores of chimpanzee relative abundance and high positive values high scores of chimpanzee relative abundance in the different forests.

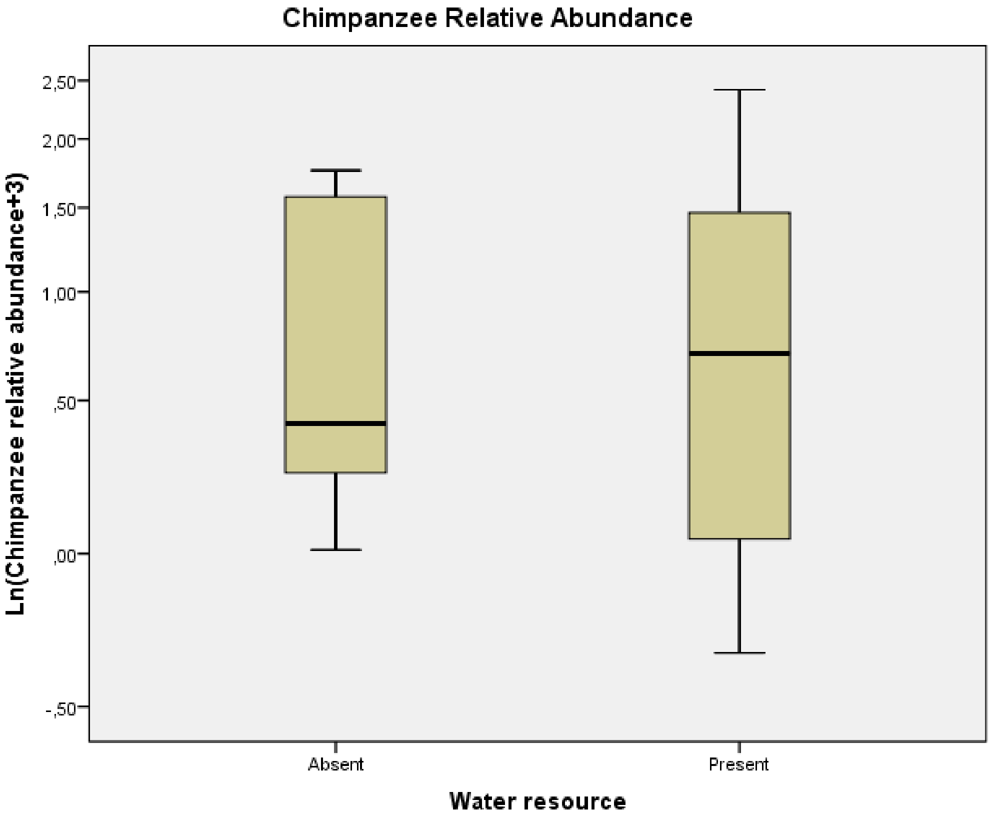

Figure 13 Box plots for Chimpanzee Relative Abundance in the group: forests with and without water resources. Low negative values of chimpanzee signs/ km² mean low scores of chimpanzee relative abundance and high positive values high scores of chimpanzee relative abundance in the different forests.

Relative abundance of chimpanzee signs

A Kruskal Wallis test was used to determine if relative abundance of different signs types related to chimpanzee presence differs between the sacred and non-sacred forests, and forests with and without water resources.

In the analysis, no statistically significant difference in the type and score of chimpanzee signs was found between sacred and non-sacred forests. Excreta per km2: $\chi 2(2)= 0.16$, $p= 0.69$ with a mean rank of 10.90 for non-sacred forests, 10.10 for sacred forests; nests per km2: $\chi 2(2)= 0.29$, $p =0.59$ with a mean rank of 11.20 for non-sacred-, 9.80 for sacred forests; food waste per km2: $\chi 2(2)= 0.76$, $p= 0.38$ with a mean rank of 9.35 for non-sacred-, 11.65 for sacred forests; marks in forest per km2: $\chi 2(2)= 0.56$, $p= 0.46$ with a mean rank of 11.30 for non-sacred-, 9.70 for sacred forests (Table 9 and 10).

Also, no significant difference was found between forests with and without water resources. Excreta per km2: $\chi 2(2)= 0.42$, $p= 0.52$ with a mean rank of 9.85 for forests without water resources, 11.15 for forests with water resources present; nests per km2: $\chi 2(2)= 0.22$, $p= 0.64$ with a mean rank of 9.90 for forests without water resources, 11.10 for forests with water resources; food waste per km2: $\chi 2(2)= 0.00$, $p= 0.97$ with a mean rank of 10.45 for forests without water resources, 10.55 for forests with water resources; marks in forest per km2: $\chi 2(2)= 0.00$, $p= 0.96$ with a mean rank of 10.55 for no-water resource - and 10.45 for forests with water resources present (Table 9 and 10).

More detail of the recorded signs related to chimpanzee occurrence and its count in each forest can be found in Annex V and VI.

Table 9 Results of the Kruskal Wallis test.

Kruskal Wallis Test Statistics				
Comparison				
Sacred and non-sacred forests				
	Excreta/ km2	Nests/ km2	Food waste/ km2	Marks in forest/ km2
Chi-Square	0.16	0.29	0.76	0.56
df	1	1	1	1
Asymp. Sig.	0.69	0.59	0.38	0.46
Forest with and without water resources				
Chi-Square	0.42	0.22	0.00	0.00
df	1	1	1	1
Asymp. Sig.	0.52	0.64	0.97	0.96

Table 10 Mean Ranks of the different type of chimpanzee signals in sacred and non-sacred forests, and forests with and without water resources.

Ranks						
	Sacred	N	Mean Rank	Water resource	N	Mean Rank
Excreta/ km2	Non-Sacred	10	10.90	Absent	10	9.85
	Sacred	10	10.10	Present	10	11.15
	Total	20		Total	20	
Nests/ km2	Non-Sacred	10	11.20	Absent	10	9.90
	Sacred	10	9.80	Present	10	11.10
	Total	20		Total	20	
Food waste/ km2	Non-Sacred	10	9.35	Absent	10	10.45
	Sacred	10	11.65	Present	10	10.55
	Total	20		Total	20	
Marks in forest/ km2	Non-Sacred	10	11.30	Absent	10	10.55
	Sacred	10	9.70	Present	10	10.45
	Total	20		Total	20	

Human disturbance

A Two-way analysis of variance was conducted to compare the score of human disturbance in the sacred and non-sacred forests, and forests with and without water resources, but also to investigate the interaction effect of sacred forest and water resource availability on human disturbance score in the different forests.

Only the effect of sacred forest availability was found to be statistically significant. At the edge of significance, ($F(1,16)= 4.12$, $p= 0.0594$), a difference in human disturbance score was detected between sacred ($M= 0.92$, $SD= 0.19$) and non-sacred forests ($M= 1.18$, $SD= 0.34$), (Table 11 and 12). Difference in human disturbance between sacred and non-sacred forests is illustrated in Figure 14. No difference was found between forest with ($M= 0.98$, $SD= 0.24$) and without water resources ($M= 1.12$, $SD= 0.35$), ($F(1,16)= 1.28$, $p= 0.28$). The combination of sacred forest availability and presence of water resource was not significant ($F(1,16)= 0.76$, $p= 0.40$), (Table 11 and 12).

Table 11 Descriptive Statistics of the Two-Way Anova. Human disturbance as the dependent variable, and sacred/ non-sacred forests and forests with and without water resources as the independent variables.

Descriptive Statistics				
Dependent Variable: Ln(Human disturbance +3)				
Sacred	Water resource	Mean	Std. Deviation	N
Non-Sacred	Absent	1.30	0.35	5
	Present	1.06	0.32	5
	Total	1.18	0.34	10
Sacred	Absent	0.94	0.27	5
	Present	0.91	0.10	5
	Total	0.93	0.19	10
Total	Absent	1.12	0.35	10
	Present	0.98	0.24	10
	Total	1.05	0.30	20

Table 12 Results of the statistical test Two-Way Anova.

Tests of Between-Subjects Effects					
Dependent Variable: Ln(Human disturbance +3)					
Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	0.47[a]	3	0.16	2.05	0.147
Intercept	22.19	1	22.19	289.18	0.000
Forest_S	0.32	1	0.32	4.12	0.059
Water_resource	0.10	1	0.10	1.28	0.275
Forest_S * Water_resource	0.06	1	0.06	0.76	0.398
Error	1.23	16	0.08		
Total	23.89	20			
Corrected Total	1.70	19			
a. R Squared = ,278 (Adjusted R Squared = ,142)					

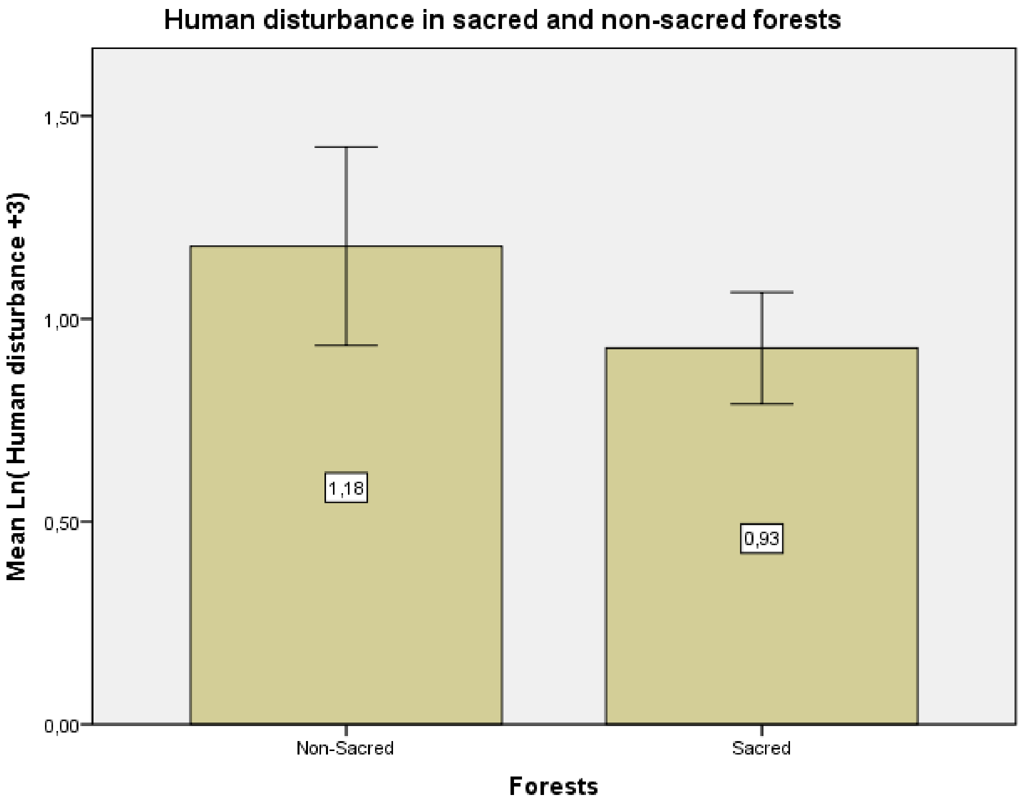

Figure 14 Bar chart on mean score of human disturbance in the sacred and non-sacred forests of the Boé. Low values mean low scores of human disturbance and high values high scores of human disturbances in the forested habitats.

Comparison of forest fragments during the late dry and early wet season

Chimpanzee relative abundance

There was no significant difference in chimpanzee relative abundance in the sacred forests between the late dry (M= 0.76, SD= 0.79) and early wet season (M= 0.78, SD= 0.92), *t*(9)= -0.15, *p*= 0.89 (Table 13 and 15). Differences in mean and standard deviation are shown in Figure 15. The two variables were strongly correlated, *r*(18)= 0.84, *p*= 0.003 (Table 13). The positive correlation between the forests of the dry and wet season indicate the forests which score higher in the dry season tend also to score higher in the wet season.

Table 13 Paired Samples Statistics of the Paired Samples T-test. Chimpanzee relative abundance in the dry season and chimpanzee relative abundance in the wet season as the paired variables.

Paired Samples Statistics					
		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	Ln (Dry season +3)	0.76	10	0.79	0.25
	Ln (Wet season +3)	0.78	10	0.92	0.29

Table 14 Paired Samples Correlations.

Paired Samples Correlations				
		N	Correlation	Sig.
Pair 1	Ln (Dry season+3) & Ln (Wet season+3)	10	0.84	0.003

Table 15 Results of the Paired Samples T- test.

Paired Samples Test								
		Paired Differences						
		Mean	Std. Deviation	95% Confidence Interval of the Difference		T	df	Sig. (2-tailed)
				Lower	Upper			
Pair 1	Ln(Dry season+3) - Ln(Wet season+3)	-0.02	0.50	-0.38	0.34	-0.15	9	0.885

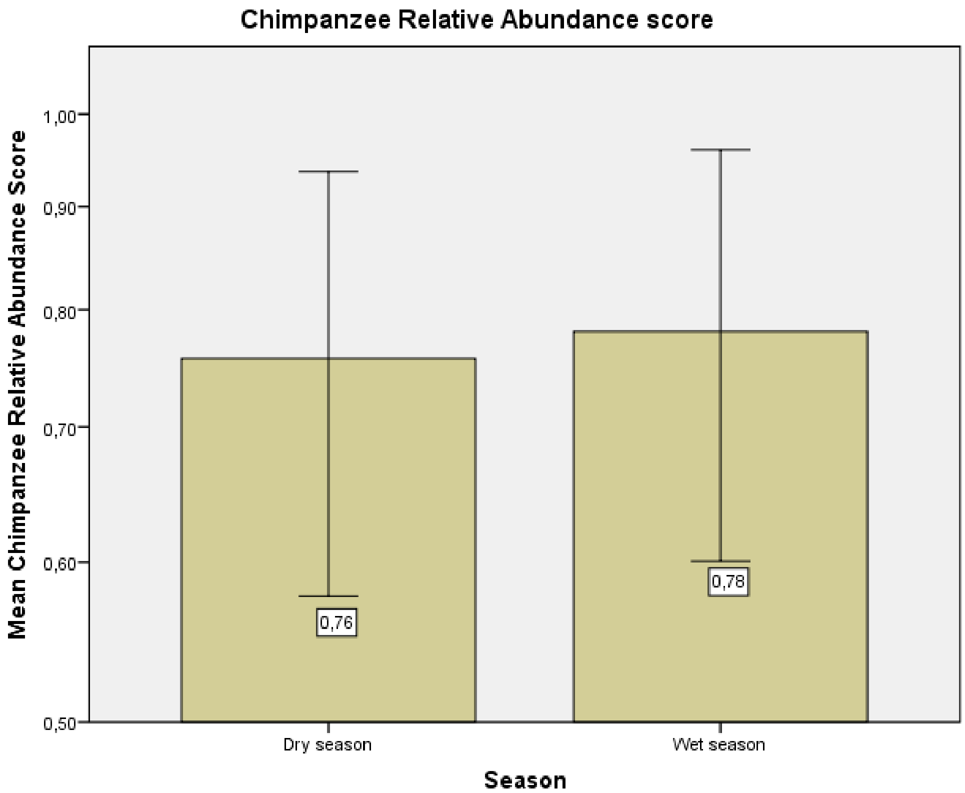

Figure 15 Bar chart on mean score of chimpanzee relative abundance in the wet and dry season in the sacred forests of the Boé region. Low values mean low scores of chimpanzee relative abundance and high values high scores of chimpanzee relative abundance in forested habitats.

Relative abundance of chimpanzee signs

A Wilcoxon signed rank test was used to investigated change in the score of different signs related to chimpanzee presence in the sacred forests from the dry to the wet season. Results of the analysis indicated that there was no significant difference in how seasonality ranks the different sign types related to chimpanzee presence (Table 15); excreta per km2 (Z= -1.111, p= 0.266), nests per km2 (Z= -0.462, p= 0.644), food waste per km2 (Z= -1.376, p= 0.169), marks per km2 (Z= -0.887, p= 0.375). The medians of the dry and wet season were; excreta per km2 (dry= 0.62, wet= 0.68), nests per km2 (dry= 0.57, wet= 0.58), food waste per km2 (dry= 0.75, wet= 0.77), marks per km2 (dry= 0.46, wet= 0.39) respectively (Table 16). Descriptive statistics can be found in Table 16 and small differences in mean between the signals are depicted in Figure 15. However, the results indicate that the dry and wet season do not elicit a significant change in score of the different chimpanzee signs.

Table 15 Statistics of the Wilcoxon Signed Rank Test. Score on relative abundance of the different chimpanzee signs does not change from the dry to the wet season.

Wilcoxon Signed Rank Test Statistics				
	Excreta/ km2 wet season - Excreta/ km2 dry season	Nests/ km2 wet season - Nests/ km2 dry season	Food waste/ km2 wet season - Food waste/ km2 dry season	Marks/ km2 wet season - Marks/ km2 dry season
Z	-1.111[b]	-0.462[b]	-1.376[c]	-0.887[c]
Asymp. Sig. (2-tailed)	0.266	0.644	0.169	0.375
b. Based on negative ranks, c. Based on positive ranks.				

Table 16 Descriptive Statistics of the Wilcoxon Signed Rank Test. Relative abundance of the different sign types as the dependent variables, and dry and wet season as the independent variables.

Descriptive Statistics						
Chimpanzee signs per km²						
Dry season	N	Mean	Std. Deviation	Minimum	Maximum	Median
Excreta	10	0.87	0.52	0.62	1.87	0.62
Nests	10	0.80	0.70	0.20	2.01	0.57
Food waste	10	1.23	1.35	0.39	4.97	0.75
Marks	10	0.92	1.10	0.46	3.89	0.46
Wet season						
Excreta	10	0.99	1.00	0.68	3.85	0.68
Nests	10	1.00	1.00	0.19	3.02	0.58
Food waste	10	1.00	1.00	0.37	3.76	0.77
Marks	10	1.00	1.00	0.39	2.88	0.39

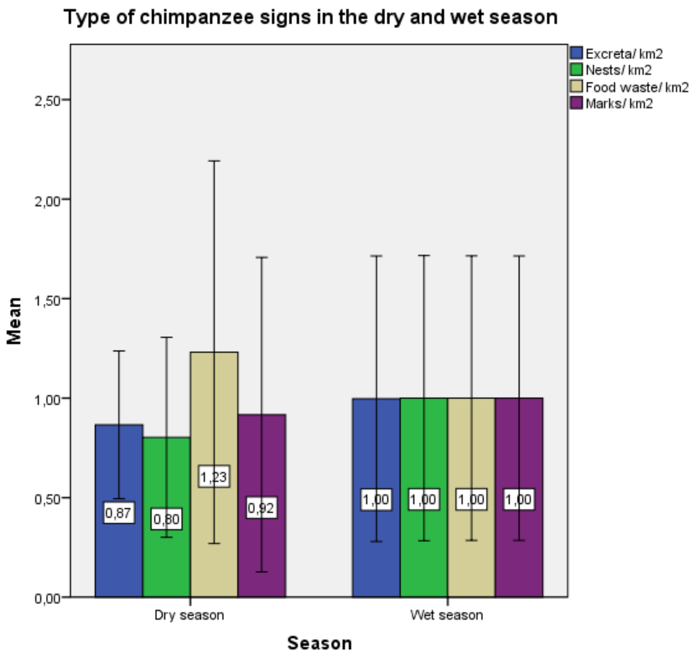

Figure 15 Type and mean number of chimpanzee signals per km² during the dry and wet season in sacred forests. Excreta: dung as well urine; Nests: individual nests and nests within groups of nests of different age (new/ recent/ old/ decayed), Food waste: Feeding remains; Marks: tool marks, travel paths and accumulated objects. Values on relative abundance were derived from transformed data on standardized values. Low scores in the charts indicate low relative abundance and high scores indicate high relative abundance of the specific sign.

Human Disturbance

A paired samples t-test was conducted to compare scores of human disturbances by the dry and wet season. There was no significant difference in the score of the dry (M= 0.58, SD= 0.58) and wet season (M= 0.00, SD= 1.00), t(9)= 1.62, p= 0.14, (Table 17 and 19) . These results suggest that seasonality does not have an effect on the score of human disturbance in the sacred forests.

Table 17 Statistics of the Paired Samples T-test. Human disturbance in the dry season and human disturbance in the wet season as the paired variables.

Paired Samples Statistics					
		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	Human disturbance/ km2 dry season	0.58	10	0.58	0.18
	Human disturbance/ km2 wet season	0.00	10	1.00	0.32

Table 18 Paired Samples Correlations.

Paired Samples Correlations				
		N	Correlation	Sig.
Pair 1	Human disturbance/ km2 dry season & Human disturbance/ km2 wet season	10	0.06	0.87

Table 19 Results of the Paired Samples T- test.

Paired Samples Test									
		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
					Lower	Upper			
Pair 1	Human disturbance dry season - Human disturbance wet season	0.58	1.13	0.36	-0.23	1.38	1.62	9	0.141

Explorative analysis

A multiple regression was run to predict chimpanzee relative abundance based on Forest size, Human disturbance in forest per km^2, Distance to nearest village (km), Waterhole size (m^2), Sacred forest availability and Water resource presence. Only the variable Distance to nearest village (km) predicted chimpanzee relative abundance F (1, 18)= 6.21, p= 0.023, with an adjusted R^2 of 0.215 (Table 20 and 21). Chimpanzee relative abundance prediction is equal to -0.164 + 0.271, where Distance to nearest village is measured in km (Table 22, Figure 16). Chimpanzee relative abundance measurement in a forest increased 0.271 for each km of distance to the nearest village in its surroundings. Other variables did not add statistical significance to the prediction, p > 0.1.

Additionally, a Pearson correlation was carried out to have a general idea on which other variables may indicate a relationship on variability of chimpanzee relative abundance. Based on the results of the Pearson correlation, only Distance to nearest village is related to Chimpanzee relative abundance, r= 0.51, p= 0.023. However, Sacred forest availability might have a relation with the variables Human disturbance per km^2 forest (r= 0.43, p= 0.058) and Distance to nearest village (km) (r= 0.40, p= 0.078) as the p values are near significance (Table 23).

Table 20 Linear regression's F-test.

ANOVA[a]						
Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	2.99	1	2.99	6.21	0.023[b]
	Residual	8.67	18	0.48		
	Total	11.66	19			
a. Dependent Variable: Ln(Chimpanzee relative abundance+3); b. Predictor: (Constant) Distance to nearest village (km)						

Table 21 Multiple linear regression model summary and overall fit statistics.

Model Summary[b]					
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	0.506[a]	0.256	0.215	0.69	2.23
a. Predictor: (Constant), Distance to nearest village (km)					

Table 22 Stepwise multiple linear regression estimates including the intercept and the significance levels.

Coefficients[a]								
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
		B	Std. Error	Beta			Tolerance	VIF
1	(Constant)	-0.164	0.41		-0.398	0.695		
	Distance to nearest village (km)	0.271	0.11	0.51	2.491	0.023	1.00	1.00
a. Dependent Variable: Ln (Chimpanzee relative Abundance+3)								

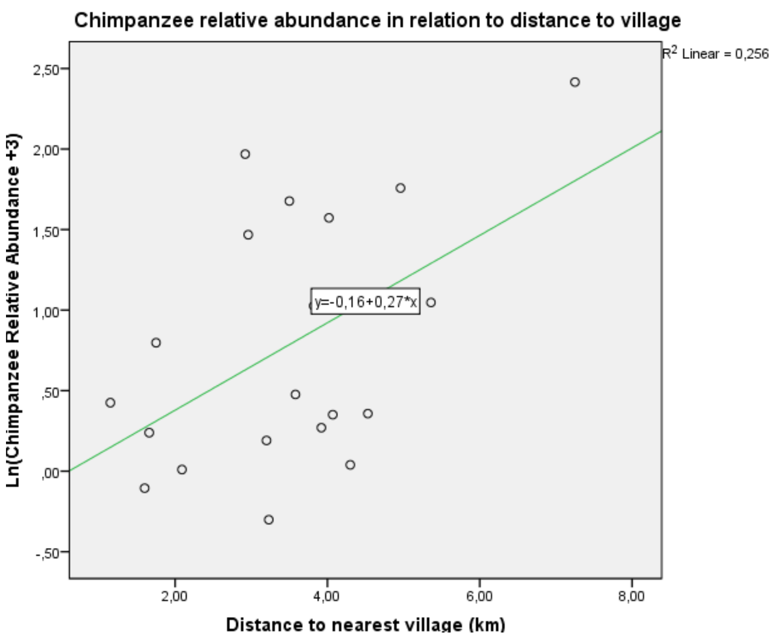

Figure 16 Scatter plot of the linear regression of Distance to nearest village (km) and Chimpanzee Relative Abundance, with the method Stepwise. Low values of chimpanzee signs per km2 mean low scores of chimpanzee relative abundance in forested habitats and high values high scores of chimpanzee relative abundance.

Table 23 Results of the Pearson Correlation.

Correlations								
		Ln (Chimpanzee relative abundance+3)	Ln (Human disturbance+3)	Forest size (ha)	Waterhole size (m2)	Water resource	Sacred	Distance to nearest village (km)
Ln (Chimpanzee relative abundance+3)	Pearson Correlation	1	-0.18	0.08	0.06	0.07	0.04	0.51*
	Sig. (2-tailed)		0.45	0.74	0.82	0.78	0.88	**0.023**
	N	20	20	20	20	20	20	20
Ln (Human disturbance+3)	Pearson Correlation	-0.18	1	-0.29	-0.22	-0.24	0.43	0.10
	Sig. (2-tailed)	0.45		0.22	0.36	0.31	**0.058**	0.664
	N	20	20	20	20	20	20	20
Forest size (ha)	Pearson Correlation	0.08	-0.29	1	-0.15	0.08	0.21	0.02
	Sig. (2-tailed)	0.74	0.22		0.53	0.74	0.39	0.95
	N	20	20	20	20	20	20	20
Waterhole size (m2)	Pearson Correlation	0.06	-0.22	-0.15	1.00	0.32	-0.32	0.19
	Sig. (2-tailed)	0.82	0.36	0.53		0.17	0.17	0.41
	N	20	20	20	20	20	20	20
Water resource	Pearson Correlation	0.07	-0.24	0.08	0.32	1.00	0.00	0.15
	Sig. (2-tailed)	0.78	0.31	0.74	0.17		1.00	0.52
	N	20	20	20	20	20	20	20
Sacred	Pearson Correlation	0.04	0.43	0.21	-0.32	0.00	1.00	0.40
	Sig. (2-tailed)	0.88	**0.058**	0.39	0.17	1.00		**0.078**
	N	20	20	20	20	20	20	20
Distance to nearest village (km)	Pearson Correlation	0.51*	0.10	0.02	0.19	0.15	0.40	1.00
	Sig. (2-tailed)	**0.023**	0.66	0.948	0.41	0.52	**0.078**	
	N	20	20	20	20	20	20	20
*. Correlation is significant at the 0.05 level (2-tailed).								

Additional findings on chimpanzee and large carnivore occurrence

Signs of chimpanzee presence and activity were found throughout the study area. However, only one chimpanzee individual was observed during the survey period. The chimpanzee young was observed in a tree of a (non-sacred) forest, with a water resource, during the dry season. Chimpanzee vocalisations were more often identified, in total 20. Other signs observed on chimpanzee presence consisted of excreta (dung and urine), nests (tree and ground nests), feed remnants and marks such as stone throwing behaviour marks, travel paths or accumulated tools. Score of these signals in the different forests during the dry and wet season can be found in Figure 15 and Annex V. Large carnivore presence was once spotted. Dung of Spotted hyena *(Crocuta crocuta)* was observed during the wet season in a sacred forest with a water resource (Annex I, forest 8). More detail of the recorded signs related to chimpanzee and large carnivore occurrence and its count in each forest during the dry and wet season can be found in Annex VI.

6. Discussion

This study has concentrated on chimpanzee occurrence in non-protected areas of the Boé region, Guinea-Bissau, where a major part of the environment has been modified by anthropogenic activities. The objective of this study was to gain more insight in the occurrence of the Western chimpanzee in the forests of this type of habitat, to identify key sites and to contribute to the establishment of effectively legally protected areas that will complement the two already established National Parks, the Boé National Park in the north east and the Dulombi National Park in the west. This in order to safeguard the Western chimpanzee since the remaining population in Guinea-Bissau is extremely threatened (Garriga, 2013; IUCN, 2016). By including sacred forests in the study on chimpanzee relative abundance in the forested habitats of the Boé region, the study also sought to develop new evidence with regard to the importance of sacred forests for chimpanzee conservation. Sacred forests were expected to form important habitats for chimpanzee conservation as they often are rich in biodiversity, limited in human activity and harbor permanent water resources as they in general are located around the origins of streams or rivers in gallery forests (Hoogveld, 2013; Kühnert, 2016; Meer, 2014; Wabeke, 2017). Preserving sacred forests has also the goal to preserve old growth forests in the area. Sacred forests have been threatened in the last years by poor governance, an increase in the exploitation of natural resources (Klepeis et al., 2016), population growth and weakening of cultural habits and practices among younger generations (Klepeis et al., 2016; Ramachandra, 2017; Wabeke, 2017). Therefore, it is of importance to increase the knowledge about these areas in order to reinforce the conservation of these forests.

Data were collected in forests with and without water resources to evaluate the effect of water availability in the different forests (sacred and non-sacred) on the relative abundance of chimpanzees. This, since chimpanzee presence according to Wenceslau (2014) is related to water availability. Sacred forests were compared between the dry and wet season in order to investigate if seasonality causes differences in chimpanzee relative abundance between the forests. According to earlier studies, during the dry season chimpanzees seem to be more restricted in their habitat use to forests harboring water resources (Pruetz & Bertoniani, 2009; Wenceslau, 2014). As the sacred forests were expected to have permanent water availability during the dry season, due to the presence of sources, high chimpanzee activity was expected in these forests compared to non-sacred forests. For this reason, lower scores of chimpanzee relative abundance in sacred forests were expected in the wet season than in the dry season. Additionally, the study collected specific geographical information on habitat preferences of chimpanzees, such as water availability in forested habitats, size of forest fragments etc., and data on human and large carnivore presence.

To investigate the degree of importance of the different forests to contribute effectively to the designation of protected areas in the Boé for chimpanzee conservation two research questions were developed:

1. Is the presence of the Western Chimpanzee *(Pan troglodytes verus)* in the forests of the Boé region during the dry season determined by the availability of sacred forests and water resources in the forests?
2. Is there a difference in chimpanzee presence in the sacred forests of the Boé region between the late dry and early wet season?

The results in relation to the first research question show no significant difference in chimpanzee relative abundance between sacred and non-sacred forests, and forests with and without water resources during the dry season (Table 8). No difference in chimpanzee relative abundance between the different forests of the Boé may be the result of chimpanzees in environments dominated by savannah, with patches of gallery and dry forests, tend to concentrate on both type of forests (Bogart, 2009; Hunt & McGrew, 2002; Oates, 2011). Similar findings have been found in the Boé, where they use the entire area as their habitat and forests are important habitats (Brugiere et al., 2009; Wenceslau, 2014). Chimpanzees may occur in the different forests for food, water, shade and nesting resources, as chimpanzees in savannah woodland environments depend on a larger habitat than mixed rainforest to obtain enough resources (Oastes, 2011). Chimpanzees in the Boé may for this reason occur in the different forests to have access to enough and different resources. In the study different chimpanzee signs related to food and nest resources were also observed in the different forests (Table 9).

In the dry season gallery forests may be selected by chimpanzees for its water resources when in the peak of the dry season water becomes limited in the Boé and the last few remaining resources are located in these forests. In gallery forests, sacred as well non-sacred forests can be found (Hoogveld, 2013). An example of water limitation in the Boé is when the well of Uncire dried up, forcing local people and me to collect water in the gallery forests. In Senegal the West African chimpanzee is also known to compete for water resources with humans during the late dry season (Kormos et al., 2003). According to Pruetz and Bertoniani (2009) as the dry season progresses, water resource availability restricts chimpanzees only to forests with available water resources. From these forests chimpanzees move to forage. When in the dry season chimpanzees move between forests with and without water resources to have access to different resources, no significant difference in chimpanzee relative abundance may be detected between sacred and non-sacred forests, and forests with and without water resources. Additionally, both forests, with and without water resources, may be selected by chimpanzees for the provision of shade. In Fongoli, a savannah-woodland area like the Boé, it was found that chimpanzees significantly preferred closed canopy fragments during the dry season, as these areas are the only permanent sources of shade during the dry season, providing cooler habitats (Pruetz & Bertoniani, 2009). In a chimpanzee study of McGrew, Baldwin, and Tutin (1981) woody vegetation was suggested to be crucial for chimpanzee survival in dry and open areas, as the apes were suggested to depend on these habitats to deal with heat and water stress.

Evidence for chimpanzee presence in dry and gallery forests throughout the year has also been suggested to be related to food and nest availability since forests have higher tree species diversity compared to other habitat types in a savanna dominated landscape (Sousa, Casanova, Barata, & Sousa, 2014). In the Boé chimpanzees depend on a variety of tree species for their dietary requirements, whereby fruits are abundant in different times of the year (Meer, 2014) and comprise the largest portion of their diet (McGrew et al., 1981; Oates, 2011). According to Wabeke (2017) plant species composition and vegetation structure differs between sacred and non-sacred forests, which may cause differences in food resources between the forested habitats, such as ripe fruit and plant availability. Since chimpanzee feeding behaviour is influenced by food availability and varies along the seasons, as they adjust their diet to plant availability, the apes may depend throughout the year on the different forests for their food resources (Kormos, Boesch, Bakarr, & Butynski, 2003; Kühl, Maisels, Ancrenaz, & Williamson, 2008; Oates, 2011). In this study no significant difference was found in chimpanzee relative abundance between the dry and wet season. Also, no change was observed in the score of food wastes from the dry to the wet season (Table 16). These results, in relation to the research questions, are in accordance with the findings above and indicate that forests might be important areas for chimpanzees, for having enough year-round food resources. Tree and plant species may show variance in foliage and fruitification characteristics in different times of the year, providing chimpanzees with food resources throughout the year. For this reason, chimpanzees may rely on the different forested habitats for their food resources and no difference was found in chimpanzee relative abundance in the forests between the seasons. A positive correlation was found between the forests of the dry and wet season (Table 13). The correlation indicates the forests which score higher in chimpanzee relative abundance in the dry season also tend to score higher in the wet season, suggesting chimpanzees might have a preference for specific forests.

Sacred forests might be used by chimpanzees for refuge and shelter resources. In this study a significant difference in human disturbance scores was found between sacred and non-sacred forests (Table 11). Non-sacred forests scored higher in human disturbance scores compared to sacred forests (Figure 12). This was also found in a Boé study of Wabeke (2017). Restrictive access in the forests was ascribed to the sacred designation of these forests. Access to the sacred forests of the Boé is restricted to site keepers, or completely inaccessible due to the inhibition of a bad spirit in the forests (Wabeke, 2017). According to Malhotra, Gokhale, Chatterjee, and Srivastava (2001) many threatened fauna species find refuge in sacred forests. Also in a study in West Bengal, India, it was found that some fauna species exclusively found refuge in relict sacred forests (Ganesh, 1997). In Indonesia, a positive effect of traditional culture was found on the preservation of primate species (Riley, 2010). Based on this, sacred forests in the Boé may form important chimpanzee habitats offering shelter in a human influenced landscape. However, more distant (sacred and non-sacred) forests to human settlements may also offer shelter to chimpanzees. In a linear regression it was found that chimpanzee relative abundance in the forested habitats significantly increases by larger distance to the nearest village (Table 22, Figure 16). This indicates there might be a negative relationship between human occurrence and chimpanzee relative abundance. In other studies displacement of chimpanzee populations and change in occurrence has been observed due to human interference and noise in their surroundings (Kormos et al., 2003). However, in the linear regression no significant relationship was found between chimpanzee relative abundance and human disturbance in the forests. This may be as chimpanzee in the Boé are also known to occur in areas close to villages (Brugiere, Badjinca, Silva, & Serra, 2009; Hoogveld, 2013). According to Hockings and McLennan (2012) chimpanzees occur throughout tropical Africa in areas of anthropogenic influence and are able to adapt in a certain range to human influenced habitats. In the Boé, when sufficient large trees are available, chimpanzees in the Boé can tolerate some anthropogenic impact in their environment (Wenceslau, 2014). For these reasons and since chimpanzees in forest mosaics and savannah depend on the forested habitats for shade, nest, food and water resources (Bogart, 2009; Oates, 2011; Sousa et al., 2014), chimpanzees in the Boé may rely on the different forests to have access to different and enough resources despite human occurrence in the forests. However, the negative relationship between chimpanzee relative abundance and distance to human settlements might indicate a preference of these animals for more distant sacred and non-sacred forests.

Altogether, the findings of this study may indicate chimpanzees in the Boé might depend on both sacred and non-sacred forests, with and without water resources in order to adapt and survive in the dry and open landscape, as well to coexist with humans. However, chimpanzees might have a preference for sacred and non-sacred forests with larger distances to human settlements. Therefore, these areas, as well as forests which score higher in chimpanzee relative abundance in the dry and wet season might be important key sites for chimpanzee conservation. Occurrence of the chimpanzees in the forests might be related to several factors, whereby resource abundance and type of resource may vary between the different forests as the forests differ in water- and vegetation characteristics, as well on human occurrence.

Chimpanzees in the Boé have managed to survive in a non-protected and degraded habitat. However, human disturbances are increasing in the area due to human population growth and increasing demand for natural resources. This emphasizes the need for further research to learn more about the demographics, dynamics and habitat use of the Boé chimpanzees in order to ensure their survival as well to find mitigation strategies to reduce the spread of human settlements into chimpanzee habitats and to reduce the level of human disturbance in the different type of forests. Considering the establishment of legally protected areas to preserve chimpanzees in the region, it is important to note that chimpanzees in the Boé might depend for their survival on specific (sacred and non-sacred) forests, with and without water in order to have enough access to nest, shelter, food and water resources, but also to maintain the ability to survive in the dry and open environment, with many anthropogenic activities.

Limitations of the study

It needs to be considered that the study was conducted in very though conditions with limited research and human resources available. This as the study was performed in one of the most isolated and poor regions of Guinea-Bissau. Access to the region depends on a ferry in bad conditions and roads become less accessible during the rainy season due to water accumulation, consequently affecting access to and in the region. In particular as it is taken into consideration that travel in the Boé was done by foot and bicycle through the savannah and rocky parts of the hilled landscape. Besides this, food and water were in general limited when conducting fieldwork in Uncire and Capebonde as people had already difficulties in feeding their own family. Drinking water was even more critical as the well of Uncire dried up in the late dry and early wet season. Sleeping conditions in these villages very also very basic and poor in hygiene. Additionally, in a specific period of the survey the local assistants followed the Ramadan, making them more fragile and tired during data collection. This altogether posed consequences on the health of the survey team, making us earlier tired, fragile, less productive and often ill. A decrease in the health state may have posed some consequences on the quality of the data. Visibility to ape, large carnivore and human signals may have been affected, leading to less sight of signals as the survey progressed in time. Often in periods of stay in Uncire and Capebonde, we could remark we become easily tired, making it more difficult to see chimpanzee signals, to maintain a constant recce speed and patience in stressful circumstances.

During the wet season, this became even more of a challenge. Heavy rainfall and thunderstorm buffered noise of humans and animals in the forests, and less light penetration through the forest canopy made detection of signs more difficult. Also, a denser vegetation structure in the rain season made sign detection probably more limited, and mud and wet rocks made assessment of the forest more difficult. At the end of the early wet season, data collection was even not possible anymore as sandy roads and lower parts of the savannah became pools or streams due to heavy rainfall, but also as mud made it impossible to travel. This is in particular related to regions in the surroundings of Capebonde, near the border with Guinea-Conakry. During the wet season, it was possible to observe clearly that in areas more to the south significantly more rain had fallen. Grass was taller and more areas in the surroundings of the village become inundated.

Conducting fieldwork in a foreign language posed also some challenges as misunderstandings happened more often and communication required more time and patience resulting in less time to sample forests. Even a smaller sample size was obtained, it was of great importance to invest a lot of time in communication as fieldwork and lodging in other villages was done in the local language. To prevent as much as possible mistakes in the research methods or forest selection it was in this study chosen to make more time available for communication. It also should be taken in consideration that not much previous research has been conducted in this area. In Uncire I was even the first person staying in the village to conduct research activities. Since people in the region are not used to research and the survey selected sacred forests, a lot of time needed to be invested in the communication with local villagers, in particular elders in order to create understanding for the research, cooperation, and to obtain permission to work in these forests.

Also, the involvement of different local people in the field may have had an influence on the collection of data as cultural and ecological knowledge varied between these persons. In particular older people seemed to have more knowledge about sacred forests, their existence, locations and borders. A difference in knowledge on sacred forest occurrence could be remarked. Older members seemed also to work more carefully in the sacred grooves compared to younger assistants. For example, less vegetation was cut by elders than by younger assistants. Signs seemed also to be easier noticed by elders. They had also more ability in explaining the age, the relation between the sign and the animal and why the specific sign could be found in a certain number or site. For these reasons most of the time surveys were conducted with the most skilled elder employee of Chimbo, however a few times research has also been done with the younger local villagers which may have affected the reliability of the data. During surveys in sacred forests near other villages, research has been done with assistance of an extra person, the respective site keeper. This may also have influenced data collection as in the research team one more person could have the function of observer. The link between the site keeper and the forests may probably make the detection of human and animal signs more easy in the forest.

The though and simple conditions created the possibility to live very close with indigenous people, get insight in their culture and traditions. At the same time the hard conditions, weakened the health and strength of the body, consequently affecting data collection and the reliability of the data. Also difference in knowledge between local assistants may have posed some consequences on the research. However, this research has tried to deal and adapt as best as possible with the given challenges and basic conditions.

7. Conclusions and recommendations

Altogether, based on the findings of this study it can be concluded that there is no difference in chimpanzee presence between sacred and non-sacred forests, and forests with and without water resources. These findings indicate that the presence of the Western chimpanzee is not determined by the availability of sacred forests and water resources in these forests. Additionally, it can be concluded that seasonality does no elicit a change in chimpanzee presence in the sacred forests of the Boé.

To adapt and survive in the non-protected dry environment, in coexistence with humans, chimpanzees might depend on both sacred and non-sacred forests, with and without water resources to get enough access to resources.

Considering the establishment of legally protected areas to preserve chimpanzees in the Boé, it is important to protect the last remaining pockets of sacred and non-sacred forests, with and without water sources. Particular attention should be given to forest pockets with relative higher scores of chimpanzee relative abundance and forests with larger distance to human settlements.

Recommendations

Chimpanzees in the Boé have managed to survive in the non-protected degraded habitat. However, human disturbances are increasing in the area due to human population growth, increasing demand for natural resources and the loss of old traditions and knowledge. This emphasizes the need for further research to learn more about the demographics, dynamics and habitat use of the Boé chimpanzees in order to ensure their survival and to find mitigation strategies to reduce spread of human settlements and activities into chimpanzee habitats. Additionally, further studies on what kind of conservation tools are needed to facilitate the coexistence of humans and chimpanzees and their habitats. It appears that chimpanzees may tolerate some human disturbance (Kormos & Boesch, 2003; Wenceslau, 2014), however to make chimpanzee and human coexistence possible, new, alternative sustainable developments in the area need to be further investigated.

It also become urgent to protect the last remaining pockets of forests, sacred and non-sacred, with and without water resources to retain water in the region to prevent further increase in water competition in the dry season between human and chimpanzees. Forests retain water due to its vegetative mass (Malhotra et al., 2001) and are therefore important to maintain water in the region available for humans, flora and fauna species, in particular during the dry season to safeguard their survival but also to prevent progressive human disturbance in chimpanzee habitats due to a decrease in water availability.

This research supports the incorporation of local institutions and inhabitants in the conservation and management of the legally protected areas as well the areas outside the National Parks. While chimpanzees seem to rely on different forest habitats for their survival in the open and dry habitat, fragmentation of and disturbances in these areas seem to increase with the rapid development and population growth in the sector.

It also is of great importance to take into account in conservation and management plans the positive attitude of people in the Boé towards chimpanzees. Local people met during the survey period in the Boé, reacted most of the times in a positive and often enthusiastic way towards chimpanzees. The western chimpanzee called by the people ‘demuro’ or ‘dari’, seemed to be linked to their indigenous culture. This was also found in other studies conducted in West Africa (Kormos, Boesch, Bakarr, & Butynski, 2003). In a study of Limoges and Robillard (1989) it was told by people of the Boé that spirits of elders sheltered in chimpanzees. From this perspective it is equally important to preserve the culture in the area as old traditions have preserved important refuge and food areas (sacred forests) for chimpanzees, and possibly many other species since also dung of the endangered spotted hyaena *(Crocuta crocuta)* was found in these forests. The maintenance of old traditions and knowledge therefore may contribute to the local protection of the fragile species in the area.

Conserving the ecological and cultural elements of the Boé, and developing at the same time a more detailed insight in how to diminish the threats on it, may help to preserve the untouched old growth forests in the area and help threatened species in the area to recover. An important aspect might be the development of new economic initiatives and alternative sources for income generating activities. Linking the conservation of the ecosystem to economic alternatives such as ecotourism, as Chimbo already has started with, might help to diminish destructive activities in the area such as logging, hunt and unsustainable agriculture activities.

The Boé sector, if well explored, might have a potential as tourist and research attraction. Tourists and researchers can appreciate a large number of wildlife species, including different primate species, amongst others the West-African Chimpanzee. The charismatic appeal of chimpanzees and their commonly recorded vocalisations in the forests enhance the value of the region for tourism and the support of the public in conservation projects. The presence of chimpanzees may help to raise awareness with regard to the importance of preserving the forests of the region for its flora and fauna and its inhabitants.

Together this survey and future studies, monitoring and educational programs aiming in creating more understanding of the cultural and ecological knowledge of the area as well mitigation actions, the area might become more attractive for the investment of research, collaboration by local inhabitants and tourist interest.

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Annex I List of Sampled forests

Table 24 Sampled forests in the surroundings of the villages Belí, Uncire and Capebonde.

Village	Forest	Forest name	Latitude	Longitude
Belí	1	Quebube	11°48'20.74"N	13°57'1.08"W
Belí	2	Bundujuri	11°50'8.53"N	13°54'30.80"W
Belí	3	Beli Um	11°49'6.05"N	13°57'5.75"W
Belí	4	Kineke	11°48'11.50"N	13°55'2.58"W
Belí	5	Bundu Quebube	11°48'40.11"N	13°56'8.74"W
Belí	6	Bundu Njuri Noku	11°50'22.21"N	13°55'9.69"W
Belí	7	Gadda Beli Um	11°49'29.51"N	13°56'28.26"W
Belí	8	Bartanjan	11°52'13.89"N	13°58'21.17"W
Capebonde	9	Vendu Queiwi	11°45'9.70"N	13°54'13.44"W
Capebonde	10	Barqueda da Um	11°43'32.73"N	13°55'0.24"W
Capebonde	11	Guenjari	11°44'0.22"N	13°52'52.58"W
Belí	12	Near Bartanjan	11°51'47.74"N	13°57'43.05"W
Belí	13	Pataque	11°52'24.29"N	13°56'45.05"W
Capebonde	14	Hore Capebonde Um	11°42'57.59"N	13°52'40.05"W
Capebonde	15	Fefine	11°41'44.95"N	13°51'20.41"W
Capebonde	16	Barqueda da Um	11°42'49.68"N	13°53'56.21"W
Uncire	17	Babal 2	11°47'1.92"N	13°53'58.54"W
Belí	18	Tuntedje 1	11°54'7.44"N	13°55'4.65"W
Belí	19	Hore Pete Kekum	11°52'22.06"N	13°56'19.67"W
Belí	20	Tuntedje 2	11°53'2.40"N	13°56'10.09"W

Annex II Forests and their respective assistants

Assistants

At the start of the survey, data have been collected with Djuma, a 23 years old man, employed by Chimbo with the objective to offer assistance and guidance during data collection in the forests in the surroundings of Belí. Djuma had a limited proficiency of Portuguese and French, making it a challenge to communicate in the field, as well during meetings about forest selection and methodology. For this reason, arrival at a not selected forest occurred. Two other employees of Chimbo, who contribute to the collection of data were Balou, and the elder Samba. Balou had a basic proficiency of English. However, caution needed to be paid to the interpretation of words and sentences. For this reason, a lot of time was invested in the explanation of research methods, forest selection and the discussion of specific topics during or after the recce walks.

Travels to more remote places, such as Uncire and Capebonde, and most of the data collection have been accomplished with Samba. Samba was the most skilled field assistant of Chimbo and compared to the other field assistants, Samba seemed to have more ecological knowledge. According to Samba learned from his father and assistance during a four-year research program of Max Planck Institute for Evolutionary Anthropology in collaboration with Foundation Chimbo. A research related to chimpanzee stone throwing behavior in the Boé. At the start of the field surveys, collaboration with Samba had some complications. This as Samba and I did not speak the same language. As I did not speak any familiar language of Samba but needed to travel, collaborate and stay for longer periods in other villages where the only spoken language was Fulah, it was of importance to become more familiar with the local languages.

Table 25 Forests and their respective assistants.

Village	Forest	Dry season	Wet season
Belí	1	Djuma	
Belí	2	Djuma	
Belí	3	Djuma	
Belí	4	Djuma	
Belí	5	Djuma	Samba
Belí	6	Djuma	Samba & Djuma
Belí	7	Djuma	Samba & Djuma
Belí	8	Balou	Samba & Alfa
Capebonde	9	Samba & Mangaboi	Samba & Marie
Capebonde	10	Samba & Sadjuma	Samba & Mangaboi
Capebonde	11	Samba & Sadjuma	Samba
Belí	12	Balou	
Belí	13	Balou	
Capebonde	14	Samba	Samba
Capebonde	15	Samba & Sadjuma	
Capebonde	16	Samba	
Uncire	17	Samba &	Samba & Sadju
Belí	18	Samba	
Belí	19	Samba	Samba
Belí	20	Samba	

Annex III Forest size

Table 26 Size of sampled forest fragments and average size of sacred and non-sacred forests, and forests with and without water resources.

Average of Forest size (ha)			
	Sacred	**Non-sacred**	**Total**
No-water resource	**11.55**	**8.12**	**9.84**
3		5.58	5.58
6	16.80		16.80
7	21.60		21.60
9	14.00		14.00
10	4.38		4.38
12		8.50	8.50
13		7.20	7.20
16		6.53	6.53
19	0.96		0.96
20		12.80	12.80
Water resource	**4.97**	**18.74**	**11.85**
1		61.60	61.60
2		8.00	8.00
4		10.20	10.20
5	4.73		4.73
8	4.59		4.59
11	7.29		7.29
14	4.96		4.96
15		4.77	4.77
17	3.26		3.26
18		9.13	9.13

Annex IV Water availability

Table 27 Water availability in the sacred and non-sacred forests. (0) No water resource, (1) Permanent water resources; (2) Non-permanent water resources. Permanent water resources are sources or waterholes, whereas non-permanent are streams or pools.

Forests	Water availability
Sacred	**0**
5	2
6	0
7	0
8	1
9	0
10	0
11	1
14	2
17	1
19	0
Non-sacred	**0**
1	2
2	2
3	0
4	2
12	0
13	0
15	2
16	0
18	2
20	0

Table 28 Water availability in sacred forests during the dry and wet season. (0) No water resource, (1) Permanent water resources; (2) Non-permanent water resources; (3) Permanent & non-permanent water resources.

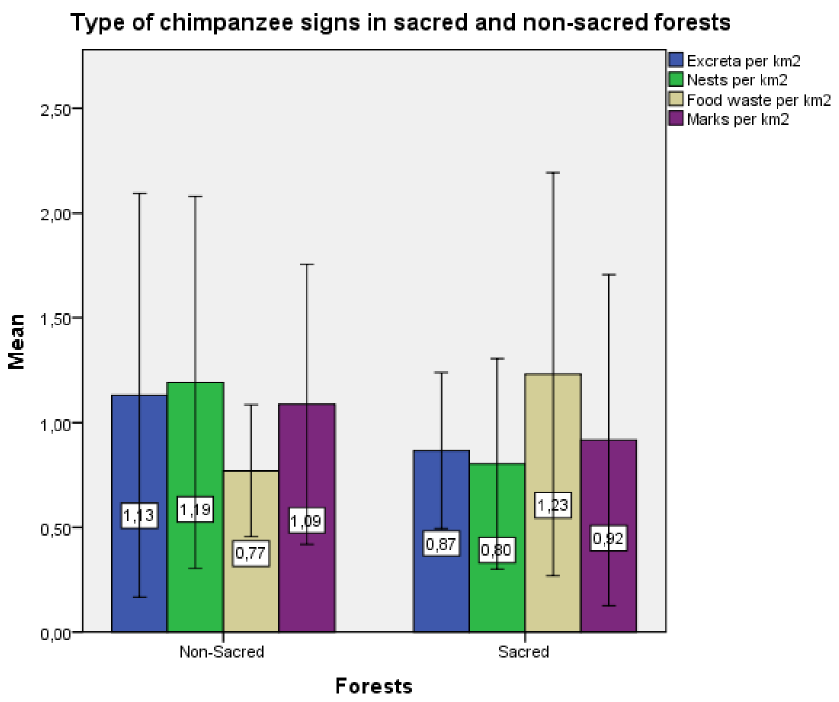
Forests	Dry season	Wet season
Sacred	**0**	**0**
5	2	2
6	0	0
7	0	0
8	1	1
9	0	0
10	0	0
11	1	3
14	2	2
17	1	1
19	0	0

Table 29 Average waterhole size (m2) in the dry and wet season.

Forests	Dry season (m2)	Wet season (m2)
Sacred	17.70	28.93
Non-sacred	No observations	No observations

Annex V Complementary graphs

Annex V gives more detail on the relative abundance on the different signs related to chimpanzee presence in the different (sacred and non-sacred) forests, with and without water during the dry and wet season, as well on the presence of human disturbance in the forests. Values on relative abundance were derived from transformed data on standardized values. Low scores in the charts indicate low relative abundance and high scores indicate high relative abundance of the specific sign.



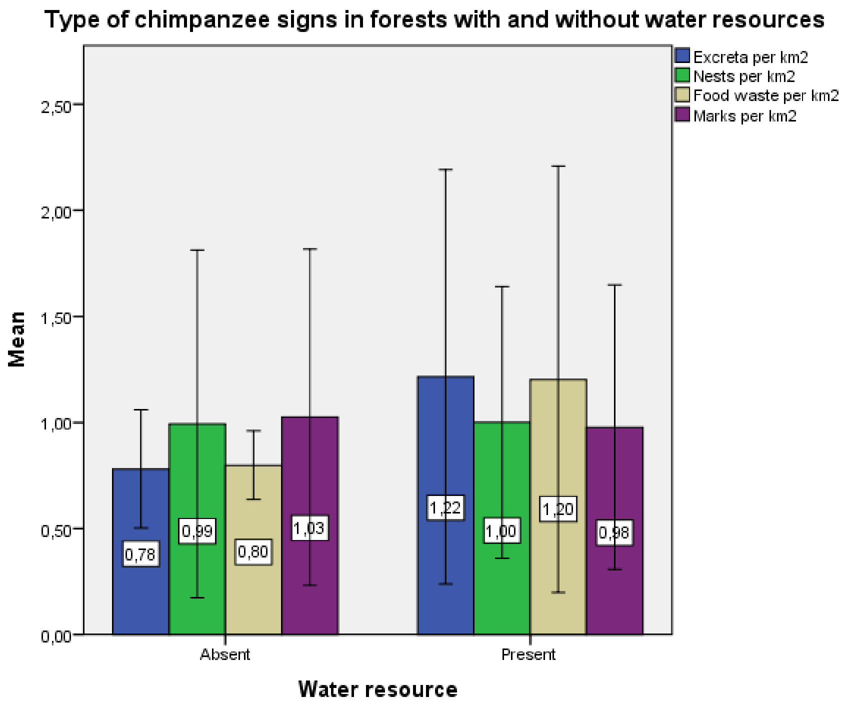


Figure 17 Type of signs related to chimpanzee presence found in sacred and non-sacred forests, and forest with and without water. Excreta: dung as well urine; Nests: individual nests and nests within groups of nests of different age (new/ recent/ old/ decayed), Food waste: Feeding remains; Marks: tool marks, travel paths and accumulated objects. Values on relative abundance were derived from transformed data on standardized values. Low scores in the charts indicate low relative abundance and high scores indicate high relative abundance of the specific sign.

Annex VI Recorded signals on chimpanzee, large carnivore and human presence

Table 29 and 30 give an overview of the recorded data on chimpanzee, large carnivore and human occurrence in each forest, detected in the surveys of the dry and wet season.

Table 30 Count of signs related to chimpanzee, large carnivore and human presence in the different forests recorded during the surveys of the dry season.

Forest	**Chimpanzee vocalisation**	**Chimpanzee**	**Excreta**	**Nests**	**Arboreal nest**	**Ground nest**	**Food waste**	**Marks in forest**	**Human presence**	**Large Carnivore**
Dry season										
1	15	1		13	14		13	1		
2	1		1	4	4		55	2	3	
3			1				43		1	
4				8	8		15		4	
5	3			1	1		20		2	
6				5	5		60		5	
7							67		4	
8				3	4		57		1	
9			3	14	14		67	4		
10				5	5		90	6		
11							41		10	
12	1			3	3		93		20	
13				2	2		52		41	
14							97		8	
15							64	1	39	
16							61		49	
17			2	5	5		241		3	
18			11	16	15	1	132	6	27	
19							32		7	
20				17	17		32	1	25	
Total	**20**	**1**	**18**	**96**	**97**	**1**	**1332**	**21**	**249**	**0**

Table 31 Count of signs related to chimpanzee, large carnivore and human presence in the different forests recorded during the surveys of the wet season.

Forest	**Chimpanzee vocalisation**	**Chimpanzee**	**Excreta**	**Nests**	**Arboreal nest**	**Ground nest**	**Food waste**	**Marks in forest**	**Human presence**	**Large Carnivore**
Wet season										
5							18	1	21	
6				7	7		59		8	
7							24		14	
8				5	4	1	74	1	2	1
9				6	6		93	1	25	
10	1			2	2		119	1	32	
11							87		5	
14			1				73		13	
17				2	2		373	1	2	
19							32		8	
Total	**1**	**0**	**1**	**22**	**21**	**1**	**952**	**5**	**130**	**1**

Annex VII Datasheet Recce

Date: ________________ Start time: ________________ End time: ________________ Team members: ________________

Season: Dry/ Wet Village: Belí/Capebonde/Uncire Forest: Sacred/ Non-sacred Water: Yes/ No

Recce ID: ________________ Tracklog ID: ________________

	Observation	Type/ status/ species/ water use	N◦ of objects	Comments length of tool/ contour water pool-source / dip-drink	Time (hh:mm)	Distance from start of recce (m)	Waypoint N◦	Longitude (UTM)	Latitude (UTM)	Forest type G/D	Canopy C/O	Topography V/S/H	Water resource (X)	Weather S/LC/C/R
1														
2														
3														
4														
5														
6														
7														
8														
9														
10														