Internship report

Inventory of the vegetation structure and food availability for the Western chimpanzee (*Pan troglodytes verus*) in the Boé region, Guinea-Bissau.

Iris van der Meer 880415-551080
May 2014
Resource Ecology Group, Wageningen University

Inventory of the vegetation structure and food availability for the Western chimpanzee (*Pan troglodytes verus*) in the Boé region, Guinea-Bissau.

Iris Pauline van der Meer 880415 551 080

May 2014

REG 70424

Supervisors:

Dr. Ignas Heitkönig (WU)
Dr. Annemarie Goedmakers (Chimbo)

Resource Ecology Group

WAGENINGEN UNIVERSITEIT
WAGENINGEN UR

TABLE OF CONTENTS

List of abbreviations

IBAP	Instituto da Biodiversidade e das Áreas Protegidas, i.e. the Institute for Biodiversity and Protected Areas
MPI	Max Planck Institute for Evolutionary Anthropology
PA	Protected Area
PANAF	Pan African Program
WUR	Wageningen University and Research Centre

Preface

There is a large gap in the ecological knowledge regarding chimpanzees, as most primate research focuses on behaviour of apes instead of their ecology (MPI 2012). For my master internship of Wageningen University I went to the Boé region in Guinea-Bissau, to collaborate with the Chimbo Foundation. Some research has been conducted in the Boé region, but the relationship between the chimpanzees and their habitat use is still poorly understood. This research is part of the larger Pan African Program of the Max Planck Institute for Evolutionary Anthropology and a small step towards increasing ecological knowledge of the habitat requirements of chimpanzees in the Boé.

Acknowledgements

This internship was financially supported by '*Stichting Het Kronendak*' and the *FONA fund*. My data collection could not have been collected and analysed without the advice and support of Joost van Schijndel in the field, Ignas Heitkönig as university supervisor and Annemarie Goedmakers as supervisor and chairperson of the Chimbo Foundation. Botanical experts Carel Jongkind and Jan Wieringa of Wageningen University are acknowledged for their help with the identification of trees. Also many thanks to the staff of Daridibó which is the local sister NGO of the Chimbo Foundation, and to the members of our field team: Benjamin van Haelst, Samba Camara, Amadu Sadjo Culubali and Djei Balde.

Summary

Deforestation and land use intensification degrade vegetation areas and induce habitat loss and fragmentation. Due to this habitat loss many primate species populations are declining. While chimpanzees are the most abundant and widespread of the ape species, they are ranked as an Endangered species on the IUCN Red List of species with many decreasing populations all over Africa. In Guinea-Bissau, the only subspecies occurring is the Western Chimpanzee (*Pan troglodytes verus*) with healthy populations in the Coastal Cantanhez zone and the Boé region, but their habitats are under pressure.

Chimpanzees depend to a large extent on their habitat, relying on trees for fruit, leaves, bark and stems as important food sources, and making nests in trees for resting and sleeping. This study focuses on the vegetation structure and phenology in the Boé region in Guinea-Bissau. The species composition, population structure, availability and seasonality of potential food trees were investigated and described, following the guidelines of Max Planck Institute (MPI). Three months of phenological data of 25 tree species, that are present in the Boé and that are known to be consumed by chimpanzees in Guinea-Bissau or elsewhere in Africa, were collected. The vegetation structure of the Aicum region has been investigated in 109 out of the 220 MPI plots.

The phenology of 25 tree species showed large variation concerning its flowering, fruiting and development of new foliage. Some tree species had their inflorescence and fruiting in line with the phenology of trees in other African regions, while others showed a completely different seasonality. Besides the differences with tree phenology in other African regions, the phenology between individuals of the same tree species in the Boé also varied substantially. In the vegetation structure plots together with the phenological data, a total of 61 plant species were identified. Of these 61 species, 72% (44 species) is potential food for chimpanzees in the Boé. Six out of the ten most common tree species in the study area are known to be important food sources for chimpanzees in Guinea-Bissau. The fruits of the species important to chimpanzees are abundant during different times of the year, inducing chimpanzees to adapt to the seasonality of plants and to being opportunistic by feeding on other resources.

The preliminary result of this study is that chimpanzees in the Aicum area seem to have sufficient food resources. However, as the Boé faces an increasing human population, with concomitant pressure on land, chimpanzee habitat is decreasing, causing human-chimpanzee conflicts to rise. To ensure the availability of their main tree resources for nesting and food, and to prevent crop-raiding and other human-primate conflicts in the Boé, it is essential to protect chimpanzee habitat. The study therefore indicates that large areas need to be conserved in order for chimpanzees to thrive in their original habitat. These findings support the plan of the government of Guinea-Bissau together with the Institute for Biodiversity and Protected Areas (IBAP), to add the Boé to the Protected Area system of Guinea-Bissau.

1) Introduction and problem statement

The growing human population and the rising consumption lead to many environmental threats worldwide. It creates conditions that cause global climate change, overexploitation of several natural resources, habitat degradation and loss, habitat fragmentation, species extinction, pollution and spread of invasive species (Groom *et al.* 2006). These events result in a decline in numbers of many animal species. Non-human primates are of special concern, with 114 primate species on the 2007 Red List of Threatened and Endangered Species, of which four (bonobo, chimpanzee, gorilla, orangutan) ape species are (critically) endangered (Redmond 2010, Hockings & Sousa 2013).

Although chimpanzees are the most abundant and widespread of the apes, with many populations in protected areas, the declines that have occurred are expected to continue to occur. Thereby it meets the criteria for ranking the species as Endangered on the Red List of the IUCN (Oates *et al.* 2013). Due to high levels of exploitation, loss of habitat and habitat quality due to expanding human activities, this species is estimated to have experienced a significant population reduction in the past 20 to 30 years. The maximum population reduction over a three-generation (i.e., 60 year) period from 1970 to 2030 is suspected to exceed 50% (Oates *et al.* 2008). The Western chimpanzee (*P. t. verus*) has an estimated population size of 38,000 (Kormos & Boesch 2003) and, together with *P. t. ellioti,* is one of the most threatened subspecies, linked to the high degree of political instability in some range states (Campbell *et al.* 2008, Oates *et al*. 2008).

To survive in the long-term, chimpanzees need large habitats, in which the regeneration and existence of their main tree resources for nesting and food availability is not in danger. Chimpanzees have a very varied diet throughout the year and adjust their diet to the seasonal plant availability (Bogart 2009).

This study is executed under the *Pan African Program* (PANAF) of the Max Planck Institute for Evolutionary Anthropology (MPI) and limited to the research questions of the PANAF protocol. This report focuses on the vegetation structure and phenology in the Boé region in Guinea-Bissau, following the guidelines of MPI. The Boé region (3288 km^2, Wit & Reintjes 1989) lays in the South-East of the country and is one of the two regions in Guinea-Bissau with an healthy chimpanzee population. The study field lies within the core of the Boé Protected Area (PA), which is currently being developed by the national institute for biodiversity and protected areas (Instituto da Biodiversidade e das Áreas Protegidas, IBAP) with assistance from Foundation Chimbo (UNDP 2010), and will increase the knowledge on ecological importance of the Boé region. The species composition, population structure, availability and seasonality of potential food trees in the Aicum area of the Boé region were investigated and described.

2) Background

2.1 Chimpanzees in West-Africa

Chimpanzees (*Pan troglodytes*) are among our closest living relatives and are indigenous to Africa. Four subspecies are commonly recognized: the West African Chimpanzee *Pan troglodytes verus*; the Nigeria-Cameroon Chimpanzee *P. t. ellioti*; the Central Chimpanzee *P. t. troglodytes*; and the Eastern Chimpanzee *P. t. schweinfurthii*. In Guinea-Bissau the only subspecies occurring within its borders is *Pan troglodytes verus* (Brugiere *et al.* 2009).

In 1988, chimpanzees were erroneously declared extinct in Guinea-Bissau and a planned nation-wide survey in the late 1990s did not take place due to a civil war, but evidence has shown the distribution of chimpanzees still to be as was stated by Kortlandt in 1983 (Kortlandt 1983 in Kormos *et al.* 2003, Gippoliti & Dell'Omo 2003). Their current range is believed to extend through the south-east of the country in the Boé region between the Corubal river and the Guinea border and in the south-west regions of Quinara and Tombali (Gippoliti & Dell'Omo 1996). Within Guinea-Bissau there are two regions where chimpanzees live in healthy populations (Kormos *et al.* 2003): the Coastal Cantanhez zone which is largely covered by tropical forest, and the Boé region which is a mosaic area of savanna and forest fragments (Gippoliti & Dell'Omo 2003). There is limited information available on their numbers in Guinea-Bissau, but for the Boé region an estimation of 700 chimpanzees has been made in 2007 (Da Silva *et al*.).

The West African Chimpanzee (*Pan troglodytes verus*) has its habitat spread between south-east Senegal to Ghana. Actually highly fragmented, the range of the western chimpanzee may have been almost contiguous from Senegal to Togo until the mid-1900s (Jolly *et al.* 1995). The western chimpanzee has already been extirpated from at least two countries (Benin, Togo), and could according to Kormos *et al.* (2003) be extirpated in future from additional countries where national populations are thought to be smaller than 1,000.

Figure 1. The range and habitat of the four chimpanzee subspecies. (Source: <http://www.janegoodall.ca/about-chimp-range-habitat.php>

Chimpanzees are found predominantly in moist and dry forests, and forest galleries extending into savanna woodlands. Chimpanzees in savanna woodland habitats have lower population densities and larger home ranges than those of chimpanzees in forested regions (Boesch & Boesch 1989 in Ogawa *et al.* 2007). Home ranges are larger in woodland forest mosaics than in mixed forest and range from 5 to 400 km². They form social communities varying from 5 to 150 animals. Chimpanzees are omnivorous, and their diet varies throughout seasons and in individual populations (Oates *et al.* 2008). They are known to be ripe fruit specialists, but leaves, bark, and stems are also important food sources (Wrangham *et al*. 1998, Oates *et al*. 2008). With chimpanzees and other primates relying on fruiting trees as important food sources, they are considered important seed dispersers in their habitat (Chapman & Onderdonk 1998). Their diet varies a lot and chimpanzees can adapt to the food available. In Guinea-Conakry, chimpanzees in the Bossou region are known to use 200 plant species as food sources (Bogart 2009). Mammals comprise a small but significant component of the diet of many populations, as do termites (Redmond 2010).

Chimpanzees, like all great apes, make nests for resting and sleeping (Pruetz *et al*. 2008). They are known to have favourite, localized nesting places and show preferences for particular species or type of trees within their home range (Aquilar 2009). In the Boé area of 300.000 ha chimpanzees make their nests predominantly in forested habitats and seem to have a preference for the tree species *Khaya senegalensis*, *Parkia biglobosa*, *Erythrophleum suaveolens* and *Cola cordifolia* (Hoogveld 2013, Van Schijndel, *pers. comm*. 2013).

2.2 The Boé region in Guinea-Bissau with its threats to chimpanzees

West-Africa has high (1.17% annually from 1990 to 2005, FAO 2007) forest losses, including Guinea-Bissau where its open and closed forests decrease by about the same annual rate of 1.17% while savanna-woodland, mangrove vegetation and plantations increased (Oom *et al.* 2009). Some areas are environmentally better preserved than others. The Boé region in the south-east of Guinea-Bissau is a remote area with some small villages but still relatively well preserved. The region has contiguous habitats and it is considered to be a very important area for chimpanzees (*Pan troglodytes verus*) in West Africa.

For all chimpanzee subpopulations, but to varying degrees in different areas, threats include habitat destruction, fragmentation and degradation (Beck & Chapman 2008), poaching for bush meat trade or pet trade, and infectious diseases due to human-chimpanzee interactions (Oates *et al.* 2008). Chimpanzees were generally not used for human consumption in Guinea-Bissau because they are considered too similar to humans (Kormos et al. 2003) and because the Muslim population, the predominant ethnic group in this part of the country, does not eat ape meat. However, Sá *et al.* (2012) discovered use and trade of chimpanzee body parts in Guinea-Bissau for traditional practices (e.g. for nutritional, medicinal or ritual purposes, or animistic rituals). During visits to Bandim market in Bissau, morphologically identified dried Chimpanzee skins were found being sold for traditional medicinal purposes (Sá *et al.* 2012).

Chimpanzees in the Boé region in Guinea-Bissau are mainly threatened due to habitat loss, fragmentation and degradation. There are more and more areas of forest being cleared by

agriculturists for shifting cultivation practices, mainly for rice and maize farming, but more and more also for cashew plantations (Wit & Reintjes 1989).

The Institute for Biodiversity and Protected Areas (IBAP), which has the broad responsibility for biodiversity conservation in Guinea-Bissau, and more specifically, for protected areas management, has developed an ambitious long-term plan for expanding the PA estate and its coverage within terrestrial ecosystems. The planned extension of Guinea-Bissau's terrestrial protected areas (PAs) includes the Boé PA (95,280 ha), the Tchetche wildlife corridor (33,604 ha), which lies partially within the Boé, and the Dulombi PA (98,951 ha), which lies in an adjacent region (UNDP 2010).

2.3 Important habitats

The Regional Action Plan for the Conservation of Chimpanzees in West-Africa (Kormos *et al.* 2003) classifies the Fouta Djallon Highlands in Guinea and Guinea-Bissau, of which the Boé area forms part, as an Exceptionally Important Priority Area for chimpanzee conservation. As chimpanzees are found in moist and dry forests, and forest galleries extending into savanna woodlands, they depend on tree species distribution for their diet and nest requirements (Oates *et al.* 2008). 'Boual', typical habitat in the Boé with its lateritic stone substrate is poor habitat for chimpanzees as no trees can grow there (Silva *et al.* 2007). In this research important and suitable habitats for nesting and dietary needs are classified as old secondary forest (roughly 15% cover of study area), gallery forest (>5%), (wooded) savanna (35%) and fallow land (10%) with other areas largely covered by boual and agricultural land (White & Edwards 2000, Silva *et al*. 2007, Koops *et al*. 2012):

- *Old secondary forest* is found further from the river channel and is a slightly disturbed forested area. The forest is often characterized by incomplete canopy cover and dense ground vegetation (White & Edwards, 2000).

- *Gallery forest* is located along a river or stream, found within larger blocks of forest as well as isolated in savanna vegetation. There is almost constant water supply to the ecosystem with the greatest species diversity close to the river. In the Boé, only at small parts there is no human activity, mostly around the origin of the river, designated as a sacred place for the people (White & Edwards 2000, Silva *et al*. 2007, Koops *et al*. 2012).

- *Wooded savanna* forms a more open landscape, where trees only grow in small pockets, often on cracks in the laterite cap. Together with the 'boual' and the different gallery forest types it forms a mosaic with the vegetation mainly consisting of savanna grasses.

- *Fallow land* is former agriculture land. The fields are cultivated in a rotation of one year crop growing and four to 10 years fallow, when the land is abandoned to recover from crop growing. The fallow land vegetation is mainly composed of dense shrubs, lianas and small wooded plants with some random grass patches as well (Wit & Reintjes 1989).

3) Research objectives

This study is part of the larger Pan African Program of MPI, to which is has aligned its research objectives and goals. Due to the large gap in the ecological knowledge regarding chimpanzees, the Pan African Program of MPI aims to improve the understanding of different chimpanzee groups and their habitats in Africa. Because chimpanzees depend on their main tree resources for nesting and food availability, it is essential to conserve their habitat to maintain reproduction capacity and population size. One of the goals of the Pan African Program is to determine which species are food sources and to establish their seasonality for different countries. Another goal of MPI is to identify the habitat structure of important chimpanzee regions. Even though the Pan African Program also looks at tool use, genetics, and parasites, amongst others, this study focusses on a description and evaluation of the habitat structure, i.e. vegetation abundance, and potential food availability for the Western chimpanzee (*Pan troglodytes verus*) in the Boé region, Guinea-Bissau.

4) Methodology

4.1 Study site

The Republic of Guinea-Bissau lies on Africa's north-western coast and covers an area of 36,125 km². The country belongs to the Niger phytogeographic region and constitutes a transition zone between sub-Saharan arid savanna ecosystems and more humid tropical forest biomes like Guinean Moist Forest (Sayre *et al.* 2013). The continental part of Guinea-Bissau can be divided into three regions: coastal lowlands, the interior plain, and the north-eastern highlands (Hockings & Sousa 2013).

Figure 2. Map of Guinea-Bissau with in pink the borders of the Boé region (Source: <http://chimbo.org/?page_id=44)>.

The Boé region is an inland zone in the south-east of Guinea-Bissau (Fig. 2) in the Gabú sector that rises to a height of 300m (western fringe of the Fouta Djallon massif) and has a total area of 3288 km^2 (Wit & Reintjes 1989). The original vegetation is mainly savanna with gallery forest and forest along the rivers and on the hills (Kormos *et al.* 2003). The annual rainy season is from June to October and shows large regional and inter-annual variation. In the Boé rainfall varies from 1600-2100 mm annually (Wit & Reintjes 1989). The average temperature is 28°C, with maximum values of 39°C in April and minimum values of 12°C in January. The region has a population of approximately 12,000 people with the majority of people having the Fulani ethnicity. Most land in the Boé region is covered by a laterite cap and this rocky ground is unusable for agriculture (Wit & Reintjes 1989). The forests have almost all been converted into agricultural fields, fallow land and cashew plantations. Patches of usually sacred forests remain at the sources of streams and as a belt along the escarpments of the valleys (Piet Wit, *pers. comm.* 2014).

A grid of 56 km^2 (7x8 km, Fig. 3) was set up in the Aicum area, in which ecological research is being conducted (Joost van Schijndel, *pers. comm.* 2013). The area referred to in this report as Aicum (11°56.8'N 13°52.8'W) is located 13.5 km north-east of the village of Beli. It is named after the Aicum hill and river.

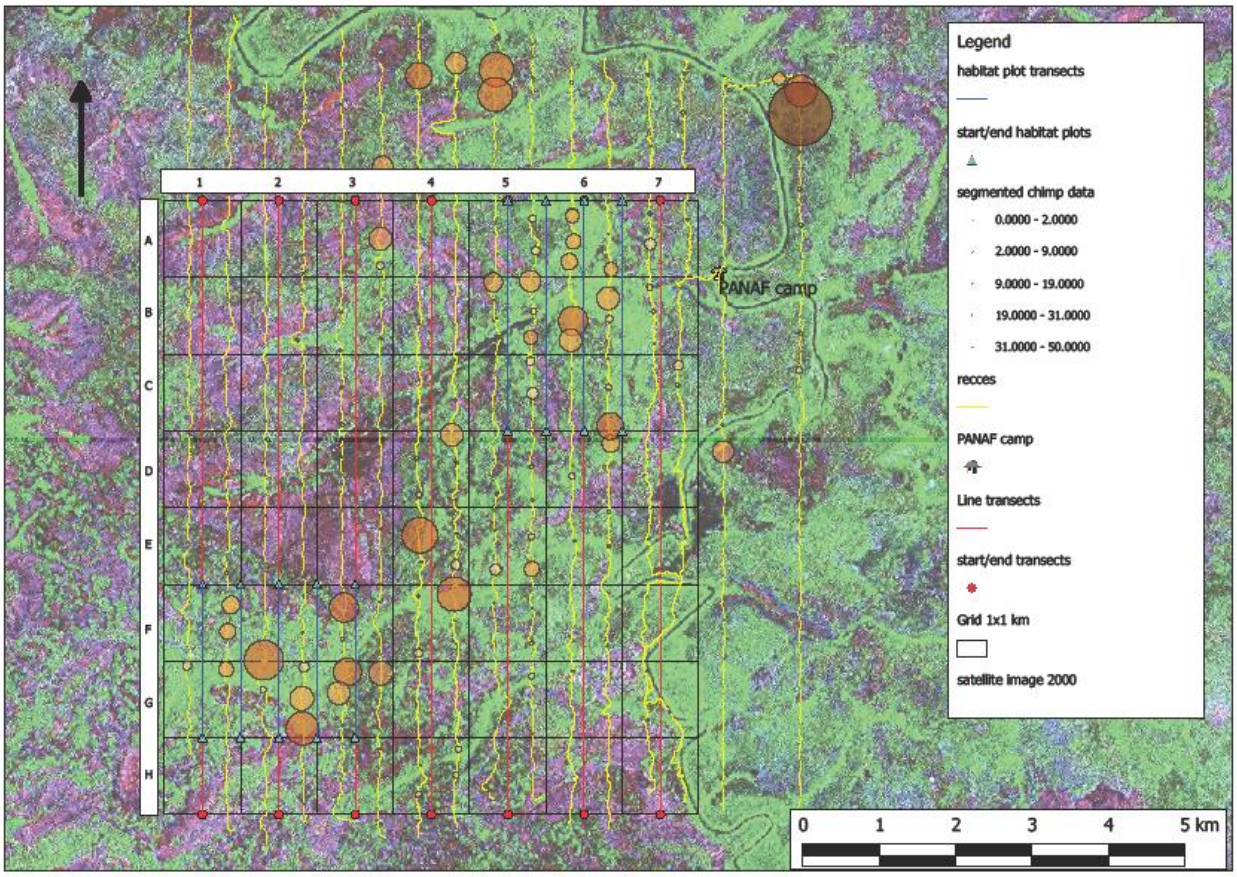

Figure 3. The grid set-up by van Schijndel with the walked recces (to find out which area could serve as one particular home range of chimpanzees, yellow lines), the planned transects (red and blue lines) and the previous signs found of chimpanzee presence (orange dots).

4.2 Study design

As this research is part of the larger Pan African Program, the protocol developed by Max Planck Institute for Evolutionary Anthropology (MPI 2012) needed to be followed.

Phenology

A phenological study is carried out over a period of at least 12 months to allow estimation of seasonal variation in forest productivity and food availability for chimpanzees. During this study phenological data were collected during a three months period (August, October, November) and evaluated. Ideally a phenological study involves a large number of plant species that are consumed by the study population of chimpanzees. However, as it was not possible, for reasons of time constraint, to first determine the diet of the study population and then collect phenology data, the selection of food plant species for the phenological study was based on published data from chimpanzee populations living in comparable habitats in the same geographic area (MPI 2012, annex 1) in combination with personal observations by Joost van Schijndel, Samba Camara and Amadu Sadjo Culubali. The selection of phenology trees was done by Joost van Schijndel and data from August 2013 had been collected by others already, while data from October and November 2013 were collected by myself together with Joost van Schijndel, local assistants and other students.

The protocol of Max Planck Institute stated that a minimum of 15 tree species that are important chimpanzee food sources needs to be identified. Of these tree species, 10 individuals needs to be selected and all trees needed to be visited once a month to assess their phenological status. In total 221 trees of 25 different species, located in the Aicum area were included in this phenological study. Most tree species had 7 to 10 individuals included in the phenology, however of two trees there were only two individuals found in the Aicum area. These tree species were still included in the phenology as they are known to be important for chimpanzees´ diet, also in the Boé region of Guinea-Bissau. The selected trees had a minimum DBH of approximately 10 cm although some climbers do not grow that big while there are still key species for food availability and are therefore included.

During the phenological assessments the selected trees were scored on the estimated proportion of the tree crown that contains flowers, fruits and leaves applying the below scoring system (Table 1). In Guinea-Bissau the dry season starts in November and lasts till May, and therefore the data sampled in this part of the program is mainly about the end of the rainy season in the Boé.

Table 1. Scoring system for tree parts to estimate the proportion flowers, fruits and leaves (MPI 2012).

% crown cover	score		
	flowers	fruits	leaves
0 - 1 %	0	0	0
1 - 25 %	1	1	1
26 - 50%	2	2	2
51 - 75%	3	3	3
76 - 100%	4	4	4

Vegetation Structure

In the grid of 56 km^2 seven line transects of 8 km are set (Fig. 3). As the vegetation in the Boé is heterogeneous with savanna's, savanna woodlands, fallow land, dry forests, gallery forests and agricultural lands the focus of the habitat structure plots will be in the forested areas as this is the main source for food and nest potentials for the chimpanzees.

Vegetation structure plot data were collected every 100 m within a 20 m x 20 m plot centered on the transect and in forested areas a habitat line was set between the transect lines (Fig. 2). The protocol states that a minimum of 200 habitat plots is required in order to get a representative sample of the vegetation. Van Schijndel has set up 220 plots in the Aicum grid. Due to time limitation a total of 109 plots (out of the 220 that will be sampled in the PANAF survey) was included in this inventory. Within these plots, all trees with a Diameter at Breast Height (DBH) of ≥ 10 cm were measured. DBH has been identified and measured at a height of 1.30 m on the up-hill side of the tree. Woody climbers that are associated with these trees were not recorded when their diameter was < 10 cm. In the case of buttress trees, the tape measure was pushed above the buttresses to take the measurement. Where there was a swelling in the tree, the girth was measured below the swelling. A tree was considered to be in the plot when the centre of the tree was inside the plot.

Within the 20x20 m plot the terrestrial herbaceous vegetation (THV, Fig. 4) was also measured in a 1x2 m plot (2 m^2) with monocotyledons and woody saplings recorded separately, but these findings will only be evaluated once the data is at the Max Planck Institute.

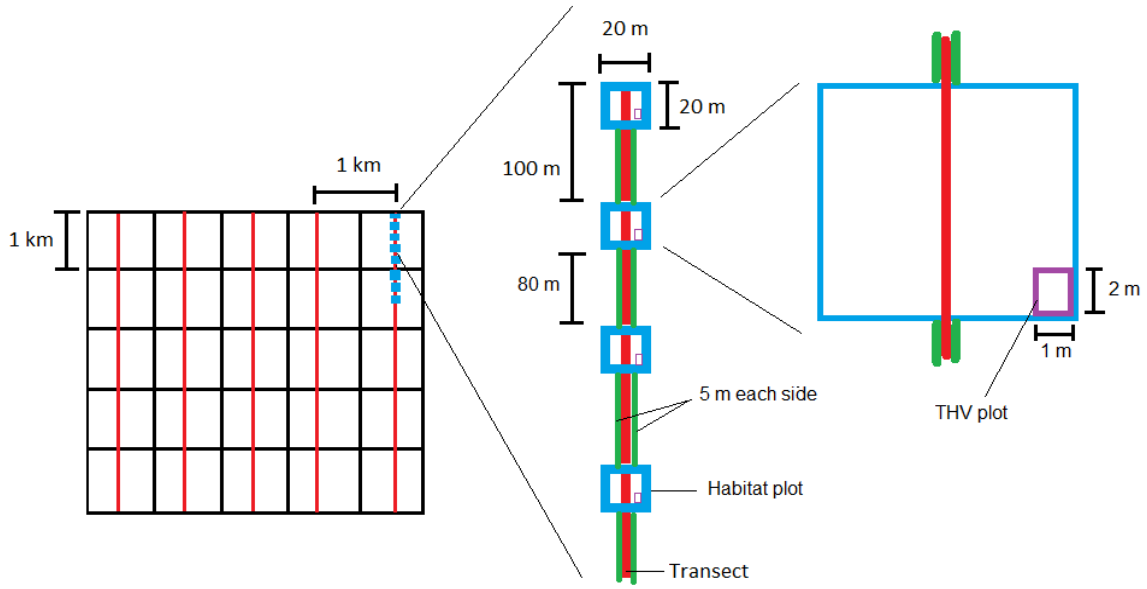

Figure 4. After MPI (2012): Grid of for example 5 x 5 m (black lines) with 5 transects (red lines) running through the center of the grid cells. The 20 x 20 m habitat plots (blue) were placed on the transect with an interval of 100 m. All trees with a DBH ≥10 cm within the habitat plots were recorded and in each habitat plot one of the corners is a 2 m^2 plot (purple), in which the numbers of herbs < 2 m was counted.

Trees were, as much as possible, identified on the spot together with local field guides and the use of identification books (Geerling 1987, Catarino *et al.* 2006, Hawthorne & Jongkind 2006). Trees that were not identified on the spot were sampled in a field herbarium and identification was done in personal communication with experts of Wageningen University (WUR) (Jongkind, C. & Wieringa, J. 2013). Unfortunately some tree species could not be identified and will only be identified when herbarium samples are sent to Leipzig and analyzed by the MPI team. This will take place after the completion of all data collection, end of 2014.

5) Results & Discussion

5.1 Phenology

Three months of phenological data of 25 tree species, that are present in the Boè and that are known to be consumed by chimpanzees in Guinea-Bissau or elsewhere in Africa, were collected. Table 2 (a & b) shows the tree species, the number of individuals included, the median DBH and the average of all trees per species per month with respect to its percentage of potential flowering, fruiting and loss or gain of leaves.

In the field it was noticeable that some individuals of a species were full of flowers or fruits, while others had no signs of inflorescence. This is visible in Table 2 with sometimes low averages indicating differences between the individuals. There were no signs of flowering, fruiting or leaving with the species *Ceiba pentandra, Lannea velutina* (which did start losing its leaves in October and November), *Parkia biglobosa*, *Pseudospondias microcarpa*, *Pterocarpus erinaceus*, and *Sorindeai juglandifolia*. This corresponds to the phenology of these species elsewhere in Africa as they flower and fruit during the dry season (Boesch *et al.* 2002, Sina & Traoré 2002, Breteler 2003, Jansen 2005, Duvall 2008, Orwa *et al.* 2009).

Some species flower when it is deciduous (i.e. when not in leaf) or when it is almost without foliage, like *Ceiba pentandra*, *Lannea velutina*, *Hexalobus monopetalus*, *Piliostigma thonningii* and *Parkia biglobosa*. They flower in the dry season, before the appearance of the leaves (Duvell 2008, Orwa *et al.* 2009). New foliage develops after peak flowering and mature fruits develop towards the end of the dry season (Sina & Traoré 2002). *P. thonningii* might also flower just after the first rains (Lemassa 2010) but in the Aicum area flowering took place in the late rainy season (October-November). According to Breteler (2003) *S. juglandifolia* is known to flower and fruit also throughout the year but this has not been observed during the three months of phenology of MPI. In the Aicum area, flowering of *H. monopetalus* has been observed in October and November and fruits were visible in August. There does not seem to be a trend in its phenology, which is in agreement with literature (Botermans 2011). In West Africa (from Senegal to Niger and Nigeria) flowering of *H. monopetalus* has been reported throughout the year with the majority of flowering specimens gathered from October to February. Fruiting has been reported in January, from March to August and in October (Botermans 2011).

Afzelia Africana, *Cordyla pinnata* and *Detarium senegalense* are also known to flower at the end of the dry season (April-May in Guinea) with fruiting taking place from December to February (Orwa *et al.* 2009). In the Boé, some trees of *A. africana* and *Detarium senegalense* had already set fruit with even some fruits fallen on the ground, indicating that some individuals fruit earlier than within the expected range of December-February. *Cordyla pinnata* is about to flower by the end of the year and one tree showed fruits in its crown in November. In Senegal *C. pinnata* also fruits in the beginning of the rainy season before the development of new leaves, but there it occurs in the months June and July (Orwa *et al.* 2009).

Cola cordifolia, *Pachystela pobeguiniana* and *Allophylus africanus* are expected to fruit in July and August (Orwa *et al.* 2009), but still had some blossom during the August phenology, while fruits were not present. *A. africanus* showed new foliage at the end of the wet season (Aug-Oct). *Adansonia digitata* only had two individuals included in this study as the tree is quite rare in the Aicum region, but is very common in other regions of the Boé and is known to occur in the chimpanzees' diet (Van Schijndel *pers. comm.* 2013). One of the trees had flowers in August and had some fruits from August to November. *A. digitata* is known to fruit from October to January, depending on the region in Africa (Boesch *et al.* 2002, Orwa *et al.* 2009).

Spondias mombin and *Parinari excelsa* are known to flower during the dry season (November-May) (FAO 1983, Oyen 2012). In this study, flowering has not been recorded. In the Boé, *S. mombin* had some new foliage as well as loss of leaves between August and November. For *S. mombin* there has been some fruiting in August while *P. excelsa* had fruits in October and November. This is in line with data elsewhere as *S. mombin* can have ripe fruit most of the year but with peaks in August-September (Boesch *et al.* 2012). In Nigeria *P. excelsa* flowers between January and May and fruit maturation peaks in November and December (Oyen 2012).

Dialium guineense was flowering in October and November which is similar to the phenology recorded in Nigeria and Ghana with flowering from September to November. Fruit normally ripens in March to May but may be earlier and may persist longer (Orwa *et al.* 2009). *Vitex doniana* is also known to flower from August to November, however this has been observed in East-Africa and is not the case in Guinea-Bissau (FAO 1983). In the Boé, flowering has not been observed during this study period, but fruiting occurred from August to November. In East-Africa *V. doniana* fruits from January to April, so perhaps Guinea-Bissau is four months ahead in its seasonality. *Ficus sur* is known to have its flowering peaks from September to March but fruits can appear repeatedly all through the year (Orwa *et al.* 2009). In the Boé, flowers and fruits were present in all studied times, (August-November) with signs of new foliage in August.

Treculia africana and *Elaeis guineensis* are both evergreen tree species. *E. guineensis* showed flowering in August-October while *T. africana* mainly showed some new foliage in October and fruits in November. This lags a bit behind Ghana, where *T. Africana* flowers in July-August and where ripe fruit is available in December. *E. guineesis* is expected to fruit 5-6 months after flowering, from February onwards (Orwa *et al.* 2009, Verheye 2010).

Landolphia latifolia, Saba senegalensis and *Nauclea latifolia* (of which the current scientific name is actually *Sarcocephalus latifolius* but the naming by MPI is followed in this report) are all three liana climbers. *L. heudelotii* showed some fruiting in August, *S. senegalensis* had a sparse number of fruits in October and *N. latifolia* had fruits in the crown in all three months, but no flowering. Most fruit was found in August, decreasing towards November which corresponds to the literature stating that most fruit will ripe between July and September (Orwa *et al.* 2009).

Table 2a. The average scoring (after Table 1) per tree species of flowering and fruiting from August, October and November 2013 with the number of individuals per species as well as the median DBH (cm) (**A. digitata* and *T. Africana* are excluded due to their low number of individuals).

Tree species	# individuals	median DBH (cm)	Total flowers			Total buds			Total fruit			Ripe fruit			Fruits on ground		
			0 = 0-1%, 1 = 1-25%, 2 = 26-50%, 3 = 51-75%, 4 = 76-100%														
			aug	oct	nov	aug	oct	nov	aug	oct	nov	aug	oct	nov	aug	oct	nov
Adansonia digitata	2	NA*	1.50	0	0	0	0	0	1.00	1.50	1.00	0	0	0	0	1.00	0.50
Afzelia africana	10	59	0	0	0	0	0	0	0	0.50	0.30	0	0	0	0.20	0.70	0
Allophylus africanus	10	8	0.40	0	0	0.40	0	0	0.30	0	0	0	0	0	0	0	0
Ceiba pentandra	11	123	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cola cordifolia	10	70	0.13	0	0	0.13	0	0	0	0	0	0	0	0	0.13	0	0
Cordyla pinnata	10	54	0	0	0	0	0	0	0	0	0.10	0	0	0	0	0	0
Detarium senegalense	10	66	0	0	0	0	0	0	1.00	1.60	1.60	0	0	0	0.57	0.10	0.10
Dialium guineensis	10	22	0	0.50	0.90	0	0.80	1.40	0	0	0	0	0	0	0	0	0
Elaeis guineensis	9	36	0.25	0.22	0	0	0	0	0	0	0	0	0	0	0	0	0
Ficus sur	10	16	0.40	0.30	0.10	0.60	0.90	0.40	0.50	0.40	0.60	0	0	0	0	0	0.1
Hexalobus monopetalus	10	21	0	1.30	1.11	0	2.80	1.78	1.11	0	0	0	0	0	0	0	0
Landolphia heudelotii	10	12	0	0	0	0	0	0	0.67	0	0	0.33	0	0	0.44	0	0
Lannea velutina	10	21	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Nauclea latifolia	7	18	0	0	0	0	0	0	0.80	0.29	0.63	0.40	0	0	0.40	0	0
Pachystela pobeguiniana	10	22	0.40	0	0	0.40	0	0	0	0	0	0	0	0	0	0	0
Parinari excelsa	9	58	0	0	0	0	0	0	0	1.00	0.89	0	0.44	0	0	0.11	0.11
Parkia biglobosa	10	69	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Piliostigma thonningii	10	27	0	2.30	1.67	0	2.60	0.89	0	0	0	0	0	0	0	0	0
Pseudospondias microcarpa	4	27	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pterocarpus erinaceus	10	46	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Saba senegalensis	10	14	0	0	0	0	0	0	0	0.10	0	0	0	0	0	0	0
Sorindeia juglandifolia	10	17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Spondias mombin	10	44	0	0	0	0	0	0	1.20	0	0	0	0	0	0	0	0
Treculia africana	2	NA*	0	0	0	0	0	0	0	0	0.50	0	0	0	0	0	0
Vitex doniana	7	36	0	0	0	0	0	0	1.00	0.71	0.43	0	0	0.14	0	0.14	0.14

Table 2b. The average scoring (after Table 1) per tree species of foliage and growth of new leaves from August, October and November 2013 with the number of individuals per species as well as the median DBH (cm) (**A. digitata* and *T. Africana* are excluded due to their low number of

Tree species	# individuals	median DBH (cm)	Total leaves per species			Young leaves		
			aug	oct	nov	aug	oct	nov
Adansonia digitata	2	NA*	4.0	4.0	4.0	0	0	0
Afzelia africana	10	59	4.0	4.0	4.0	0	0	0
Allophylus africanus	10	8	4.0	3.9	3.9	0.20	0.10	0
Ceiba pentandra	11	123	4.0	4.0	4.0	0	0	0
Cola cordifolia	10	70	4.0	4.0	4.0	0	0.10	0
Cordyla pinnata	10	54	4.0	4.0	3.9	0.10	0	0
Detarium senegalense	10	66	4.0	4.0	4.0	0	0	0
Dialium guineensis	10	22	4.0	4.0	4.0	0	0.10	0
Elaeis guineensis	9	36	4.0	4.0	4.0	0.25	0	0
Ficus sur	10	16	4.0	4.0	4.0	0.40	0	0
Hexalobus monopetalus	10	21	4.0	4.0	3.9	0	0	0
Landolphia heudelotii	10	12	4.0	4.0	4.0	0	0	0
Lannea velutina	10	21	4.0	3.9	3.1	0	0	0
Nauclea latifolia	7	18	4.0	4.0	4.0	0	0	0
Pachystela pobeguiniana	10	22	4.0	4.0	4.0	0	0	0
Parinari excelsa	9	58	4.0	4.0	4.0	0	0	0.22
Parkia biglobosa	10	69	4.0	4.0	4.0	0	0	0
Piliostigma thonningii	10	27	4.0	4.0	4.0	0	0	0
Pseudospondias microcarpa	4	27	4.0	4.0	4.0	0	0	0
Pterocarpus erinaceus	10	46	4.0	4.0	4.0	0	0	0
Saba senegalensis	10	14	4.0	4.0	4.0	0	0	0.10
Sorindeia juglandifolia	10	17	4.0	4.0	4.0	0	0	0.20
Spondias mombin	10	44	4.0	4.0	3.7	0.60	0.40	0
Treculia africana	2	NA*	4.0	4.0	4.0	0	0.50	0
Vitex doniana	7	36	4.0	4.0	4.0	0.30	0.14	0

5.2 Vegetation Structure

The vegetation structure of the Aicum region has been investigated in 109 out of the 220 MPI plots. Most plots were in old secondary forest parts (43) and in wooded savanna areas (39 plots). Other plots were classified as herbaceous savanna (10), gallery forest (6), fallow land (4), forest on rock (3), savanna on rock (3) and maize plantation (1). In total 57 woody species were identified, five species of which only the local name is known and another five species of which no local name or scientific name is known at this time. Four other species from the phenology were not sampled during the first half of vegetation structure. The total number of measured trees was 896 trees in 109 plots, representing 4.36 ha which gives a total tree density of 205 trees (with DBH > 10.0 cm) per hectare. This number is expected to be lower for the general vegetation structure of the Aicum as the previous vegetation plots have been investigated in the more forested areas.

The ten most common tree species in the study region of the Boé are shown in Table 3. The total list of tree species and their densities can be found in appendix 2. Four of the most common species are from the *Fabaceae* or *Leguminosae* family (nine in the total vegetation structure), the common family found in tropical rainforests and in dry forests in the Americas and Africa (Gentry 1988, Burnham & Johnson 2004). This group is widely distributed and is the third-largest land plant family in terms of number of species, behind only the *Orchidaceae* and *Asteraceae* (Stevens 2012). *Fabaceae* grow in closed lowland tropical rainforest, but they are often members of more open vegetation, even of early successional communities, in both tropical and temperate regions of the world. Perhaps 16% of all woody species in neotropical rainforest are members of *Fabaceae*. They make up perhaps the second most important family of lianas, both ecologically and in terms of number of species (Burnham & Johnson 2004). Associations of *Fabaceae* with nitrogen-fixing bacteria are very common and substantial amounts of nitrogen can be fixed (Batterman *et al*. 2013).

Table 3. Density of the ten most common tree species with DBH ≥ 10 cm in the vegetation plots.

Family	Tree genus	Tree species	Local name (Fula)	Trees/ species	trees/ha
Annonaceae	*Hexalobus*	*monopetalus*	Boyle cundjé	125	28.7
Fabaceae	*Pterocarpus*	*erinaceus*	Baní	86	19.7
Bignoniaceae	*Markhamia*	*tomentosa*	Kafawangdu	78	17.9
Sterculiaceae	*Sterculia*	*tragacantha*	Tchapeleguê	53	12.2
Combretaceae	*Combretum*	unidentified	Boyle mauba	49	11.2
Fabaceae	*Cordyla*	*pinnata*	Dúki	37	8.5
Anacardiaceae	*Lannea*	*velutina*	Tchuko jaude	35	8.0
Fabaceae	*Xeroderris*	*stuhlmannii*	Po de sang branku *	34	7.8
Fabaceae	*Parkia*	*biglobosa*	Neté	29	6.7
Anacardiaceae	*Spondias*	*mombin*	Tchaleh	28	6.4

The most common species in the study area, *Hexalobus monopetalus*, has one of the widest distributions known in African *Annonaceae*, ranging from West Africa to East Africa. The genus' center of diversity lies in Cameroon with four species, including one narrow endemic species, *H. salicifolius.* Only a few other species such as *Xylopia aethiopica* have such an extensive distribution. However, in contrast to *Xylopia aethiopica*, *H. monopetalus* grows in drier ecosystems such as savannas and woodlands, and its distribution reflects the distribution of these xeric ecosystems (Botermans 2011). The Boé has wooded savannas as well as gallery forest and old secondary forests and *H. monopetalus* seems to thrive in this region. One other species of *Annonaceae* is identified in this study: *Annona senegalensis* of which only one individual was found in the study area (appendix 2).

Two species of the family *Anacardiaceae* were found amongst the ten most common species: *Lannea Velutina* and *Spondias mombin*. *Anacardiaceae* includes trees as well as lianas and are found worldwide in dry to moist, mostly lowland habitats, primarily in the tropics and subtropics but extending into the temperate zone. This family includes *Anacardium*, the cashew which is widely cultivated all over Guinea-Bissau (Mitchell & Mori 1987)

In the total of plots, seven species of the *Combretaceae* family were identified of which six species belonged to *Combretum* genus and one to *Terminalia* (appendix 2). Not all trees could be identified to the scientific name on species level, but they were clearly all *Combretum.* Savannas in Africa, in particular those growing on rocky soils, are often dominated by *Combretum* and its close relative *Terminalia* (Hogan 2012). It is therefore not surprising that many *Combretaceae* were found in the wooded savanna systems of the Boé. The last species of the most common ones found in this study is *Markhamia tomentosa* of the family *Bignoniaceae*, a tree typically found in forest parts from Guinea to the DRC. The other species of this family found in the region is *Newbouldia laevis* with some scattered trees.

Six of the ten most common species found in the study area were independently of the habitat study included in the phenology study, which was based on local food preferences by chimpanzees. The next paragraph will discuss the potential link of habitat structure with food availability.

5.3 Potential food availability

The phenology is based on tree species that all serve as food resources to chimpanzees in the Boé, and the vegetation structure is a general overview of tree species occurring in the study area. Of all species occurring in the region, many trees provide food resources for chimpanzees. As mentioned in the previous chapter, six out of the ten most common tree species are included in the phenology and are known to be important food sources for chimpanzees in Guinea-Bissau. Three other species (*Markhamia tomentosa*, *Combretum* spp., *Xeroderris stuhlmannii*) are not known to be eaten by chimpanzees, while leaves of *Sterculia tragacantha* are known to be consumed by chimpanzees in at least Tanzania (Nishida 2012).

Some species of the phenology study were not found during the vegetation structure inventory in the first 109 plots. However, as the phenology survey took place in the same study area, these data were included in the total species overview (Table 4 with eaten and not eaten species). It is likely that the phenology species will be found in other areas of the vegetation structure, as they are common in some parts of the grid. The identified tree species are reviewed in comparison with other areas in Africa where they are known to be eaten by chimpanzees. The identified species of the vegetation structure together with the phenology study give a total number of 61 identified tree species. Of these 61 species, 17 species are not known to be consumed by chimpanzees which makes 72% (44 species) potential food for chimpanzees in the Boé. It is expected that this number will be much higher when a larger area is investigated and when shrubs and grasses are included. For instance, in Guinea-Conakry, the chimpanzees of Bossou are known to consume 200 plant species as food sources which is 30% of the available species in the region (Bogart 2009). However, the study region in Aicum represents a home range of one group of chimpanzees. This indicates that there might be even more edible species for chimpanzees in the Boé but these plants will not be accessible for all chimpanzees as a group is restricted to the area covered by its home range. Another chimpanzee group will have access to the other edible species, but is likely that species available for this group will not be accessible for other groups due to limitations for species diversity in the Boé.

Table 4. Potential food trees for chimpanzees occurring on Guinea-Bissau (Sugiyama & Koman 1992, Duvall 2000, Hockings 2007, Bogart 2009, MPI 2011, Watts *et al.* 2012, Van Schijndel & Camara *pers. comm.* 2013).

Family	Genus	species	Local name (Fula or * Creole)	Part Consumed: Fruit, Flowers, Leaves, Bark, Pith, Gum, Seed or Not eaten
Anacardiaceae	*Lannea*	*acida*	Tchuko nebadé	fruit
Anacardiaceae	*Lannea*	*velutina*	Tchuko	fruit
Anacardiaceae	*Pseudospondias*	*microcarpa*	Gowbi	fruit
Anacardiaceae	*Sorindeia*	*juglandifolia*	Sandji bombo	fruit
Anacardiaceae	*Spondias*	*mombin*	Tchaleh	fruit
Annonaceae	*Annona*	*senegalensis*	Dokumè	fruit
Annonaceae	*Hexalobus*	*monopetalus*	Boyle cundjé	fruit
Apocynaceae	*Holarrhena*	*floribunda*	Endama	not eaten
Apocynaceae	*Landolphia*	*heudelotii*	Pore padja	fruit, leaves
Apocynaceae	*Saba*	*senegalensis*	Porè	bark, fruit, pith
Arecaceae	*Borassus*	*aethiopum*	Cibedje	fruit
Arecaceae	*Elaeis*	*guineensis*	Tubi	fruit, leaves, pith
Bignoniaceae	*Markhamia*	*tomentosa*	Kafawangdu	not eaten
Bignoniaceae	*Newbouldia*	*laevis*	Suncundé	leaves
Caesalpinaceae	*Erythrophleum*	*suaveolense*	Teli	seed
Caesalpiniaceae	*Detarium*	*microcarpum*	Pompon dogoh	fruit

Caesalpiniaceae	*Detarium*	*senegalense*	Botoh	fruit
Chrysobalanaceae	*Neocarya*	*macrophylla*	Bansuma	not eaten
Chrysobalanaceae	*Parinari*	*excelsa*	Kura	fruit
Combretaceae	*Combretum*	spp. (6x)	diverse	not eaten
Combretaceae	*Terminalia*	*macroptera*	Bori	not eaten
Euphorbiaceae	*Bridelia*	*ferruginea*	Dafi	fruit
Fabaceae	*Acacia*	*macrostycha*	Buleh	bark
Fabaceae	*Afzelia*	*africana*	Lenguè	seed
Fabaceae	*Albizia*	*zygia*	Marroné, tali	bark
Fabaceae	*Cassia*	*sieberiana*	Sinja	not eaten
Fabaceae	*Cordyla*	*pinnata*	Dúki	seed
Fabaceae	*Dalbergia*	*saxatilis*	unknown	not eaten
Fabaceae	*Dialium*	*guineensis*	Mèko	fruit
Fabaceae	*Faidherbia*	*albida*	Bulé boal	not eaten
Fabaceae	*Parkia*	*biglobosa*	Neté	fruit
Fabaceae	*Piliostigma*	*thonningii*	Barquè	seed
Fabaceae	*Pterocarpus*	*erinaceus*	Baní	bark, flowers, leaves
Fabaceae	*Xeroderris*	*stuhlmannii*	Po de sang branku *	not eaten
Fragilariaceae	*Hannea*	*undulates*	unknown	not eaten
Hypericaceae	*Harungana*	*madagascariensis*	unknown	fruit
Loganiaceae	*Strychnos*	*spinosa*	Fata couleh	fruit
Malvaceae	*Bombax*	*costatum*	Lukum	flowers
Malvaceae	*Ceiba*	*pentandra*	Bantam	flowers
Malvaceae	*Cola*	*cordifolia*	Tábá	fruit, seed
Malvaceae	*Adansonia*	*digitata*	Boé	flowers, fruit
Meliaceae	*Khaya*	*senegalensis*	Cáe	fruit
Moraceae	*Ficus*	spp.	-	fruit, leaves
Moraceae	*Ficus*	*sur*	Ibé	fruit, leaves
Moraceae	*Treculia*	*africana*	Taba	fruit
Oleaceae	*Schrebera*	*arborea*	unknown	flower
Phyllanthaceae	*Hymenocardia*	*acida*	Peli toro	leaves
Rubiaceae	*Mitragyna*	*inermis*	unknown	not eaten
Rubiaceae	*Morinda*	*geminata*	Wanga	fruit
Rubiaceae	*Nauclea*	*latifolia*	Doendukè	fruit
Rutaceae	*Zanthoxylum*	*leprieurii*	Boquelem	not eaten
Sapindaceae	*Allophylus*	*africanus*	Kordeala	fruit
Sapotaceae	*Pachystela*	*pobeguiniana*	Wouna dowdih	fruit
Sterculiaceae	*Sterculia*	*tragacantha*	Tchapeleguê	fruit, leaves
Verbenaceae	*Vitex*	*doniana*	Bumè	fruit, leaves
Verbenaceae	*Vitex*	*madiensis*	Bumel babé	fruit, leaves

The most important constituent of the chimpanzee diet is fruit, but they also feed on plant seeds, leaves, buds, shoots, flowers, the pith of stems, inner bark, xylem, roots, and gums.

They supplement their diet with ants, termites, bees, honey, larvae and some small vertebrates. Although chimpanzees are considered ripe fruit specialists, they show high levels of ecological and behavioral flexibility and are able to adapt to areas of secondary vegetation and human agriculture. Chimpanzees are therefore known to be generalists and opportunistic feeders, they will eat what they can find and consume the ripe fruits (Kormos *et al.* 2003, Watts *et al.* 2012, Hocking & Sousa 2013). The fruits of the species important to chimpanzees are abundant during different times of the year with the actual staple food changing year by year (Kormos *et al.* 2003, Nishida 2012). During periods of fruit scarcity, chimpanzees will rely and concentrate on different ‘‘keystone resources’’ or ‘‘fallback foods,’’ which will depend on their habitat and the feeding traditions of their community (Kormos *et al.* 2003).

One of the keystone resources is the fig, which is available throughout the year (Nishida 2012). Another tree where chimpanzees can heavily rely upon is the oil palm *Elaeis guineensis.* This is de case in Bossou, Guinea-Conakry, where the tree provides chimpanzees with year-round food resources, including the rich mesocarp of the fruit, the oily nut kernel, the petiole of young palm fronds, the base of immature flowers, the pith of mature leaves and the sugary and nutritious palm heart (Yamakoshi in Kormos *et al.* 2003). Fig trees and the oil palm occur throughout the Boé and can be essential for chimpanzees in the region. However, the trees do not have large densities in the Aicum area, indicating that chimpanzees need more trees to depend on for their dietary requirements. In the Nimba Mountains region of Côte d'Ivoire, *Nauclea* trees, which produce a succulent fleshy fruit play an important role for the chimpanzees, due to their availability in times when the abundance of other fruits is low (Kormos *et al.* 2003). *Nauclea latifolia* also occurs in the Boé and could serve as fallback food.

Many plant species that are eaten by chimpanzees are also consumed or used for medicinal or construction purposes by humans (Hockings & Sousa 2013). In Cantanhez National Park in Guinea-Bissau, but also in the Boé, the majority of local people depend largely on forest resources and their agricultural fields for a living (Hockings & Sousa 2013, Van Schijndel & Camara *pers. comm.* 2013). As a consequence of a shared habitat, chimpanzees frequently conflict with the interests of local people due to crop raiding and competition for overlapping resource use. For instance, in the Tomboronkoto region in Senegal, 17 naturally occurring plant species were eaten by both humans and chimpanzees. The fruit from the forest liana *Saba senegalensis* is a critical food source for chimpanzees at Fongoli in the dry season, but it also serves as a cash crop for humans during times of hardship. Another shared resource are three species of palm trees in the chimpanzees’ known range, namely *Elaeis guineensis*, *Borassus aethiopum* and *Phoenix reclinata*. In most areas of in West Africa, oil palms are scattered on the edges of the forest, but in the Boé the trees are close to rivers. Local people harvest the fruits mainly to produce oil (Hocking & Sousa 2013). Chimpanzees use the same palm trees to eat the fruit, pith and flowers which can cause competition between primates and humans. Potentially this might lead to human-primate conflicts.

Besides conflicts over forest resources, conflicts also arise due to crop raiding habits of primates in agricultural fields of local people. In Uganda, chimpanzees, but also olive baboons (*Papio cynocephalus*) and redtail monkeys (*Cercopithecus ascanius*) are reported to feed on

crops inducing human-primate conflicts. They do not forgo wild foods, but they add crop-raiding to other foraging activities (Naughton-Treves *et al.* 1998). From an animal's perspective, fields of ripe maize may be analogous to the mast fruiting of forest trees (Janzen 1976 in Naughton-Treves *et al.* 1998). However, animals raid crops less heavily during mast-fruiting events in the forest compared with periods of scarcity of natural resources. With more land being converted in agricultural field, less natural space will be available resulting in a higher need of primates to feed elsewhere (Naughton-Treves et al. 1998). An inevitable consequence is a continuing rise in human-primate interactions and with that, conflicts (Hocking & Sousa 2013).

Other species are not eaten by chimpanzees, but do have medicinal use for humans like the *Combretum* species, *Cassia sieberiana* and *Markhamia tomentosa* (Orwa *et al.* 2009). Chimpanzees might use some of these species as well for self-medication as has been observed for great apes in Uganda, Tanzania, Congo, Guinea-Conakry amongst other countries in Africa (Huffman 1997).

Besides the tree use for feeding purposes and suspected medicinal use, chimpanzees also depend on the trees for nesting. This study did not specifically consider tree use for nesting but previous studies showed that chimpanzees are selective in the choice of their nesting site (Hoogveld 2013). Most studies of nesting in chimpanzees reveal that nests accumulate in specific areas depending on forest type and proximity to water and food resources. Trees that are indicated as preferred species in some areas include *Cola cordifolia*, *Elaeis guineensis, Erythrophleum suaveolens*, *Khaya senegalensis, Parinari excels, Parkia biglobosa, Pterocarpus erinaceus* and *Sterculua tragacantha* (Ham 1998 in Kormos *et al.* 2003, Hoogveld 2013). All these tree species also function as food resources for chimpanzees and are key habitat for chimpanzees.

5.4 Potential impact for Protected Area status

The preliminary results of this study, as well as the final results of the Pan African Program, lead towards increased ecological knowledge of the habitat of chimpanzees in the Boé. The study has indicated that large areas need to be conserved in order for chimpanzees to thrive in their original habitat. Chimpanzees are widespread in the Boé and are dependent on the available tree species for their diet as well as for nesting. The master's research done by Jasper Hoogveld (2013) showed that nesting is preferred in large trees, with an higher density near rivers. This study showed that chimpanzees need a large variety of trees and that trees flower and fruit in different times of the years. As chimpanzees need large trees and a large variety of trees, a great area is required to cover their home range. These findings support the plan of the government of Guinea-Bissau together with the Institute for Biodiversity and Protected Areas (IBAP) to add the Boé to the Protected Area system of Guinea-Bissau.

6) Strengths and limitations of this study

This internship study was part of the larger Pan African Program of the Max Planck Institute for Evolutionary Anthropology (MPI), in Guinea-Bissau executed by the Chimbo Foundation. This research studied the phenology of specific tree food sources for chimpanzees and the habitat structure in the Aicum area of the Boé. Little research has taken place in this part of West-Africa and little is known about its chimpanzee populations and their food preference in the region. Therefore this study is key to gain more knowledge about the ecology of the Boé and in general to improve the understanding of chimpanzee groups and their habitats. This study was however limited to the research questions and methods according the PANAF protocol. Time constraints limited the findings of this part of the program, but most of these will be solved once the Pan African Program is completed. Another limitation for the phenology and habitat structure is that the method only takes adult trees with a diameter ≥ 10 cm into consideration. Some liana species bear important fruits for chimpanzees but were not included due to their small diameter.

7) Conclusion

The objective of this study was to evaluate the phenology of important food trees for the western chimpanzee, and the habitat structure in the Boé region in Guinea-Bissau. The species composition, population structure, availability and seasonality of potential food trees were investigated and described following the guidelines of MPI.

The phenology of 25 tree species showed large variation in terms of their flowering, fruiting, and development of new foliage. Some tree species had their inflorescence and fruiting in line with the phenology of trees in other African regions, while others showed a completely different seasonality. Besides the differences with tree phenology in other African regions, the phenology between individuals of the same tree species in the Boé also varied substantially. Due to time constraints, this study only had phenology data available from three months of research. Phenology studies should be performed for at least 12 consecutive months to be able to draw some more firm conclusions.

In the habitat structure combined with the phenological data, a total number of 61 species were identified. Of these 61 species, 17 species are not known to be consumed by chimpanzees which makes 72% (44 species) potential food for chimpanzees in the Boé. Six out of the ten most common tree species in the study area are known to be important food sources for chimpanzees in Guinea-Bissau. The fruits of the species important to chimpanzees are abundant during different times of the year inducing chimpanzees to adapt to the seasonality of plants and to be opportunistic by feeding on other sources.

Although this study is a very small part of the larger Pan African Program, the preliminary result is that chimpanzees in the Aicum home range seem to have sufficient food resources and key resources. This will need to be confirmed when more data is available and

analyzed. However, as the Boé has an increase of human populations with exerted pressure on land, chimpanzee habitat is decreasing causing human-chimpanzee conflicts to rise. To ensure the availability of their main tree resources for nesting and food, and to prevent crop-raiding and other human-primate conflicts in the Boé, it is essential to protect chimpanzee habitat. The study has indicated that large areas need to be conserved in order for chimpanzees to thrive in their original habitat. These findings support the plan of the government of Guinea-Bissau together with the Institute for Biodiversity and Protected Areas (IBAP) to add the Boé to the Protected Area system of Guinea-Bissau.

8) Recommendations for further research

The first recommendation for this research is obviously to continue and complete the Pan African Program in order to allow MPI to analyze the data from all regions in Africa executing a Pan African Program. Another suggestion is to include climbers into phenology and habitat structure research as these species can be important food sources for chimpanzees and other wildlife. Phenology studies could be continued for over the 12 months of Pan African Program because seasonality can vary between years depending on temperature and precipitation.
This study showed the habitat structure in a small part of the Boé. As the Boè itself varies greatly in its soil conditions and levels of disturbances, it would be recommended to have more plots and the plots better spread in the Boè region in order to cover a larger species diversity. Chimpanzees depend on the trees as food resources and nesting possibilities and will require trees in the long-term. It is therefore suggested to investigate the population and regeneration dynamics of important main tree resources. Particularly those that take long to mature and fruit, such as *Adansonia digitata*, *Ceiba pentandra, Cola cordifolia*, *Eryhthophleum suaveolens* and *Khaya senegalensis*.

References

Batterman, S. A., Wurzburger, N., & Hedin, L. O. 2013. Nitrogen and phosphorus interact to control tropical symbiotic N2 fixation: a test in Inga punctata. *Journal of Ecology*, 101 (6), 1400-1408.

Beck, J. & Chapman, H. 2008. A population estimate of the endangered chimpanzee Pan troglodytes verus in a Nigerian montane forest: Implications for conservation. *Oryx* 42(3): 448–451.

Boesch, C., Hohmann, G. & Marchant, L. 2002. Behavioural Diversity in Chimpanzees and Bonobos. Cambridge: Cambridge University Press.

Bogart, S. L. 2009. Behavioral ecology of savanna chimpanzees (*Pan troglodytes verus*) with respect to insectivory at Fongoli, Senegal. Graduate Dissertation. Iowa State University.

Botermans, M., Sosef, M. S. M., Chatrou, L. W. & Couvreur, T. L. P. 2011. Revision of the African Genus *Hexalobus* (Annonaceae). *Systematic Botanyystematic Botany* 361 (1), 33-48.

Breteler, F. J. 2003. The African genus *Sorindeia* (Anacardiaceae): A synoptic revision. *Adansonia* 25, sér. 3, 93-113.

Brugiere, D., Badjinca, I., Silva, C., & Serra, A. 2009. Distribution of chimpanzees and interactions with humans in Guinea-Bissau and Western Guinea, West Africa. *Folia Primatologica* 80: 353–358.

Burnham, R. J., & Johnson, K. R. 2004. South American palaeobotany and the origins of neotropical rainforests. *Philosophical Transactions of the Royal Society B: Biological Science* 359: 1595-1610.

Catarino, L., Martins, E. S., Pinto-Basta, M. F., & Diniz, M. A. 2006. *Plantas vasculares e briófitos da Guiné-Bissau*. Instituto de Investigação Científica Tropical e Instituto Portugûes de Apoio ao Desenvolvimento, Lisboa.

Campbell, G., Kuehl, H., N'Goran Kouamé, P. & Boesch, C. 2008. Alarming decline of West African chimpanzees in Côte d'Ivoire. *Current Biology* 18 (19), 903-904.

Chapman, C. A. & Onderdonk, D. A. 1998. Forests Without Primates: Primate/Plant Codependency. *American Journal of Primatology* 45: 127–141.

Duvall, C. S. 2008. **Pterocarpus erinaceus** Poir. Record from PROTA4U [internet]. Louppe, D. Oteng-Amoako, A. A. & Brink, M. (Editors). PROTA (Plant Resources of Tropical Africa), Wageningen, The Netherlands. <http://www.prota4u.org/search.asp>

FAO. 1983. Food and Fruit-Bearing Forest Species. 1: Examples from East Africa. FAO Forestry Paper 44/1. FAO, Rome.

FAO. 2007. State of World Forests. Forest Department, FAO, United Nations, Rome.

Geerling, C. 1987. *Guide de terrain des ligneux Sahéliens et Soudano Guinéens*. Agricultural University Wageningen, Wageningen, The Netherlands

Gentry, A.H. 1988. Changes in plant community diversity and floristic composition on environmental and geographical gradients. *Annals of the Missouri Botanical Garden*, 75, 1-34.

Gippoliti, S. & Dell'Omo, G. 1996. Primates of the Cantanhez Forest and the Cacine Basin, Guinea-Bissau. *Oryx* 30, 74-80.

Gippoliti, S., Embalo, D. S. & Sousa, C. 2003. Guinea-Bissau, in Kormos, R., Boesch, C., Bakarr, M. I., & Butynski, T. M. (eds.). *West African Chimpanzees. Status Survey and Conservation Action Plan*. IUCN/SSC Primate Specialist Group. IUCN, Gland, Switzerland and Cambridge, UK.

Groom, M. J., Meffe, G. K. & Carroll, C. R. 2006. *Principles of Conservation Biology*. Third Edition. Massachusetts: Sinauer associates.

Hawthorne, W. & Jongkind, C., 2006. *Woody plants of Western African forests: A guide to the forest trees, shrubs and lianes from Senegal to Ghana*. Kew Publishing, Royal Botanic Gardens, Kew.

Hockings, K. J. 2007. Human-chimpanzee coexistence at Bossou, the Republic of Guinea: a chimpanzee perspective. PhD thesis, Department of Psychology, University of Stirling.

Hockings, K. J. & Sousa, C. 2013. Human-Chimpanzee Sympatry and Interactions in Cantanhez National Park, Guinea-Bissau: Current Research and Future Directions. *Primate Conservation* 26, 57-65.

Hogan, C.M. 2012. Kunene River. Topic ed. P.Saundry. *Encyclopedia of Earth*. National Council for Science and the Environment. Washington DC.

Hoogveld, J. 2013. Using field data collected by local people to expand the knowledge of a large chimpanzee *(Pan troglodytes verus)* population in the Boé region of Guinea Bissau. Unpublished. Masterthesis Radboud University, Nijmegen, The Netherlands.

Huffman, M. A. 1997. Current evidence for self-medication in primates: a multidisciplinary perspective. *American journal of physical anthropology*, *104*(25), 171-200.

Jansen, P.C.M. 2005. **Lannea velutina** A.Rich. In: Jansen, P.C.M. & Cardon, D. (Editors). PROTA 3: Dyes and tannins/Colorants et tanins. [CD-Rom]. PROTA, Wageningen, Netherlands.

Jolly, C. J., Oates, J. F. & Disotell, T. R. 1995. Chimpanzee kinship. *Science* 268, 185-186.

Koops, K., T. Humle, E. H. M. Sterck, and T. Matsuzawa. 2007. Ground-nesting by the chimpanzees of the Nimba Mountains, Guinea: environmentally or socially determined? *American Journal of Primatology* 69, 407-419.

Kormos, R., Boesch, C., Bakarr, M.I. & Butynski, T.M. (eds) 2003. *West African Chimpanzees: Status Survey and Conservation Action Plan*. IUCN/SSC Primate Specialist Group. IUCN, Gland, Switzerland and Cambridge, UK.

Lemessa, D. 2010. **Piliostigma thonningii** (Schumach.) Milne-Redh. In: Brink, M. & Achigan-Dako, E.G. (Editors). Prota 16: Fibres/Plantes à fibres. [CD-Rom]. PROTA, Wageningen, The Netherlands.

Max Planck Institute for Evolutionary Anthropology (MPI). 2012. *Pan African Programme: The cultured chimpanzee*. Pan African Programme Data Collection. Max Planck Institute for Evolutionary Anthropology, Leipzig, Germany (unpublished).

Mitchell, J. D. & S. A. Mori. 1987. The cashew and its relatives (Anacardium: Anacardiaceae). *Memoirs of the New York Botanical Garden* 42: 1-76.

Naughton-Treves, L., Treves, A. Chapman, C. & Wrangham, R. 1998. Temporal patterns of crop-raiding by primates: linking food availability in croplands and adjacent forest. *Journal of Applied Ecology* 35: 695-606.

Nishida, T. 2012. *Chimpanzees of the lakeshore: natural history and culture at Mahale*. Cambridge University Press.

Oates, J.F., Tutin, C.E.G., Humle, T., Wilson, M.L., Baillie, J.E.M., Balmforth, Z., Blom, A., Boesch, C., Cox, D., Davenport, T., Dunn, A., Dupain, J., Duvall, C., Ellis, C.M., Farmer, K.H., Gatti, S., Greengrass, E., Hart, J., Herbinger, I., Hicks, C., Hunt, K.D., Kamenya, S., Maisels, F., Mitani, J.C., Moore, J., Morgan, B.J., Morgan, D.B., Nakamura, M., Nixon, S., Plumptre, A.J., Reynolds, V., Stokes, E.J. & Walsh, P.D. 2008. *Pan*

troglodytes. In: IUCN 2013. IUCN Red List of Threatened Species. Version 2013.1. Available from: <www.iucnredlist.org>.

Ogawa, H., Idani, G., Moore, J., Pintea, L. & Hernandez-Aguilar, A. 2007. Sleeping Parties and Nest Distribution of Chimpanzees in the Savanna Woodland, Ugalla, Tanzania. *International Journal of Primatology* 28: 1297-1412.

Oom, D., Lourenço, P., Cabral, A. I. R., Vasconcelos, M. J. P., Catarino, L., Cassamá, V. & Moreira, J. 2009. Quantification of deforestation rates in Guinea-Bissau – a baseline carbon trading under REDD. 33rd International Symposium on Remote Sensing of Environment, 4-8 May 2009, Stresa, Italy.

Orwa C., Mutua A., Kindt R., Jamnadass R. & Simons A. 2009. Agroforestree Database:a tree reference and selection guide version 4.0 (http://www.worldagroforestry.org/af/treedb/)

Oyen, L. P. A. 2012. **Parinari excelsa** Sabine. [Internet] Record from PROTA4U. Lemmens, R.H.M.J., Louppe, D. & Oteng-Amoako, A.A. (Editors). PROTA (Plant Resources of Tropical Africa / Resources végétales de l'Afrique tropicale), Wageningen, Netherlands. Available from: <http://www.prota4u.org/search.asp>.

Pruetz, J. D., Fulton, S. J., Marchant, L. F., McGrew, W. C., Schiel, M., & Waller, M. 2008. Arboreal Nesting as Anti-predator Adaptation by Savanna Chimpanzees (Pan troglodytes verus) in Southeastern Senegal. *American Journal of Primatology* 70: 393–401.

Redmond, I. *2010. Primates of the World: the amazing diversity of our closest relatives*. New Holland Publishers (UK) Ltd.

Sá, R. M. M., da Silva, M. F., Sousa, F. M. & Minhós, T. 2012. The Trade and Ethnobiological Use of Chimpanzee Body Parts in Guinea-Bissau. *TRAFFIC Bulletin* 24, 31-34.

Sayre, R., P. Comer, J. Hak, C. Josse, J. Bow, H. Warner, M. Larwanou, E. Kelbessa, T. Bekele, H. Kehl, R. Amena, R. Andriamasimanana, T. Ba, L. Benson, T. Boucher, M. Brown, J. Cress, O. Dassering, B. Friesen, F. Gachathi, S. Houcine, M. Keita, E. Khamala, D. Marangu, F. Mokua, B. Morou, L. Mucina, S. Mugisha, E. Mwavu, M. Rutherford, P. Sanou, S. Syampungani, B. Tomor, A. Vall, J. Vande Weghe, E. Wangui, and L. Waruingi. 2013. *A New Map of Standardized Terrestrial Ecosystems of Africa*. Washington, DC: Association of American Geographers.

Silva, C., A. Serra, & E. Lopes. 2007. Étude de faisabilité du projet «*Développement touristique de la Boé au profit de la conservation des Chimpanzés et des populations locales*». IBAP and Daridibó, Bissau.

Sina, S. & Traoré, S. A. 2002. **Parkia biglobosa** (Jacq.) R.Br. ex G.Don. [Internet] Record from PROTA4U. Oyen, L.P.A. & Lemmens, R.H.M.J. (Editors). PROTA (Plant Resources of Tropical Africa / Ressources végétales de l'Afrique tropicale), Wageningen, Netherlands. Available from: <http://www.prota4u.org/search.asp>.

Stevens, P. F. (2001 onwards). Angiosperm Phylogeny Website. Version 12, July 2012. Available from: <http://www.mobot.org/MOBOT/research/APweb/>.

Sugiyama, Y., & Koman, J. 1992. The flora of Bossou: its utilization by chimpanzees and humans. *African study monographs*, *13*(3), 127-169.

United Nations Development Programme (UNDP), Executing Agency: Institute for Biodiversity and Protected Areas (IBAP), General Directorate of Forests and Wildlife, Ministry of Agriculture and Rural Development (MARD), Government of Guinea-Bissau. 2010. UNDP Project Document, UNDP GEF PIMS # 3650. *Support to the Consolidation of a Protected Area System in Guinea-Bissau's Forest Belt.* UNDP, Bissau.

Verheye, W. 2010. Growth and production of oil palm. In: W. Verheye (ed.). Land use, land cover and soil science. Encyclopedia of life support systems (EOLSS). UNESCO-EOLSS Publishers; Oxford.

Watts, D. P., Potts, K. B., Lwanga, J. S., & Mitani, J. C. 2012. Diet of chimpanzees (Pan troglodytes schweinfurthii) at Ngogo, Kibale National Park, Uganda, 1. Diet composition and diversity. *American journal of primatology*, *74* (2), 114-129.

White, L. & Edwards, A. (eds.). 2000. *Conservation research in the African rain forests: a technical handbook*. Wildlife Conservation Society, New York.

Wit, P. & Reintjes, H. C. 1989. An agro-ecological survey of the Boé province, Guinea Bissau. *Agriculture, Ecosystems & Environment* 27**,** 609-620.

Wrangham, R. W., Conklin-Brittain, N. L. & Hunt, K. D. 1998. Dietary response of chimpanzees and cercopithecines to seasonal variation in fruit abundance. I. Antifeedants. *International Journal of Primatology* 19(6): 949-956.

Annexes

Annex I: Total list of tree species for phenology with its location in Africa (after MPI 2012).

ID	Location	Species name	Family	Part consumed
1	All	*Celtis mildbraedii*	*Ulmaceae*	fruit
2	All	*Elaeis guineensis*	*Arecaceae*	nut, pith, flower, fruit
3	All	*Ficus mucuso*	*Moraceae*	ripe fruit
4	All	*Klainedoxa gabonensis*	*Irvingiaceae*	fruit
5	All	*Parinari excelsa*	*Chrysobalanaceae*	fruit, nut
6	All	*Treculia africana*	*Moraceae*	fruit
7	West	*Adansonia digitata*	*Bombacoideae*	fruit, seed
8	West	*Albizia zygia*	*Mimosaceae*	gum
9	West	*Allophylus africanus*	*Sapindaceae*	fruit
10	West	*Beilschmiedia manii*	*Lauraceae*	fruit
11	West	*Calpocalyx aubrevillei*	*Mimosaceae*	pod
12	West	*Ceiba pentandra*	*Bombacaceae*	flower, seed
13	West	*Cola cordifolia*	*Sterculiaceae*	fruit, seed
14	West	*Detarium senegalense*	*Caesalpiniaceae*	fruit
15	West	*Dialium aubrevillei*	*Caesalpiniaceae*	fruit
15	West	*Dialium guineensis*	*Caesalpiniaceae*	fruit
16	West	*Diospyros sanza-minika*	*Ebenaceae*	fruit
17	West	*Erythrina mildbraedi*	*Fabaceae*	flower, leaf, fruit
18	West	*Gilbertiodendron splendidum*	*Caesalpiniaceae*	fruit
19	West	*Musanga cercopoides*	*Moraceae*	fruit, flower
20	West	*Nauclea latifolia*	*Rubiaceae*	fruit
21	West	*Pachystela pobeguiniana*	*Sapotaceae*	fruit
22	West	*Pterocarpus erinaceus*	*Papilionceae*	flower, leaf, bark
23	West	*Saba senegalensis*	*Apocynaceae*	fruit, pith
24	West	*Spondias mombin*	*Anacardiaceae*	fruit
25	West	*Uapaca esculenta*	*Euphorbiaceae*	fruit
26	West	*Vitex madiensis*	*Verbenaceae*	fruit
27	West & Central	*Afzelia africana*	*Caesalpiniaceae*	fruit, seed
28	West & Central	*Coula edulis*	*Olacaceae*	seed, leaf
29	West & Central	*Diospyros mannii*	*Ebenaceae*	fruit, flower
30	West & Central	*Ficus ingens*	*Moraceae*	fruit
31	West & Central	*Irvingia gabonensis*	*Irvingiaceae*	fruit
32	West & Central	*Irvingia grandifolia*	*Irvingiaceae*	fruit, flower, seed
33	West & Central	*Mammea africana*	*Guttiferae*	fruit
34	West & Central	*Myrianthus arboreus*	*Moraceae*	fruit
35	West & Central	*Nauclea didderichi*	*Rubiaceae*	fruit

36	West & Central	*Panda oleosa*	*Pandaceae*	seed
37	West & Central	*Parkia bicolor*	*Mimosaceae*	fruit
38	West & Central	*Pentaclethra macrophylla*	*Mimosaceae*	pod
39	West & Central	*Sacoglottis gabonensis*	*Humiriaceae*	fruit
40	West & Central	*Santiria trimera*	*Burseraceae*	fruit
41	West & Central	*Sterculia tragacantha*	*Sterculiaceae*	leaf, bark
42	West & Central	*Strombosia glaucesens*	*Olacaceae*	fruit
43	West & Central	*Tetrapleura tetraptera*	*Mimosaceae*	leaf
44	West & Central	*Triplochiton scleroxylon*	*Sterculiaceae*	flower
45	West & Central	*Uapaca guineensis*	*Euphorbiaceae*	fruit
46	West & Central	*Xylopia quintasii*	*Annonaceae*	fruit
47	West & East	*Aningeria altissima*	*Sapotaceae*	fruit
48	West & East	*Entandrophragma angolense*	*Meliaceae*	seed
49	West & East	*Ficus capensis*	*Moraceae*	fruit
49	West & East	*Ficus exasperata*	*Moraceae*	fruit, leaf
49	West & East	*Ficus variifolia*	*Moraceae*	fruit, leaf
50	West & East	*Lannea welwitschii*	*Anacardiaceae*	ripe fruit, wood
51	West & East	*Morus mesozygia*	*Moraceae*	fruit
52	West & East	*Pseudospondias microcarpa*	*Anacardiaceae*	fruit
53	West & East	*Strychnos aculeata*	*Loganiaceae*	fruit
54	West & East	*Syzygium guineense*	*Myrtaceae*	seed
55	Central	*Staudtia gabonensis*	*Myristicaceae*	fruit
56	Central & East	*Monodora angolensis*	*Annonaceae*	pulp
57	East	*Beilschmiedia ugandensis*	*Lauraceae*	fruit
58	East	*Mimusops bagshawei*	*Sapotaceae*	fruit
59	East	*Uvariopsis congensis*	*Annonaceae*	fruit

Annex 2: Habitat structure of all tree species with the tree density (trees/ha)

Some species could not be identified to species level or in general and are documented and unidentified.

Family (sub-family)	Tree genus	Tree species	Local name (Fula)	Trees/ species	Trees/ha
Anacardiaceae	*Lannea*	*acida*	Tchuko nebadé	27	6.2
Anacardiaceae	*Lannea*	*velutina*	Tchuko jaude	35	8.0
Anacardiaceae	*Sorindeia*	*juglandifolia*	Sandji bombo	9	2.1
Anacardiaceae	*Spondias*	*mombin*	Tchaleh	28	6.4
Annonaceae	*Annona*	*senegalensis*	Dokumè	1	0.2
Annonaceae	*Hexalobus*	*monopetalus*	Boyle cundjé	125	28.7
Apocynaceae	*Holarrhena*	*floribunda*	Endama	1	0.2
Apocynaceae	*Landolphia*	*heudelotii*	Pore padja	6	1.4
Apocynaceae	*Saba*	*senegalensis*	Porè	3	0.7
Arecaceae	*Borassus*	*aethiopum*	Cibedje	1	0.2
Bignoniaceae	*Markhamia*	*tomentosa*	Kafawangdu	78	17.9
Bignoniaceae	*Newbouldia*	*laevis*	Suncundé	3	0.7
Caesalpinaceae	*Erythrophleum*	*suaveolens*	Teli	10	2.3
Caesalpiniaceae	*Detarium*	*senegalensis*	Botoh	5	1.1
Caesalpiniaceae	*Detarium*	*microcarpum*	Pompon dogoh	9	2.1
Chrysobalanaceae	*Neocarya*	*macrophylla*	Bansuma	5	1.1
Chrysobalanaceae	*Parinari*	*excelsa*	Kura	3	0.7
Combretaceae	*Combretum*	*micranthum*	unknown	1	0.2
Combretaceae	*Combretum*	*canca liba*	unknown	1	0.2
Combretaceae	*Combretum*	unidentified	unknown	9	2.1
Combretaceae	*Combretum*	unidentified	Dodge	11	2.5
Combretaceae	*Combretum*	unidentified	Boyle mauba	49	11.2
Combretaceae	*Combretum*	*unidentified*	Notorron boal	9	2.1
Combretaceae	*Terminalia*	*macroptera*	Bori	19	4.4
Euphorbiaceae	*Bridelia*	*ferruginea*	Dafi	8	1.8
Fabaceae	*Acacia*	*macrostycha*	Buleh	1	0.2
Fabaceae	*Afzelia*	*africana*	Lenguè	3	0.7
Fabaceae	*Cassia*	*sieberiana*	Sinja	8	1.8
Fabaceae	*Cordyla*	*pinnata*	Dúki	37	8.5
Fabaceae	*Faidherbia*	*albida*	Bulé boal	10	2.3
Fabaceae	*Parkia*	*biglobosa*	Neté	29	6.7
Fabaceae	*Piliostigma*	*thonningii*	Barquè	9	2.1
Fabaceae	*Pterocarpus*	*erinaceus*	Baní	86	19.7
Fabaceae	*Xeroderris*	*stuhlmannii*	Po de sang branku *	34	7.8
Fragilariaceae	*Hannea*	*undulates*	Colonzo	3	0.7
Hypericaceae	*Harungana*	*madagascariensis*	Sungala	1	0.2
Leguminosae	*Dalbergia*	*saxatilis*	unknown	1	0.2

Leguminosae	*Dialium*	*guineensis*	Mèko	7	1.6
Loganiaceae	*Strychnos*	*spinosa*	unknown	1	0.2
Malvaceae	*Bombax*	*costatum*	Lukum	8	1.8
Malvaceae	*Ceiba*	*pentandra*	Bantam	1	0.2
Malvaceae	*Cola*	*cordifolia*	Tábá	4	0.9
Meliaceae	*Khaya*	*senegalensis*	Cáe	2	0.5
Moraceae	*Ficus*	*lutea*	unknown	2	0.5
Moraceae	*Ficus*	*sur*	Ibé	6	1.4
Oleaceae	*Schrebera*	*arborea*	unknown	2	0.5
Phyllanthaceae	*Hymenocardia*	*acida*	Peli toro	9	2.1
Rubiaceae	*Mitragyna*	*inermis*	unknown	1	0.2
Rubiaceae	*Morinda*	*geminata*	Wanga	5	1.1
Rubiaceae	*Nauclea*	*latifolia*	Doendukè	3	0.7
Rubiaceae	unidentified	unidentified	Quere	13	3.0
Rutaceae	*Zanthoxylum*	*leprieurii*	Boquelem	8	1.8
Sapindaceae	*Allophylus*	*africanus*	Kordeala	13	3.0
Sapotaceae	*Pachystela*	*pobeguiniana*	Wouna dowdih	5	1.1
Sterculiaceae	*Sterculia*	*tragacantha*	Tchapeleguê	53	12.2
Unknown	unidentified	unidentified	Marnei	2	0.5
Unknown	unidentified	unidentified	maronai	2	0.5
Unknown	unidentified	unidentified	Belendeh	8	1.8
Unknown	unidentified	unidentified	Bori-Bileh	4	0.9
Unknown	unidentified	unidentified	Fulfeli	17	3.9
Unknown**	unidentified	unidentified	unknown**	14	3.2
Verbenaceae	*Vitex*	*doniana*	Bumel babé	5	1.1
Verbenaceae	*Vitex*	*madiensis*	Bumè	6	1.4

* is creole name, ** are all individuals that could not be identified, more than 1 species