African Study Monographs, 21(4): 173-203, December 2000

IMPORTANT HABITAT FOR CHIMPANZEES IN MALI

Chris S. DUVALL
Department of Environmental Studies, San Jose State University

ABSTRACT Analysis of botanical data is presented from the standpoint of chimpanzee natural history. The Sudano-Guinean gallery forest type dominated by the tree *Gilletiodendron glandulosum* appears to be important habitat for chimpanzees due to vegetation structure, presence of permanent surface water, and, particularly, abundance of diverse food plants throughout the year. Based on fecal analysis, observation of feeding remains, observation of sympatric primates, ethnographic research, and literature review, sixty probable chimpanzee food plants have been identified in the *Gilletiodendron* forest of Mali. Phytogeographical analysis indicates that chimpanzees in Mali's Sudanian climate zone eat mainly Sudano-Guinean plant species. Heavy reliance on Sudano-Guinean vegetation may indicate that modern chimpanzee populations in savanna areas are relicts, and that the species was originally adapted to mesic Guinean forests. There appears to be niche separation based on topography between humans and chimpanzees which breaks down in times of human food shortage, and the potential for competition is high.

Key Words: *Pan troglodytes verus*; Diet; *Gilletiodendron glandulosum*; Maninka; Bafing; Mali.

INTRODUCTION

The presence of chimpanzees (*Pan troglodytes verus*) in the Republic of Mali was first reported by Sayer (1977), who hypothesized that the animal is restricted to riparian forests in the upper Senegal River basin. Since then, researchers working in West Africa's Sudano-Guinean and Sudanian climate zones have shown that savanna-dwelling chimpanzees utilize, at least seasonally, several different plant communities, including gallery forest, woodland, wooded grassland and grassland areas (Baldwin, 1979; Baldwin *et al*., 1981; McGrew *et al*., 1981, 1982; Baldwin *et al*., 1982; McBeath & McGrew 1982; Moore, 1985; McGrew *et al*., 1988). (For definitions of vegetation terms used in the present paper, Table 1.)

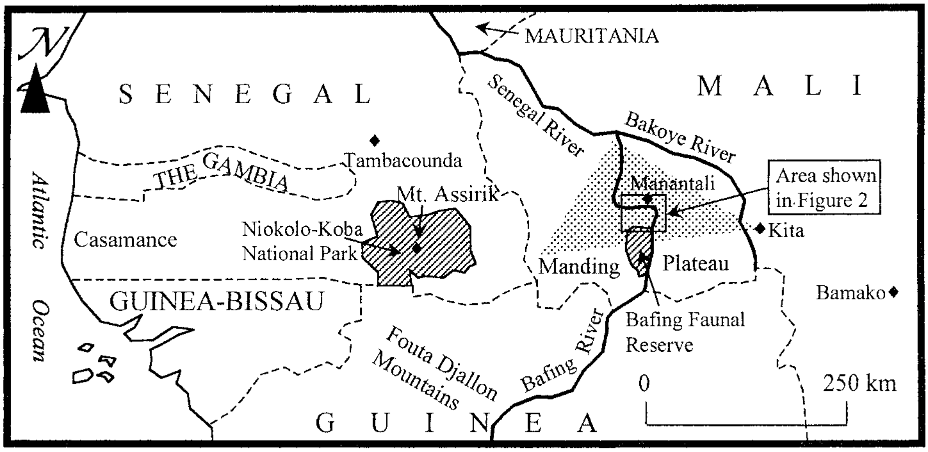
A consistent emphasis of these researchers has been on the importance of Sudano-Guinean gallery forests as chimpanzee habitat. In gallery forests, canopy structure (Tutin *et al*., 1983), abundance of food plants (de Bournonville, 1967; Baldwin, 1979; Baldwin *et al*., 1981; McGrew *et al*., 1988), and microclimate (Baldwin, 1979; McGrew *et al*., 1981) are valued by chimpanzees. As a result, group size, nest group size and frequency of observation are all higher in gallery forests relative to other vegetation formations (de Bournonville, 1967; Baldwin, 1979; Tutin *et al*., 1983). The fact that gallery forests often contain a permanent source of surface water also attracts chimpanzees, which require water daily. Elsewhere in Africa, other authors have also reported the importance of gallery for-

Table 1. Vegetation terms used in this study. Additional terms in the text given in quotation marks refer to specific plant communities described by the cited authorities.

Term	Definition
forest:	"A continuous stand of trees, with a closed upper canopy at least 8m tall. Forest may be deciduous, evergreen or semi-evergreen, or more usually a mixture hereof" (Lawesson, 1995: 24).
formation:	A "physiognomic category" (Lawesson, 1995: 24) of vegetation description referring to a unit greater in extent and floral diversity than a type.
gallery forest:	Forest which "depends on riverine conditions" (Lawesson, 1995: 24). Gallery forests are separated from riparian forests by an intervening area of non-forest vegetation.
Gilletiodendron forest:	The plant community dominated by *Gilletiodendron glandulosum.*
grassland:	"Land covered with herbs, either without woody plants or the latter not with more than 10% cover of the ground" (Lawesson, 1995: 24).
phytochorion: (*pl*., phytochoria)	"A floristic unit of any rank such as Region or any of its subdivisions" (White, 1979: 42).
plant community:	A uniform assemblage of plants indicative of common ecological and environmental conditions whether continuous or non-continuous in extent (Küchler, 1988).
riparian forest:	A generally narrow, continuous band of edaphic vegetation with dense undergrowth present along major waterways in the Sudanian climate zone.
savanna:	A general, imprecise term which refers to plant communities having abundant grasses (Kortland, 1983). These plant communities can be woodland, wooded grassland, or grassland.
type:	A "floristic category" (Lawesson, 1995: 24) of vegetation description referring to a specific, unique, more-or-less widespread assemblage of plant species with a single physiognomy.
wooded grassland:	"Land covered with herbs, with woody plants covering 10-40% of the ground" (Lawesson, 1995: 24).
woodland:	"An open stand of trees with a canopy at least 8m tall and with a canopy of 40% or more. The field layer is usually dominated by grasses" (Lawesson, 1995: 24).

est types as chimpanzee habitat in semi-arid areas (e.g. Izawa & Itani, 1966; Suzuki, 1969; Izawa, 1970; Kano, 1972; Clutton-Brock & Gillet, 1979; Nishida & Uehara, 1983).

Characteristics of chimpanzee habitat in Mali are virtually unknown. In unpublished works, Moore (1984) and Pavy (1993) report very limited results from a small number of vegetation samples, too few upon which to generalize. No other original data is available. In his literature review, Kortland (1983: 233) cited Jaeger (1956) to show that there appeared to be "good chimpanzee habitats" in southwestern Mali. A purpose of Jaeger (1956) was to report on the biology and systematics of *Gilletiodendron glandulosum*, a tree endemic to the Manding Plateau area of southwestern Mali (Fig. 1). *Gilletiodendron* forest occurs in isolated groves primarily in ravines and ledges along cliffs and steep, rocky slopes (Fig. 2). Although this plant community has been frequently described as a type of "Sudanian dry forest"



░ Approximate distribution of *Gilletiodendron glandulosum* as described by Jaeger (1956, 1959); exact distribution of this plant unknown (Duvall, 2000)

Fig. 1. Map of Western Mali and Surrounding Areas.

Fig. 2. *Gilletiodendron* forest grove. Most *Gilletiodendron* forest groves are found in seasonal drainage channels along the edges of plateaux. This is research Site 16, which lies along a semi-permanent stream and a permanent water hole. The probable chimpanzee food tree *Spondias mombin* is abundant in this grove, and chimpanzees frequent this site during its fruiting season (August to November), and possibly also in the dry season (March to July).

(White's [1983] term; see also Aubréville [1939], Jaeger [1950, 1956, 1959, 1966, 1968], Jaeger & Jarovoy [1952], Jaeger & Lechner [1957], Schnell [1976], Lawesson [1995]), it is more similar floristically to other Sudano-Guinean gallery forest types (Duong, 1947; Duvall, 2000). Environmental conditions in *Gilletiodendron* forest—including air temperature, soil temperature, humidity, soil moisture content, luminosity, and wind speed—are considerably more equable than those in neighboring Sudanian vegetation types (Jaeger, 1956). As a result, *Gilletiodendron* forest vegetation is characterized by a distinctive flora, rich in Sudano-Guinean species, rare or absent elsewhere in Mali's Sudanian climate zone (Duvall, 2000). Kortland (1983) only suggested that *Gilletiodendron* forest may be suitable for chimpanzees. At the time, there had been no field research on the animal in Mali. Both Moore (1985) and Pavy (1993) reported that "isolated forest patches on the steep slopes" (Moore, 1985: 60) of Mali's Bafing Faunal Reserve (BFR) area were important chimpanzee habitat. However, these authors provided virtually no data on vegetation composition, nor did they cite any sources which indicated that *Gilletiodendron* forest is indeed chimpanzee habitat.

The abundance of Sudano-Guinean plants in *Gilletiodendron* forest indicates that this is a relict community which serves as a refugium for Guinean mesophytes which were formerly more widespread (Duvall, 2000). No data is available which date how long *Gilletiodendron* forest has been isolated from other Guinean vegetation. Based on research conducted primarily in the Guineo-Congolian moist forest block, it is possible that *Gilletiodendron* forest has been isolated only since about 7,500 years before present (BP), although it is more likely that its isolation dates from at least 20,000 BP, and possibly as long as 70,000 BP (Maley, 1987; Hamilton, 1992; Dupont & Weinelt, 1996). Sudanian vegetation, on the other hand, including so-called 'dry forests' with closed canopies, are derived from more xerophytic formations which have expanded in area during the past 70,000 years due primarily to climate desiccation (Sowunmi, 1986; Jürgens, 1997). In West Africa, savanna vegetation is Sudanian in origin (Lawson, 1986; Lawesson, 1995).

While some botanical data on *Gilletiodendron* forest is available (Portrères, 1939; Aubréville, 1939; Duong, 1947; Jaeger, 1950, 1956, 1959, 1966, 1968; Jaeger & Jarovoy, 1952; Jaeger & Lechner 1957), several details remain unclear about *Gilletiodendron* forest, which limits the understanding of chimpanzee habitat in Mali relative to other semi-arid areas where the animal occurs. What plants occur in this community, and in what abundance? Most importantly, is *Gilletiodendron* forest critical habitat for chimpanzees? If so, how may vegetation composition influence chimpanzee use of this forest type? Duvall (2000) analyzed the vegetation structure and composition of *Gilletiodendron* forest and concluded that it is a type of Sudano-Guinean gallery forest contributing significantly to floral beta diversity in Mali's Manding Plateau area. The purpose of the present paper is to clarify botanical aspects of chimpanzee habitat in the Sudanian climate zone by examining chimpanzee diet in terms of phytogeography.

METHODS

I. Site Description

From August to December 1999, seventeen *Gilletiodendron* forest groves were studied in the area immediately north of the BFR, in the Manding Plateau of western Mali (Figs. 1 & 3). Rainfall in the research area generally comes during June to October, with annual totals usually in the range of 900 to 1500mm (Kortland, 1983; PIRT, 1983; de Bie, 1991; Pavy, 1993; PREMA, 1996). However, there is significant annual variation in rainfall quantity and temporal distribution. Potential evapotranspiration is high through much of the year, while during the rainy season there is a surplus of moisture (Fig. 4). The dry season in the Bafing area may last, on average,

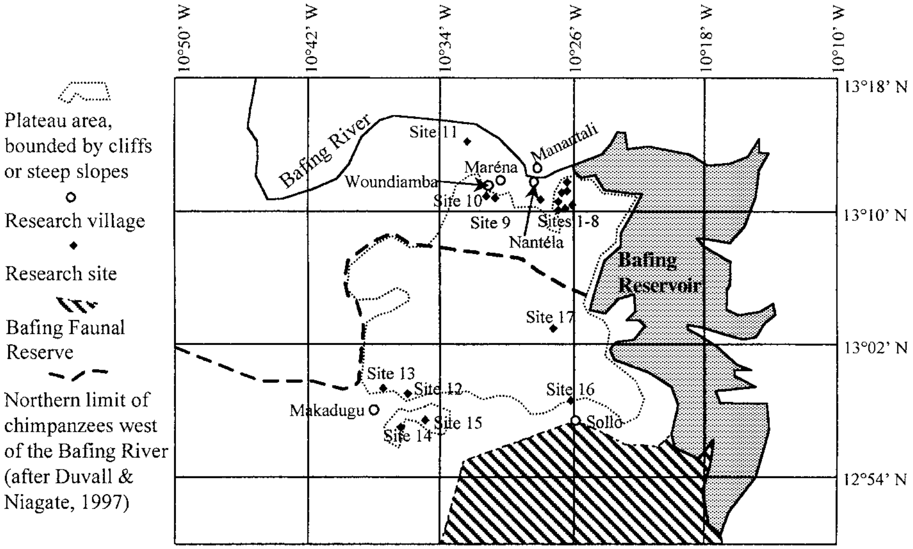


Fig. 3. Location of research sites and chimpanzee distribution in the BFR area.

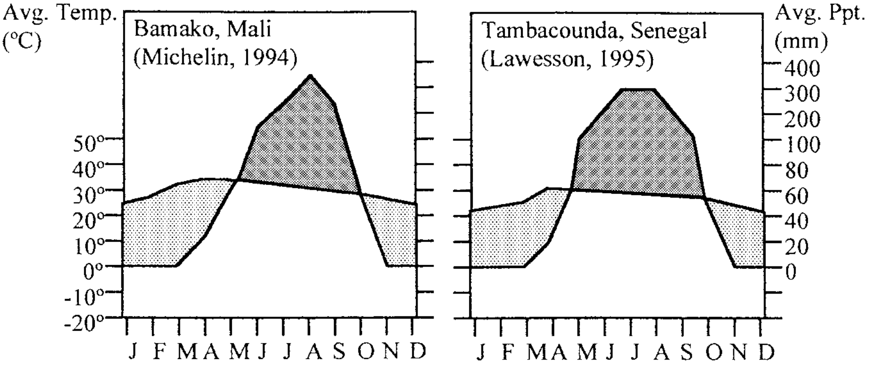


Fig. 4. Average monthly temperature and precipitation for Bamako, Mali and Tambacounda, Senegal. Abbreviations: Avg. Temp. = average temperature; Avg. Ppt. = average preciptation.

about 6.5 months (from mid-December to late June); the dry harmattan wind is a significant desiccating factor during this period throughout West Africa (Kortland, 1983; Moore, 1992). Climate in the Bafing area appears grossly similar to that of southeastern Senegal, which Baldwin (1979) and McGrew *et al*. (1981) described in detail.

The Manding Plateau area is one of the most remote and least developed parts of Mali south of the Sahel. The human population density is relatively low (5-10 persons per square kilometer [Moore, 1985; Pavy, 1993]), and the transportation infrastructure is skeletal at best (Pavy, 1993; PREMA, 1996). The natural resources in this area remain less heavily impacted by human activity especially compared with the rest of southern Mali, which is both more densely populated and more accessible (Duvall, 2000).

The research area lies within White’s (1983) “Sudanian regional center of endemism,” and contains the country’s largest remaining tracts of intact “Sudanian savanna woodland” (Warshall, 1989). Floristics and structure of vegetation in the Sudanian climate zone have been described for many sites by numerous authors since the nineteenth century, including an excellent recent monograph by Lawesson (1995) working in Senegal. Duong (1947), Aberlin (1986) and Projet Inventaire (1990) provide descriptions of floral composition of vegetation in Mali’s Sudanian climate zone. The nation’s floral resources are poorly surveyed, and the condition, distribution, and composition of rare plant communities, including *Gilletiodendron* forest, are basically unknown (Warshall, 1989; Davis *et al*., 1986). Before Duvall (2000), there had been no vegetation surveys in southwestern Mali beyond the Kita area (Boudet *et al*., 1986; Lawesson, 1995), except for a remote-sensing project which produced a vegetation map with resolution too coarse to show individual *Gilletiodendron* forest groves (Projet Inventaire, 1990).

Although population growth has led to the endangerment of some highly valued plant species, overall demand for wild plant resources has declined in the past two decades (Horowitz *et al*., 1990), particularly in locations which are marginal in the Maninka land use system (Duvall, 2000). Prior to this time, the use of plant resources found in marginal areas, such as steep slopes and plateau tops, was also probably low because these areas were largely uninhabited except in times of war (Jaeger, 1950; Cissé, 1970). *Gilletiodendron* forest groves generally occur in narrow ravines and other inaccessible locations, and are thus relatively protected from human exploitation (Duong, 1947). Although humans do have uses for plants characteristic of the *Gilletiodendron* forest, individual plants found in more accessible locations are preferentially harvested, and in most groves there is little evidence of human disturbance (Duvall, 2000). Additionally, most *Gilletiodendron glandulosum* groves are protected by topography from fire (Jaeger 1956, 1959, 1966; Jaeger & Lechner, 1957), the primary indirect effect of human activity on vegetation in the area. Thus, vegetation in the research area—specifically, in *Gilletiodendron* gallery forest groves—remains relatively undisturbed. While the effects of long-term human disturbance are not always readily evident (Kortland, 1983), the size and abundance of adult trees and lianas in most *Gilletiodendron* forest groves attest to the relatively stable ecological history of the vegetation type.

The Manding Plateau presents a magnificent landscape dominated by towering sandstone cliffs and mesas which rise to nearly 800 meters in elevation (Service Géographique d'A.O.F., 1958). The characteristic sandstone dates from the Palaeozoic era, and overlays Precambrian gneisses and schists (Jaeger & Jarovoy, 1952; Jaeger, 1959 ; de Bie, 1991). Diverse topography in the Manding Plateau creates numerous microclimates which accommodate a wide range of plant communities despite relatively poor soil quality (Duong, 1947; Killian & Schnell, 1947; Jaeger, 1956, 1959, 1966; Jaeger & Jarovoy, 1952; Schnell, 1960, 1976; Aberlin, 1986; Lawesson, 1995). Bowals, rocky laterite formations of hardened, iron-rich soils unsuitable for agriculture and are patchily covered by short grasses, are common throughout the area. On the upper surfaces of mesas, bare sandstone flats are characterized by a sparse xerophytic flora. The sandstone cliffs and plateaux erode to form deep, narrow ravines and steep, rocky slopes which are dominated by gallery forest vegetation (Killian & Schnell, 1947; Jaeger & Jarovoy, 1952; Schnell, 1960, 1976). This type of vegetation covers less than 5% of the area (Projet Inventaire, 1990), similar to the amount reported for gallery forest in the Mt. Assirik area (Baldwin, 1979; McGrew *et al*., 1981) and in the lower range for ecologically marginal chimpanzee sites reported by Kortland (1983: 267).

Lowland areas have thin clayey and sandy top soils which originate from erosion and sedimentation and are poor for agriculture (de Bie, 1991; Pavy, 1993; PREMA, 1996). Savanna woodland vegetation dominates these areas, which are favored for agriculture by the indigenous Maninka people (Duvall, 2000). As a result, most woodland areas are burnt each year, and vegetation composition and structure has been modified through eons of human activity (Aubréville, 1962; Schnell, 1976; White, 1983; Lawson, 1986; Hamilton, 1992).

II. Data Collection Techniques

1. *Botanical methods*

(1) Botanical diversity assessment

From August to November, 1999 (Table 2), individual *Gilletiodendron glandulosum* groves were located by asking Maninka residents about local vegetation and by

Table 2. Temporal distribution of data collection. Abbreviations: p.o.: participant observation; e.i.: ethnographic interviews.

Year	1995							1996												1997				1999				
Month	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	A	S	O	N	D
Fecal Samples								x	x	x	x							x	x	x	x					x	x	
Chimp. Habitat Use	x							x	x	x	x	x		x	x			x	x	x	x				x	x	x	
Vervet Diet	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	
Baboon Diet	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	
Vegetation Composition																								x	x	x	x	
Human Plant Use (p.o.)	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Human Plant Use (e.i.)																									x	x	x	x

surveying likely locations shown on topographical maps. Each of the seventeen groves located in this way was considered a single research site. The latitude and longitude of each site was recorded using a hand-held Garmin GPS-12 receiver, which has an accuracy of 15m (Garmin, 1999; Fig. 3). Site altitude was estimated to the nearest 20m based on the topographic map of the Service Géographique d'A.O.F. (1958).

At each site, voucher specimens were prepared of all ligneous plant species observed. Plants were identified using pertinent flora and botanical field guides, particularly Aubréville (1950, 1959), Hutchinson & Dalziel (1954-1972), Berhaut (1967, 1971-1979), and Geerling (1987). Specimens were deposited at the Missouri Botanical Garden (MO). All sites were visited at least twice, usually 5-10 times, over the course of 2-10 days. Although each grove was sampled independently of the others, analyses summarized data for all sites.

Two widely used indices of biological diversity were calculated for *Gilletiodendron* forest. The Simpson index estimates diversity based on the calculation, as a weighted average of abundance, of the number of occurrences of a species in a data set (Stiling, 1996). This measure is heavily weighted toward the most abundant species, and undervalues the contribution of rare species to diversity. Thus, it is not a good indicator of floral diversity in *Gilletiodendron* forest, which is heavily dominated by a small number of species. The Shannon diversity index is much more sensitive to the contribution of rare species (Stiling, 1996), and has been shown to be accurate in estimating diversity in tropical forest vegetation, which is characterized by small numbers of individuals per species (Condit *et al*., 1996). A drawback to the Shannon index is that it assumes all species present in a community are represented in the sample, a condition which is rarely met (Stiling, 1996). However, Condit *et al*. (1996) found that, for sample sizes >1000 stems, a condition which is met by the present data set ($n=3158$), the Shannon index was acceptably accurate. Both diversity indices were calculated using data from $10\text{m} \times 10\text{m}$ quadrat samples (described below).

(2) Vegetation composition and structure

Four commonly measured quantitative structural characteristics were determined using point-quarter, line intercept, and quadrat sampling. These sampling techniques, described by Barbour *et al*. (1999), are generally used to estimate the density, cover and basal dominance, frequency and importance value of plants in a community. Importance value summarizes the overall contribution of a species by combining its density, dominance and frequency values relative to other species.

A bias present in all vegetation structure data sets is that inaccessible parts of groves were not sampled with the same intensity as more accessible locations. Cliff faces, wet slopes, and narrow cliff ledges were not, in general, sampled due to safety concerns. As a result, the contribution of some plant species to vegetation structure may be inaccurately low. Since many of the species characteristic of cliff faces and wet slopes are relatively rare, this source of bias may cause estimates of the floral diversity of *Gilletiodendron* forest to be low.

i) Point-quarter sampling

The point-quarter method samples the nearest plant in each of four quadrants around a randomly placed point (Barbour *et al*., 1999). The point-to-plant distance and basal area of each plant is measured, and from this data, the frequency, density, and basal dominance values for each species can be determined. For the present research, only plants $\geq$10cm diameter at breast height (DBH) were sampled. In most instances, point-to-plant distances were measured to the nearest 0.1m using a measuring tape or fixed line. In instances where it was impossible to safely travel from point to plant because of local topography, point-to-plant distance was estimated to the nearest 0.5m. Basal area was calculated from trunk circumference. Sample points were located at the ends of randomly placed transect lines (see below), and were generally 10m apart unless greater distance was necessary to avoid sampling an individual more than once. Bamboo (*Oxytenanthera abyssinica*) was not included in this survey.

ii) Line-intercept sampling

The line-intercept method estimates plant density, cover dominance, and frequency based on the distance plants intercept randomly placed transect lines (Barbour *et al.*, 1999). Maximum plant width perpendicular to the transect line is also recorded. For the present research, two different canopy levels were sampled separately, the lower being $\leq$8m high, the upper greater than this height. This designation agrees with Lawesson's (1995) description of forest vegetation structure. However, cover was recorded per species rather than per canopy level, so that the final data reflect total percent cover rather than actual percent cover; that is, overlap of the crowns of plants in the same canopy level but belonging to different species resulted in an addition to the total transect distance actually overlain by vegetation equal to the length of overlap. Cover by *Gilletiodendron* sucker sprouts was recorded separately from cover by main stems if the main stem and sucker sprouts of an individual occupied different canopy levels. This was done due to the density of sucker sprout growth in many sites. Cover by all other plant species, including lianas, was recorded as belonging to the level occupied by more than 50% of an individual's crown. Intercept and plant width measurements were estimated to the nearest 0.25m using lines marked at meter intervals.

Consecutive 10m transect segments were laid along a line randomly chosen using degree increments on a compass and the random number generator of a hand-held calculator. Upon reaching the edge of a grove (which was generally quite apparent due to the near absence of grasses [Poaceae] within groves), the number of possible degree points of travel was determined, and the range of possible random numbers was divided by this number in order to classify directional options. The first random number generated thus determined the direction of travel along the transect line. Subsequent transect lines were chosen in the same manner once the edge of a grove had been reached on the previous transect.

iii) Quadrat sampling

Quadrat sampling entails collecting data on plants present in multi-dimensional plots (Barbour *et al.*, 1999). For the present research, quadrats were rectangular and 10m×10m (100m^2), or rarely 5m×20m due to local topography. This is the size and shape of quadrats used by Lawesson (1995) in his survey of similar vegetation in southeastern Senegal. Square quadrats tend to give lower estimates for the total number of species relative to other quadrat shapes (Condit *et al.*, 1996). In each quadrat: 1) DBH of every plant taller than 1m was measured, 2) the height of every plant greater than 10cm DBH was visually estimated; and 3) the number of individuals per species was recorded. Data from quadrat sampling were used to calculate diversity indices, as described above. Quadrats were located along alternating sides of alternating, randomly placed line transect segments.

Quadrat sampling was the most thorough method used, because individuals of all ages except seedlings were sampled. As a result, estimates of some vegetation structural characteristics based on quadrat sampling differ to an apparently high degree from those based on the other methods used. For instance, density estimates based on point-quarter sampling were lower because only larger individuals, which naturally occur at lower densities, were sampled. Line-intercept sampling yields data on both small and large individuals, so the density estimates based on this method had intermediate values.

2. *Ethnobotanical research*

Ethnobotanical research was conducted in the town of Manantali, the villages of Nantéla, Maréna and Makadugu, and the hamlets Woundiamba and old Sollo (Fig. 3). Two complementary methods of collecting ethnobotanical data were used in this research: participant observation and ethnographic interviews. Participant observation can be less structured and more informal, while ethnographic interviews can offer precision and clarify meanings behind ambiguous observations (Spradley, 1980).

(1) Participant observation

Participant observation is a widely used method in ethnographic research. While using this method, a researcher interacts with informants while doing the things they do as they do them in order to learn aspects of situations which can only be appreciated by participation (Spradley, 1980). This research technique is generally combined with formal and informal interviews. Participant observation has been used successfully in research on the Maninka and other related peoples (e.g. Shafer & Cooper, 1980; Cashion, 1982). Participant observation was conducted during all study months (Table 2).

(2) Ethnographic interviews

Ethnographic interviews were conducted between September and December, 1999 (Table 2). During the initial portion of this period, research goals were explained in a way which would not bias later responses. Specifically, the subject of research was described as an assessment of the diversity, quantity and usefulness of “yirolu min yè kuru to” (the trees found on the rocky parts of the hills) rather than something to do with *sènsão* (*Gilletiodendron glandulosum*) itself. (Maninka orthography in this paper follows Bailleul [1981]; Bird [1982] describes pronunciation in the research area.) It was feared that regular mention of the relatively uncommon tree would result in an unnaturally high rate of recall in preference-ranking questions which came later. After a significant number of semi-formal interviews had been completed, the research was described more exactly so that informants would know of the interest *Gilletiodendron glandulosum* holds for conservationists.

After a period of three weeks, ethnographic interviews were undertaken in an informal, semi-formal, or formal manner, as described by Spradley (1980). All interviews were conducted in the Maninka language. During informal interviews, informants were engaged in conversation on pertinent general subjects, without an effort to ask specific, preconceived questions. In semi-formal interviews, informants were engaged in conversation on general subjects, with usually four or five specific, preconceived questions asked as they fit comfortably into the conversation. No recording device was used during these interviews, and responses were written usually five to ten minutes afterward. Informal and semi-formal interviews were used primarily to gather general information on Maninka plant use and to clarify observations. Approximately 30 informants were interviewed informally or semi-formally.

Formal interviews were used to elicit names and uses of plants. A total of 37 informants, 9 females and 28 males aged 13 to 80, were interviewed independently in this way. During formal interviews, informants were shown fresh plant specimens and asked to identify these by name and explain their uses, as described by Cotton (1996) and Berlin (1992). Responses were written at the time of the interview. Some specific questions used semiformal and formal interviews were “nin yè yiro jumèn ti?” (Which tree is this?) and “nin yiro nafa yè mun ni mun ti?” (What are the uses of this tree?). Several informants were asked independently to identify the same plant species, and individual informants were often asked more than once on different days to identify a plant species they had previously identified. The knowledgeability of an informant was assessed informally and subjectively: rapidity of response, agreement with other informants’ responses, certainty, non-verbal communication, and depth of knowledge contributed to an overall impression of the reliability of an informant’s answers.

Determining which plant name and uses to accept as correct was usually a simple matter: the name or use cited most often by the most knowledgeable informants was accepted. No name or use was accepted as correct if cited by only one person. Rarely, when it was uncertain if a name or use which had been given by two or more individuals was correct and no other informants could independently offer a name or use, knowledgeable informants were presented with the plant in question and asked if the previously elicited name or use was correct. Such inquiries were useful in stimulating the memory of knowledgeable informants, and often elicited valuable information on plant use.

Finally, cited plant uses were attached as a piece of information to specific Maninka plant names, rather than to biological species. That is, if an informant identified a plant species with a certain Maninka name and described that plant’s use, the use was not attributed to the biological species if later interviews showed that the informant gave an incorrect name for the plant species in question.

3. *Chimpanzee habitat use*

The data reported here come from two separate periods of research. First, from June, 1995 to April, 1997 the author worked with Malian forestry agents (especially Mamadou Kamissoko) and Peace Corps Volunteers (James Shambaugh, Andrew Webster, Bradley Mulley & Josh Miller) in the Manantali area to institutionalize the BFR. While collecting data on the abundance and distribution of wildlife, the author opportunistically collected information on the distribution, diet and nesting behavior of chimpanzees. During this period, the author traveled approximately 600km on foot in the BFR area (Duvall & Niagaté, 1997). Second, seventeen *Gilletiodendron* *glandulosum* groves in the BFR area were surveyed for chimpanzee use by the author between August and December, 1999 (Fig. 3). The exact months during which data were collected is shown in Table 2.

To determine chimpanzee use of *Gilletiodendron* forest, presence of nests, feces, tracks, and evidence of feeding were recorded. The author was often accompanied by indigenous Maninka hunters (particularly Mahdi Dionsã, Famagan Dembélé & Koundioun Dembélé), who aided in the identification of evidence. The most commonly observed types of evidence were chimpanzee nests and feces. Since chimpanzee nests which still have leaves attached (an age class which Pavy, in an unpublished work [Pavy n.d. (1995)], estimated to be less than 35 days old in the BFR area) have a highly characteristic appearance, it is unlikely that any structures identified as nests were actually not evidence of chimpanzees. Indeed, it is more likely that actual chimpanzee nests were overlooked by the researcher. The standards used to identify chimpanzee feces are described below.

Chimpanzee tracks can be difficult to positively identify depending on the substrate. For instance, on mud or soft soil, distorted baboon prints can look like chimpanzee prints, which are generally larger. On harder surfaces, or if a light impression is made, chimpanzee prints can look like human prints, and vice versa. Except in a small percentage of observations, chimpanzee print identification is a fairly subjective matter, at least for an observer as inexperienced as the author. Although many ($n > 75$) probable chimpanzee prints were observed, few ($n < 10$) were recorded as positive indications of chimpanzee presence.

Chimpanzees in this area are not habituated to human observers, and sightings were rare and fleeting. No attempt has been made to follow chimpanzee groups, or to habituate animals through feeding or other means. As a result, none of the data presented here are based on direct observation of chimpanzees.

4. *Chimpanzee diet*

The techniques used to determine diet are similar to those used by Sabater Pí (1979), and meet the “rejected but likely” criteria established by McGrew *et al*. (1988: 216) for analyzing evidence of chimpanzee feeding. In other words, the results presented here are preliminary, and require direct observation of chimpanzees to confirm, but are likely grossly accurate (cf. Moreno-Black, 1978; McGrew *et al*., 1988). All plants identified in the present study as possibly part of the chimpanzee diet in the Bafing area are called “probable” chimpanzee food plants, although the preliminary nature of the findings requires additional research to accurately determine chimpanzee diet in the Bafing area.

Only plants occurring in *Gilletiodendron* forest are included in this data. However, no chimpanzee food plant has been identified for the BFR area which does not occur in *Gilletiodendron* forest, although it is likely there are such plants.

When chimpanzee fecal matter was discovered, it was collected in a plastic bag, then later dried and dissected. Individual fecal piles were not stored separately, but many piles of the same approximate dryness were collected in a single bag during the course of a day. Fecal analysis focused solely on identification of seeds. No data was collected on the presence or absence of other types of floral remains or animal remains in feces, although chimpanzees in the BFR area are probably not purely frugivorous. After dissection, all seeds were collected and identified, sometimes with the assistance of Maninka farmers or hunters. Analysis was purely qualitative (presence/absence). Only feces found directly under chimpanzee nests was analyzed. Although in many instances the fecal matter was fresh, much of the time it was not. Despite the reservations of McGrew *et al*. (1988), data collected in this way seems reliable because: 1) chimpanzees defecate daily from sleeping nests, and feces expelled in this way, at least by adult animals, tend to have a characteristic location (below a nest), shape, and texture, even when dry; and 2) the presence of most seeds in feces is unlikely to be due to "contamination" (McGrew *et al*., 1988: 215), since even relatively large seeds are clearly embedded in the fecal matrix. Disturbance of feces by dung beetles (Scarabidae), although not noted in the field, is unlikely to have influenced results because analysis did not test for insect remains, and was qualitative, not quantitative. While it is possible that baboon feces may have been falsely identified since these animals also feed on plants found in *Gilletiodendron* forest, baboon defecation sites in the Bafing area often occur on prominent rocks or cliff ledges on the edge or outside of gallery forests. By analyzing only feces found immediately below chimpanzee nests, the likelihood of misidentifications has been minimized. *Ficus* seeds were only identified to the generic level in fecal analysis. A total of 40 separate fecal groups were dissected by the author between January, 1996 and December, 1999. This data set has the following limitations: the number of samples per month is low ($\overline{X} = 4.35$), and samples have been collected only during seven months of the year (Table 2).

Second, direct observation of the diet of vervet (*Cercopithecus aethiops sabeus*) and baboon (*Papio papio*) identified several plants which are likely eaten by chimpanzees based on the known palatability and processability of the food. These primates were observed by the author in a non-systematic, opportunistic manner between June, 1995 and April 1997, and August and December, 1999. Observations were made during all months (Table 2). Although this criterion was used by McGrew *et al*. (1988), the present data are less robust because they are not derived from systematic studies of these primates, unlike McGrew *et al*.'s studies, which were part of the University of Stirling Primate Research Project.

Third, congeners of plants which met other criteria for likely chimpanzee use were also included, based on the likely chemical similarity of congeners as well as the difficulty of identifying specific traits of some seeds, especially for *Ficus* spp. This criterion is as described by McGrew *et al*. (1988). However, the validity of this criterion has yet to be shown experimentally.

Finally, the data include results from an ethnographic analysis of Maninka use of plant species found in *Gilletiodendron* forest. The methodology used is described above. Equal weight was given to human use as use by vervet or baboon in determining likely chimpanzee food plants, as long as human use did not require any type of processing by tools or fire.

Additionally, plant species characteristic of *Gilletiodendron* forest which have been reported as chimpanzee foods for *P. t. verus* from other locations in West Africa were identified through a literature review. It is less likely but nonetheless probable that these plants are eaten by chimpanzees in the Bafing area. Plants occurring in *Gilletiodendron* forest which have been reported as chimpanzee foods for *P.*

t. troglodytes or *P. t. schweinfurthii* but not for *P. t. verus* were not considered to be probable chimpanzee foods in the Bafing area.

Although there were tantalizing traces of chimpanzees feeding on bamboo (*Oxytenanthera abyssinica*) and various *Ficus* species, these observations were not included in the data set due to the unreliability of such circumstantial evidence.

RESULTS

I. Vegetation Structure and Composition

For complete results, see Duvall (2000).

1. *Canopy structure*

Gilletiodendron forest has two canopy levels, the upper greater than 8m high, the lower less than this (Fig. 5). The upper canopy is more continuous than the lower, although the latter can be more dense. In many places, the lower canopy is non-existent, and herbaceous vegetation rare. There is a remarkable consistency in the structure of the canopy, which reflects the topography characteristic of *Gilletiodendron* groves. *Grewia bicolor* and *Combretum micranthum* are the most abundant edge species, with the *Grewia* dominant in moister downslope areas, and both species abundant in more xeric upslope locations. Various lianas, especially *Hippocratea indica*, connect lower canopy shrubs and bushes to upper canopy trees especially on the mesic downslope edge of groves. On upslope edges, there are fewer lianas connecting the canopy levels, because the upper canopy is often nearly the same height as terrain bounding the upper edge of the grove. Indeed, in some locations the crown of a tree 20-25m high may hang only 1-2m above the bare upper surface of a plateau. The lower canopy is especially dense along seasonal drainage channels and around seepage areas which occur at the junction of sedimentary layers.

While the lower canopy is consistently between 3 and 7m, the height of the upper canopy seems to vary based on ecological variables, including height of boundary slopes, vegetation density, soil humidity and level of disturbance. In undisturbed, humid sites bordered by high cliffs or slopes, the upper canopy can rise 25-30m. Such sites are very well shaded and have virtually no lower canopy or herbaceous vegetation, although lianas may be present in the upper canopy. Often, shorter saxicolous trees, such as *Ficus glumosa*, *F. cordata* and *Gyrocarpus americanus*, form part of the high canopy although rooted in the rock face of the bordering cliff.

In parts of groves found along cliff edges, rock ridges, or in relatively open, flat areas, upper canopy trees tend to be lower, between 8 and 12m high. Often, in such locations, it can be difficult to clearly distinguish the two canopy levels, as several characteristic lower canopy shrubs and small trees can grow to heights of 10-12m. In locations where the upper canopy is below about 12m in height, it tends to be rather patchy, while the lower canopy is often dense.

2. *Floral diversity*

One hundred twenty-one species of woody plants belonging to at least 42 families were observed and collected (Table 3). Although the majority of plant species observed were sampled in the course of the vegetation structure survey (96 of 121), most species were relatively uncommon as a consequence of the overwhelming dominance of *Gilletiodendron glandulosum*, *Grewia bicolor* and *Hippocratea*

Fig. 5. Canopy structure in *Gilletiodendron* forest. This photo shows how the upper canopy of many *Gilletiodendron* forest groves reaches the height of neighboring cliffs or slopes. In most groves the upper and lower canopies are quite distinct in terms of height and species composition. The lower canopy can be more dense in places, but it is more patchy than the upper canopy. Chimpanzee behavior in relation to canopy structure in the BFR area is not known.

indica. The dominance of these three species contributed to the relatively low inverse Simpson index, 8.26. This score was considerably lower than that of other Sudano-Guinean gallery forest types reported by Lawesson (1995: 89), which are in the range 17.96-60.94. The Shannon index was also relatively low, 2.96, again reflecting the dominance of the three species. Additional data is necessary to understand the relative meaning of these indices.

It is important to note that *Gilletiodendron* forest contributes strongly to beta diversity in southwestern Mali (Duvall, 2000). Many plants found in *Gilletiodendron* forest are not found in other vegetation types in the area, or are present only in very low numbers. Many of the plants found in this vegetation type are characteristic of more southerly phytochoria and may reach their northern distribu-

Table 3. Ligneous plant species observed in *Gilletiodendron* forest. Maninka orthography follows Bailleul (1981); for pronunciation see Bird (1982). Sources for ‘Distribution Type’ column: Hutchinson & Dalziel (1954-1972), White (1979), Guinko (1985), Aberlin (1986), Lawesson (1995) and others. Plant distribution type abbreviations: SG = Sudano-Guinean; Su = Sudanian; W = Widespread.

Species	Maninka Name	Family	Dist. Type	Maninka Plant Use
Acacia ataxacantha DC.	wandindinwariso	Mimosoideae	W	
Acacia polyacantha Willd. ssp. *campylacantha* (Hochst. ex A. Rich.) Brenan	dènba wara si	Mimosoideae	SG	
Acridocarpus chevalierii Sprague	?	Malpighiaceae	Su	
Adansonia digitata L.	sito	Bombacaceae	W	leaves, fruit food; various
Albizia zygia (DC.) J.F. Macbr.	jakola	Mimosoideae	Su	twigs toothbrush
Allophyllus cobbe (L.) Raeusch	kada	Sapindaceae	SG	leaves medicine
Anogeissus leiocarpus (DC.) Guill. & Perr.	kèrèkèto	Combretaceae	W	lumber; various
Anthocleista nobilis G. Don	dèn ba yiro	Loganiaceae	SG	
Asparagus flagellaris (Kunth) Bak.	sòsò ngani	Liliaceae	Su	
Baissea multiflora A.DC.	kulu saba nòmbo	Apocynaceae	SG	leaves medicine; various
Berlinia grandiflora (Vahl.) Hutch. & Dalz.	?	Caesalpinoideae	SG	
Bombax costatum Pellegr. & Vuillet	bunkun	Bombaceae	W	petals food, forage; various
Boscia angustifolia A. Rich.	jaba nginjão	Capparaceae	W	leaves medicine
Boscia salicifolia Oliv.	jaba nginjão	Capparaceae	Su	
Bridelia ferruginea Benth.	dahing	Euphorbiaceae	W	leaves medicine
Burkea africana Hook. f.	kòsio	Caesalpinoideae	Su	lumber; various
Canthium sp.?	?	Rubiaceae		
Canthium venosum (Oliv.) Hiern.	wara sa kamã	Rubiaceae	W	
Celtis integrifolia Lam.	kaman yão	Ulmaceae	W	leaves food
Chaetacme aristata Planch.	sagé	Ulmaceae	SG	
Christiana africana DC.	?	Tiliaceae	SG	
Cissus populnea Guill. & Perr.	gumbão	Vitaceae	Su	sap food; various
Cissus quadrangularis L.	wulujòlòkò	Vitaceae	W	
Coccinia grandis (L.) J.C. Voigt	?	Cucurbitaceae	W	
Cola cordifolia (Cav.) R. Br.	tabo	Sterculiaceae	SG	fruit food
Cola laurifolia Mast.	bakan lè	Sterculiaceae	SG	fruit food
Combretum collinum Fresen. ssp. *hypopilinum* (Diels) Okafor	jambakatan muso	Combretaceae	SG	
Combretum glutinosum Perr. ex DC.	jambakatan kè	Combretaceae	W	firewood
Combretum micranthum G. Don	lake	Combretaceae	W	leaves, roots medicine
Combretum nigricans Lepr. ex Guill. & Perr.	sama labali jambakatan	Combretaceae	W	leaves medicine
Combretum paniculatum Vent.	kònòding dòlò	Combretaceae	W	
Combretum tomentosum G. Don	lake fing	Combretaceae	Su	stems rope
Cordia africana Lam.	?	Boraginaceae	Su	
Cordia myxa L.	daramu	Boraginaceae	W	fruit food; bark rope
Crateva adansonii DC. ssp. *adansonii*	sinamu	Capparaceae	W	leaves food
Crotalaria pallida Ait.	nginyi nginyõ	Papilionoideae	SG	
Croton sp.?	koromòndiyon	Euphorbiaceae		
Cryptolepis sanguinolenta (Lindl.) Schltr.	bonjè	Apocynaceae	SG	
Desmodium velutinum (Willd.) DC.	?	Papilionoideae	W	
Detarium microcarpum Guill. & Perr.	?	Caesalpinoideae	SG	
Detarium senegalense J.F. Gmel.	?	Caesalpinoideae	SG	
Dialium guineense Willd.	?	Caesalpinoideae	SG	
Dichrostachys cinerea (L.) Wight & Arn. ssp. *africana* Brenan & Brummit	tèrigo	Mimosoideae	W	
Diospyros abyssinica (Hiern) F. White	koronkòye fing	Ebenaceae	Su	
Diospyros mespiliformis Hochst ex A.DC.	jonbo	Ebenaceae	W	fruit food; lumber
Erythrina senegalensis DC.	tènye	Papilionoideae	Su	

Table 3. (continued)

Species	Maninka Name	Family	Dist. Type	Maninka Plant Use
Erythrophleum guineense G. Don	talo	Caesalpinoideae	SG	
Eugenia sp.?	?	Myrtaceae		
Euphorbia sudanica A. Chev.	hamo	Euphorbiaceae	Su	latex poison
Feretia apodanthera Del. ssp. *apodanthera*	tun su ma	Rubiaceae	W	leaves medicine
Ficus abutifolia (Miq.) Miq.	kobo	Moraceae	SG	leaves, bark medicine; shade
Ficus asperifolia Miq.	?	Moraceae	SG	
Ficus cordata Thunb.	(kònò dumun) seko	Moraceae	Su	fig food
Ficus glumosa Del.	toro (nganya)	Moraceae	SG	fig food
Ficus ingens (Miq.) Miq.	?	Moraceae	Su	
Ficus sur Forssk.	(dèn ba) toro	Moraceae	W	
Ficus sycomorus L. ssp. *gnaphalocarpa* (Miq.) C.C. Berg.	toro (nganya)	Moraceae	SG	
Ficus thonningii Blume	lèbe lèbe	Moraceae	W	latex medicine
Garcinia livingstonei T. Anders.	zere	Clusiaceae	Su	
Gardenia imperialis K. Schum.	kumbukamba juo	Rubiaceae	SG	
Gardenia sokotensis Hutch.	hatakulu te	Rubiaceae	Su	leaves medicine
Gilletiodendron glandulosum (Port.) J. Léonard	sènsão	Caesalpinoideae	Su	lumber
Grewia bicolor Juss.	sambe fing	Tiliaceae	W	
Grewia flavescens Juss.	sambe ge	Tiliaceae	SG	
Grewia lasiodiscus K. Schum.	?	Tiliaceae	Su	
Gyrocarpus americanus Jacq.	sabarõ	Gyrocarpaceae	Su	wood drums; seeds beads
Hexalobus monopetalus (A. Rich.) Engl. & Diels.	kunje	Annonaceae	SG	fruit food
Hibiscus sterculiifolius (Guill. & Perr.) Steud.	bami	Malvaceae	SG	stems rope
Hippocratea africana (Willd.) Loes. ex Engl.	?	Celastraceae	W	
Hippocratea indica Willd.	koronkòye	Celastraceae	W	stems tools; leaves medicine
Indigofera arrecta Hochst.	yirindin suma ko	Papilionoideae	W	
Ixora brachypoda DC.	kò kuna	Rubiaceae	Su	
Khaya senegalensis (Desr.) A. Juss.	jalo	Meliaceae	SG	lumber
Kigelia africana (Lam.) Benth.	magalintan	Bignoniaceae	W	fruit medicine
Lannea microcarpa Engl. & K. Krause	hego (nunko)	Anacardiaceae	SG	fruit food
Lannea nigritana (Sc. Elliot) Keay	?	Anacardiaceae	SG	
Lannea velutina A. Rich.	hego (nganya)	Anacardiaceae	W	
Lepisanthes senegalensis (Juss. ex Poir) Leenh.	bòòmbo	Sapindaceae	SG	
Leptactina senegambica Hook. f.	jègè bòrò	Rubiaceae	Su	stems tools
Leptadenia hastata (Pers.) Decne.	sarahate	Apocynaceae	Su	leaves food; sap medicine
Lonchocarpus laxiflorus Guill. & Perr.	?	Papilionoideae	SG	
Lophira lanceolata Van Tiegh. ex Keay	mana se	Ochnaceae	SG	leaves, stems medicine
Malacantha alnifolia (Bak.) Pierre	kababa	Sapotaceae	SG	lumber
Manilkara multinervis (Bak.) Dubard	hara to se	Sapotaceae	SG	leaves food
Maytenus senegalensis (Lam.) Exell.	tòre	Celastraceae	W	
Opilia celtidifolia (Guill. & Perr.) Endl. ex Walp.	?	Opiliaceae	W	
Oxytenanthera abyssinica (A. Rich.). Munro	bo	Poaceae	W	various
Pachystela brevipes (Bak.) Baill. ex Engl.	kamba	Sapotaceae	SG	bark rope
Paullinia pinnata L.	kalo wanjõ	Sapindaceae	SG	twigs toothbrush
Piliostigma thonningii (Schum.) Milne-Redhead	haro	Papilionoideae	SG	leaves spice
Pseudocedrela kotschyi (Schweinf.) Harms	?	Meliaceae	SG	
Psychotria psychotrioides (DC.) Roberty	?	Rubiaceae	SG	

Table 3. (continued)

Species	Maninka Name	Family	Dist. Type	Maninka Plant Use
Pterocarpus erinaceus Poir.	genu	Papilionoideae	W	lumber; leaves forage
Pterocarpus lucens Lepr. ex Guill. & Perr.	baro	Papilionoideae	W	lumber; forage; various
Pterocarpus santalinoides L'Hér. ex DC.	jagungo	Papilionoideae	SG	seeds food; lumber
Raphia sudanica A. Chev.	ban	Arecaceae	SG	sap fermented; furniture
Saba senegalensis (A.DC.) Pichon	saba	Apocynaceae	SG	fruit food
Sarcocephalus latifolius (Smith) Bruce	batio	Rubiaceae	SG	fruit food
Securinega virosa (Roxb. & Willd.) Baill.	gòròngòra	Euphorbiaceae	W	stems fencing
Smeathmannia laevigata Soland.	?	Passifloraceae	SG	
Solanum dasyphyllum Schum. & Thonn.	?	Solanaceae	SG	
Spondias mombin L.	minkòn	Anacardiaceae	Su	fruit food
Stereospermum kunthianum Cham.	mògò yiro	Bignoniaceae	W	bark, sap medicine
Strophanthus sarmentosus DC.	bonje	Apocynaceae	SG	
Syzygium guineense (Willd.) DC. ssp. *guineense*	kubu kabo	Myrtaceae	SG	
Tamarindus indica L.	tombiyõ	Caesalpinoideae	W	fruit, leaves food
Tapinanthus dodoneaefolius (DC.) Danzer	yiri la dòn	Loranthaceae	Su	
Tephrosia mossiensis A. Chev.	kalaliyon	Papilionoideae	Su	leaves spice
Terminalia macroptera Guill. & Perr.	wòlò	Combretaceae	W	lumber; firewood
Trema orientalis (L.) Blume	sukurão	Ulmaceae	W	forage; various
Trichilia emetica Vahl.	wulu dun kun	Meliaceae	SG	leaves medicine; sap poison
Unknown #1	?	Asteraceae		
Unknown #2	?	Rubiaceae		
Uvaria chamae P. de Beauv.	kara	Annonaceae	SG	
Vepris heterophylla (Engl.) R. Let.	gèngèliba	Rutaceae	Su	leaves medicine
Vernonia colorata (Willd.) Drake	kò safuno	Asteraceae	Su	leaves, stems medicine
Vitex doniana Sweet	kutuba	Verbenaceae	W	leaves food
Xeroderris stühlmannii (Taub.) Mendonça & E.P. Sousa	mansarin genu	Papilionoideae	W	
Xylopia elliotii Engl. & Diels	nkankalan je	Annonaceae	SG	
Zanha golungensis Hiern	?	Sapindaceae	Su	
Ziziphus mucronata Willd. ssp. *mucronata*	surukun tòmbòròn	Rhamnaceae	SG	fruit food, medicine

tion limit in *Gilletiodendron* forest.

Many riparian species were collected, such as *Cola laurifolia*, *Pterocarpus santalinoides* and *Garcinia livingstonei*, reflecting the mesic conditions characteristic of the forest type. Indeed, fifteen of seventeen groves had a permanent or semi-permanent source of surface water. As in other Sudano-Guinean gallery forest types, *Diospyros mespiliformis*, *Sarcocephalus latifolius*, *Saba senegalensis*, *Cissus quadrangularis*, *Spondias mombin*, *Malacantha alnifolia* and *Cissus populnea* were common in *Gilletiodendron* forest (for data on other Sudano-Guinean gallery forest types, see Roberty, 1940; Duong, 1947; Adam, 1956, 1962a, 1962b, 1963, 1965, 1966, 1968; Jaeger & Winkoun, 1962; Lawesson, 1995). Additionally, several plants which are only (or primarily) reported from gallery forests in the Sudano-Guinean phytochorion were present in *Gilletiodendron* forest, such as *Anthocleista nobilis*, *Christiana africana*, *Leptactina senegambica*, *Erythrophleum guineensis* and *Pachystela brevipes*. Not surprisingly, *Gilletiodendron* forest vegetation contained more Sudano-Guinean than Sudanian floral elements. Of 116 species whose distribution type can be determined, 41.3% (48 of 116) were of Sudano-Guinean distribution types, 34.5% (40 of 116) were widespread species, and 23.3% (27 of 116) were Sudanian-type plants. This indicates a clear Sudano-Guinean affinity for this plant community.

II. Chimpanzee Use of *Gilletiodendron* Forest

Five of six groves surveyed within currently known chimpanzee range (Fig. 3) had strong evidence of chimpanzee use. Nests were observed in Sites 13, 14 and 16, while Sites 12 and 15 were immediately adjacent to nest groups, contained permanent surface water, and showed evidence of chimpanzee presence. Additionally, Maninka hunters reported that Sites 9 and 11 were inhabited by chimpanzees until about 15 years ago. Data on chimpanzee nesting behavior in the Bafing area will be reported in a later paper.

A remarkably high number of plants characteristic of *Gilletiodendron* forest was probably eaten by chimpanzees. Table 4 lists 60 species which were probable chimpanzee food plants in the BFR area. If all these plants are indeed eaten by chimpanzees, at least 47.6% (60 of 126) of the ligneous species found in *Gilletiodendron* forest is used by these animals. While few of these species were individually abundant, as a group, likely chimpanzee food plants comprised about 35% of *Gilletiodendron* forest in terms of density, frequency, basal and cover dominance, and importance value (Table 5).

Chimpanzee diet varies seasonally, whether in forest or savanna sites (e.g. Baldwin, 1979; Doran, 1997; Yamakoshi, 1998). Additionally, chimpanzee use of different vegetation types seems to be linked to availability of food (Suzuki, 1969; Baldwin *et al*., 1982). *Gilletiodendron* forest appears to be especially important habitat for chimpanzees in the period late August to early December (the cool, humid season), because *Spondias mombin*, *Diospyros mespiliformis*, *Diospyros abyssinica*, *Sarcocephalus latifolius*, *Ziziphus mucronata*, various *Ficus* spp. and *Cola laurifolia* generally bear fruit during this period. No other probable chimpanzee food plants in the Bafing area fruit regularly during this season (see Aberlin [1986] for phenological data). In late November and December, *Adansonia digitata*

Table 4. Probable chimpanzee food plants in the BFR area. Codes for 'Parts Eaten' column: Fr = fruit; F/I = flower/inflorescence; L = leaf; L/Sh = leaf/shoot; St = stem; S/P = seed/pod; B/C = bark/cambium. Codes for 'Evidence' columns: C = chimpanzee feces; B = baboon use as food; V = vervet use as food; G = congeneric with species which meets other criteria; H = human use as food; D = documentary evidence from elsewhere in West Africa. Codes for 'Life Form' column: T = tree; S = shrub; L = liane; V = vine. Codes for 'Distribution Type' column: W = widespread; Su = Sudanian; SG = Sudano-Guinean. Codes for 'Site and Source' column: M = Mali, as reported in the present study; S = Senegal, as reported by [1] McGrew *et al*. (1988) or [2] Bermejo *et al*. (1989); G = Guinea, as reported by [3] de Bournonville (1967), [4] Sugiyama & Koman (1987), [5] Sugiyama & Koman (1992), or [6] Kortland & Holzhaus (1987); C = Côte d'Ivoire, as reported by [7] McGrew *et al*. (1997); SL = Sierra Leone, as reported by [8] Whitesides (1985).

Scientific Name	Family	Parts Eaten	Evidence						Life Form	Dist. Type	Site and Source
			C	B	V	G	H	D			
Adansonia digitata	Bombaceae	Fr	x				x	x	T	W	M; S, [1], [2]
Albizia zygia	Fabaceae	B/C						x	T	Su	G, [4], [5]
Allophyllus cobbe	Sapindaceae	Fr						x	S	SG	S, [1]; G, [4]
Bombax costatum	Bombacaceae	F/I					x	x	T	W	M; S, [1]; G, [3]
Boscia angustifolia	Capparaceae	Fr			x			x	T	W	M; S, [1]

Table 4 (Continued*)*

Scientific Name	Family	Parts Eaten	Evidence						Life Form	Dist. Type	Site and Source
			C	B	V	G	H	D			
Bridelia ferruginea	Euphorbiaceae	Fr			x			x	S	W	M; G, [4], [5]
Cissus populnea	Vitaceae	Fr	x	x	x	x		x	L	Su	M; S, [1]
Cissus quadrangularis	Vitaceae	Fr			x	x			V	W	M
Cissus rufescens	Vitaceae	Fr				x		x	V	W	M; S, [1]
Coccinia grandis	Cucurbitaceae	Fr			x				V	W	M
Cola cordifolia	Sterculiaceae	Fr			x	x	x	x	T	SG	M; S, [1]; G [3], [4], [5]
Cola laurifolia	Sterculiaceae	Fr			x	x	x		T	SG	M
Combretum tomentosum	Combretaceae	S/P						x	L	Su	S, [1]
Cordia africana	Boraginaceae	Fr				x			L	W	M
Cordia myxa	Boraginaceae	Fr			x		x	x	T	W	M; S, [1]
Crateva adansonii	Capparaceae	L					x		S	W	M
Detarium microcarpum	Fabaceae	S/P						x	T	SG	C, [7]; G, [4], [5]
Detarium senegalense	Fabaceae	S/P						x	T	SG	G, [3], [6]; SL, [8]
Dialium guineense	Fabaceae	S/P						x	T	SG	G, [3], [4], [5]
Dichrostachys cinerea	Fabaceae	L/Sh						x	T	W	G, [4]
Diospyros abyssinica	Ebenaceae	Fr			x	x			T	Su	M
Diospyros mespiliformis	Ebenaceae	Fr			x	x	x	x	T	W	M; S, [1]
Erythrophleum guineense	Fabaceae	F/I						x	T	SG	S, [1]; G, [3]
Ficus (identified to genus)	Moraceae	Fr	x								M
Ficus abutifolia	Moraceae	Fr			x	x			T	Su	M
Ficus asperifolia	Moraceae	L/Sh						x	S	SG	G, [4], [5]
Ficus cordata	Moraceae	Fr			x	x	x		T	Su	M
Ficus glumosa	Moraceae	Fr			x	x	x	x	T	SG	M; S, [1]
Ficus ingens	Moraceae	Fr		x	x	x	x	x	T	Su	M; S, [1]
Ficus sur	Moraceae	Fr			x	x	x	x	T	Su	M; G, [3], [4], [5]
Ficus sycomorus	Moraceae	Fr			x	x	x	x	T	SG	M; S, [1]; G, [4], [5]
Ficus thonningii	Moraceae	Fr				x		x	T	W	M; G, [4], [5]
Garcinia livingstonei	Clusiaceae	Fr			x				T	SG	M
Grewia bicolor	Tiliaceae	Fr	x	x	x	x	x		S	W	M
Grewia lasiodiscus	Tiliaceae	Fr		x	x	x	x	x	S	Su	M; S, [1]
Hexalobus monopetalus	Annonaceae	Fr					x	x	T	SG	M; S, [1]
Khaya senegalensis	Meliaceae	Fr						x	T	SG	S, [1]
Lannea microcarpa	Anacardiaceae	Fr			x	x	x	x	T	SG	M; S, [1]; G, [3]
Lannea velutina	Anacardiaceae	Fr				x	x	x	T	W	M; S, [1]
Leptadenia hastata	Asclepiadaceae	L					x		L	Su	M
Lophira lanceolata	Ochnaceae	B/C						x	T	SG	S, [1]; G, [3]
Malacantha alnifolia	Sapotaceae	Fr						x	T	SG	S, [1]
Manilkara multinervis	Sapotaceae	L					x		T	SG	M
Manilkara multinervis	Sapotaceae	Fr						x	T	SG	S, [1]
Opilia celtidifolia	Opiliaceae	Fr						x	L	W	S, [1]
Oxytenanthera abyssinica	Poaceae	St						x	S	W	S, [1]; G, [3]
Paullinia pinnata	Sapindaceae	Fr						x	L	SG	S, [1]
Piliostigma thonningii	Fabaceae	S/P						x	T	SG	S, [1]
Pterocarpus erinaceus	Fabaceae	F/I						x	T	W	S, [1]; G, [3]
Pterocarpus lucens	Fabaceae	F/I						x	T	W	S, [1]
Pterocarpus santalinoides	Fabaceae	S/P					x	x	T	SG	M; G, [4], [5]
Raphia sudanica	Arecaceae	Fr					x	x	T	SG	M; S, [1]
Saba senegalensis	Apocynaceae	Fr	x				x	x	L	SG	M; S, [1]; G, [3]
Sarcocephalus latifolius	Rubiaceae	Fr		x	x		x	x	L	SG	M; S, [1]; G, [3], [4], [5]
Spondias mombin	Anacardiaceae	Fr	x	x	x		x	x	T	Su	M; S, [1]; G, [3], [4], [5]
Syzygium guineense	Myrtaceae	Fr						x	T	SG	G, [3]
Tamarindus indica	Fabaceae	S/P		x	x		x	x	T	W	M; S, [1]
Uvaria chamae	Annonaceae	Fr						x	L	SG	G, [3]
Vitex doniana	Verbenaceae	L					x		T	W	M; G, [3], [4], [5]
Xylopia elliotii	Annonaceae	Fr					x		T	SG	M
Ziziphus mucronata	Rhamnaceae	Fr		x	x	x	x	x	S	SG	M; S, [1]

Table 5. Contribution of probable chimpanzee food plant species to vegetation composition in *Gilletiodendron* forest. For full scientific names, see Table 3. Abbreviations: Dens.=density; Dom.=dominance; Rel. Freq.=relative frequency; Imp. Val.=importance value; Cov. Dom.=cover dominance; Wtd. Freq.=weighted frequency; Avg. Imp. Val.=average importance value. Seven additional species (*Cissus rufescens*, *Detarium microcarpum*, *Ficus asperifolia*, *Ficus thonningii*, *Lannea velutina*, *Piliostigma thonningii*, *Pterocarpus lucens*) did not occur in samples, but occur in *Gilletiodendron* forest at low densities and frequencies.

	Point-quarter Survey				Line Intercept Survey				Quadrat Survey				
Scientific Name	Dens. (#/ha)	Dom. (mha)	Rel. Freq.	Imp. Val.	Dens. (#/ha)	Cov. Dom.	Wtd. Freq.	Imp. Val.	Dens. (#/ha)	Dom. (m/ha)	Freq.	Imp. Val.	Avg. Imp. Val.
Gr. bi.	68.45	1.29	15.25	11.65	166.00	23.02	101.00	12.66	287.80	1.14	0.70	7.22	10.51
Di. ab.	5.53	0.08	1.77	1.09	127.60	4.29	53.09	6.02	154.00	0.10	0.37	3.35	3.49
Sp. mo.	15.21	1.08	4.61	3.86	67.88	5.12	18.82	3.29	71.94	0.55	0.22	2.25	3.13
Fi. co.	4.15	0.16	13.48	4.98	26.49	0.93	5.51	0.83	14.39	0	0.06	0.43	2.04
Ad. di.	1.38	3.02	0.35	3.52					1.44	0.05	0.01	0.11	1.82
Ox. ab.					8.58	1.51	5.29	0.58	53.24	2.16	0.08	3.01	1.80
Di. me.	5.53	0.48	1.42	1.41	25.63	2.55	5.82	1.30	84.89	0.03	0.19	1.73	1.48
Ci. po.					37.04	2.67	10.11	1.77	28.78	0	0.16	1.05	1.41
Bo. co.	8.99	0.38	2.48	1.92	17.51	1.63	4.31	0.88	43.17	0.14	0.10	1.04	1.28
Sa. se.	2.07	0.02			30.63	2.58	7.17	1.47	37.41	0.02	0.12	0.96	1.22
Sa. la.	3.46	0.04	1.06	0.66	16.99	2.48	4.54	1.04	63.31	0.02	0.13	1.27	0.99
Co. to.			0.35	0.19	27.87	2.10	6.22	1.28	51.80	0.01	0.16	1.29	0.92
Ma. al.	4.15	0.06	1.42	0.85	8.69	1.14	2.07	0.50	46.04	0.12	0.14	1.24	0.86
La. mi.	4.15	0.57	1.42	1.41	6.11	2.56	1.59	0.69	4.32	0.0	0.03	0.19	0.76
Ma. mu.	4.84	0.34	1.42	1.21	3.66	1.67	0.76	0.43	17.27	0.04	0.09	0.64	0.76
Co. gr.					17.49	0.83	4.16	0.72	18.71	0	1.14	0.57	0.65
Kh. se.	0.69	0.89	0.35	1.14	0.57	0.70	0.24	0.16					0.65
Ci. qu.					13.72	1.50	3.92	0.76	12.95	0	0.07	0.46	0.61
Fi. su.	2.07	0.02	0.71	0.42	1.07	0.12	0.22	0.06	1.44	0	0.01	0.08	0.56
Bo. an.	4.15	0.15	1.42	0.95	7.08	0.60	1.47	0.33	8.63	0.01	0.06	0.38	0.55
De. se.	0.69	1.11	0.35	1.38	0.53	0.19	0.22	0.06	1.44	0	0.01	0.08	0.51
Col. co.	2.07	0.35	0.71	0.78	1.64	0.99	0.33	0.24	4.32	0.02	0.02	0.15	0.39
Br. fe.					10.70	0.42	2.78	0.44	8.63	0	0.05	0.32	0.38
Gr. la.					8.65	0.73	2.10	0.42	10.07	0	0.05	0.34	0.38
Di. ci.					19.23	0.01	4.00	0.60	4.32	0	0.02	0.14	0.37
Pt. er.	1.38	0.29	0.35	0.54	0.53	0.36	0.11	0.08	8.63	0	0.04	0.28	0.30
Al. co.	0.69	0.01	0.35	0.18	7.98	0.32	2.21	0.33	14.39	0	0.04	0.33	0.28
Co. af.	0.69	0.01	0.35	0.18	4.19	0.66	0.87	0.26	30.22	0	0.02	0.40	0.28
Fi. gl.	1.38	0.11	0.35	0.34	2.12	0.89	0.59	0.24	4.32	0.01	0.03	0.20	0.26
Lo. la.	3.46	0.10	0.71	0.61	0.69	0.26	0.14	0.07	4.32	0	0.01	0.09	0.26
Fi. sy.	2.77	0.08	0.35	0.41	2.88	0.28	0.60	0.14	5.76	0.01	0.03	0.21	0.25
Al. zy.									14.39	0	0.02	0.24	0.24
Co. la.	1.38	0.04	0.71	0.38	4.30	0.69	2.40	0.26	4.32	0	0.01	0.09	0.24
Le. ha.					1.92	0.10	0.80	0.40	1.44	0	0.14	0.08	0.24
He. mo.	0.69	0.06	0.35	0.24	5.03	0.14	1.05	0.18	8.63	0	0.04	0.28	0.23
Zi. mu.					3.21	0.04	0.67	0.11	7.19	0	0.05	0.31	0.21
Xy. el.	0.69	0.01	0.35	0.18									0.18
Op. ce.					2.77	0.25	0.57	0.13	5.76	0	0.03	0.20	0.17
Sy. gu.	0.69	0.04	0.35	0.21					1.44	0	0.01	0.08	0.15
Uv. ch.									5.76	0	0.02	0.15	0.15
Co. my.									4.32	0	0.02	0.14	0.14
Fi. in.									4.32	0	0.02	0.14	0.14
Ra. su.	0.69	0.02	0.35	0.19	1.07	0.24	0.22	0.08					0.14
Fi. ab.	0.69	0.04	0.35	0.21	0.84	0.10	0.17	0.04					0.13
Ga. li.	1.38	0.03	0.35	0.25	1.60	0.12	0.33	0.07	1.44	0	0.01	0.08	0.13

Table 5-*Continued*

	Point-quarter Survey				Line Intercept Survey				Quadrat Survey				
Scientific Name	Dens. (#/ha)	Dom. (m^2/ha)	Rel. Freq.	Imp. Val.	Dens. (#/ha)	Cov. Dom.	Wtd. Freq.	Imp. Val.	Dens. (#/ha)	Dom. (m^2/ha)	Freq.	Imp. Val.	Avg. Imp. Val.
Vi. do.	0.69	0.02	0.35	0.19	0.66	0.26	0.14	0.07					0.13
Di. gu.					3.13	0.19	0.65	0.13	1.44	0	0.01	0.08	0.11
Pt. sa.	0.69	0.02	0.35	0.19	0.84	0.19	0.17	0.06	1.44	0	0.01	0.08	0.11
Pa. pi.					0.80	0.36	0.17	0.09					0.09
Cr. ad.									2.88	0	0.14	0.08	0.08
Er. gu.									1.44	0	0.01	0.08	0.08
Ta. in.									1.44	0	0.01	0.08	0.08
Totals: (chimp. foods)	155.54	10.92			695.92	65.79			1165.6	4.43			
Totals: (all spp.)	438.31	30.52			1599.1	175.50			3289.3	34.42			
Chimp. foods, % of total	35.5%	35.8%			43.5%	37.5%			35.4%	12.9%			

(i.e. baobab) fruits ripen, and the chimpanzee diet appears to concentrate on this food (as at Mt. Assirik [McGrew *et al*., 1981]). Baobab is much more abundant outside *Gilletiodendron* forest, so chimpanzees are more likely to be found in woodland and dry forest vegetation types during the cool, dry season, although *Diospyros mespiliformis* and *Diospyros abyssinica* continue to fruit until January or February. Moore (1985) found during his survey of the Bafing area in December 1984, that most nest groups were located near fruiting baobabs. Baobab fruit remains available until about March when a variety of other wild fruits ripen, including *Grewia bicolor*, which is abundant in *Gilletiodendron* forest. However, chimpanzee food preference in the BFR area is uncertain for the period March to August (the hot, dry and hot, humid seasons). At Mt. Assirik, *Saba senegalensis*, *Cola cordifolia*, *Ficus* spp. and *Lannea* spp. are important foods during this season (McGrew *et al*., 1981; McBeath & McGrew, 1982). These plants are relatively abundant in *Gilletiodendron* forest (Duvall, 2000). At Mt. Assirik, the period May-July is the nadir of plant food supply, and increased consumption of animal foods may occur (McGrew *et al*., 1979). In any case, *Gilletiodendron* forest probably remains important chimpanzee habitat during this period because of the permanent water, shade and cool air temperatures found within groves. Indeed, use of gallery forest habitat by chimpanzees is most frequent in the dry season at Mt. Assirik (Baldwin *et al*., 1981; McGrew *et al*., 1981).

Of probable chimpanzee food plants in *Gilletiodendron* forest, 46.7% (28 of 60) were Sudano-Guinean distribution types, 35.0% (21 of 60) were widespread distribution types, and 18.3% (11 of 60) were Sudanian distribution types (Table 6). Based on analysis of the phytogeographical affinities of plants reported by McGrew *et al*. (1988), the diet in the Mt. Assirik area also consists of a higher percentage of plants with Sudano-Guinean phytogeographical affinities: 58.3% (42 of 72) are of this distribution type, while 27.8% (20 of 72) are widespread and 13.9% (10 of 72) Sudanian.

Table 6. Distribution types of probable chimpanzee food plants in the Bafing and Mt. Assirik areas. ‘Total plant species’ indicates species with analyzable phytogeographical affinities. Numbers of ‘Mt. Assirik food plants’ based on phytogeographic analysis of the plant species listed by McGrew *et al*. (1988).

	Total plant species	Sudano-guinean plants	Sudanian plants	Widespread plants
Probable chimpanzee food plants (Bafing)	60	28 (46.7%)	11 (18.3%)	21 (35.0%)
Known, likely and probable chimpanzee food plants (Mt. Assirik)	72	42 (58.3%)	10 (13.9%)	20 (27.8%)

III. Human Use of Plants in *Gilletiodendron* Forest

Many (62 of 126) plant species characteristic of *Gilletiodendron* forest have known uses for the Maninka (Table 3). (See Duvall [2000] for a complete list of Maninka plant uses.) Potential human food or medicinal use of probable chimpanzee food plants was greater than 50% (35 of 60 species). However, actual use was quite low due to the relative difficulty in accessing most *Gilletiodendron* forest groves, as well as an overall decline in use of wild plant resources over the past two decades (Horowitz *et al*., 1990; Duvall, 2000). Previous analyses of potential competition between humans and chimpanzees in West Africa have reported lower levels of overlap in plant food use, but have not included formal ethnographic research (e.g. McGrew *et al*., 1982; Sugiyama & Koman, 1992).

Few human food plants found in *Gilletiodendron* forest are marketed, and virtually all are harvested in significant quantities only during times of famine. *Saba senegalensis* fruit and *Tamarindus indica* pods are the only human foods which are regularly harvested for the market; *Bombax costatum* flowers are occasionally sold as livestock forage. *Adansonia digitata* fruit is quite commonly used, but not generally marketed. Other popular foods, particularly *Spondias mombin* fruit, *Sarcocephalus latifolius* fruit and *Lannea microcarpa* fruit, are usually harvested only opportunistically, or as a snack by children. Most other wild food plants are used only in famine years. For instance, the seeds of *Pterocarpus santalinoides* substitute for peanuts during famine, but may be eaten seasonally by chimpanzees (Sugiyama & Koman, 1987, 1992). Medicinal use of plants by humans does not heavily impact any plant population in *Gilletiodendron* forest except for the endangered shrub *Vepris heterophylla* (Duvall, 2000).

Most wild plant products used by the Maninka, including those listed above, appear to come from individual plants not found in *Gilletiodendron glandulosum* groves, while chimpanzee use of this plant community appears to be relatively intensive. The plants used most commonly are commonly used only because they are abundant outside of *Gilletiodendron* forest, in more accessible locations. Many of the most popular food plants are planted or husbanded in locations near villages, and these individual plants are heavily harvested. Fallow land is an important reservoir of useful wild plants, and is where most harvesting occurs. Plants in less accessible locations are rarely harvested. On the other hand, chimpanzee use of food plants, including cultivars, in or near villages is low (Pavy, 1993; Duvall & Niagaté, 1997). However, increased demand for wild plant resources stimulated by human population growth or improved transportation to large markets may increase the frequency of human use of *Gilletiodendron* forest (Duvall, 2000).

DISCUSSION

Gilletiodendron forest appears to be crucial habitat for chimpanzees in the Bafing area due to the abundance of food plants it contains. A considerable proportion of the vegetation consists of probable chimpanzee food plants, and these plants fruit throughout the year. Although chimpanzee use of food plants is likely to vary from year to year and relatively short-term studies are not likely to identify the majority of foods for an area (Nishida & Uehara, 1983), *Gilletiodendron* forest seems to represent a secure and diverse source of food for chimpanzees.

While vegetation structure in *Gilletiodendron* forest is interesting to consider from the standpoint of chimpanzee ecology, the absence of solid data on chimpanzee behavior in the Bafing area means that no conclusions can be made. For instance, at Mt. Assirik, chimpanzees nest frequently in gallery forest, perhaps because canopy structure provides abundant escape routes (Tutin *et al*., 1983). However, *Gilletiodendron* forest canopy exhibits some characteristics which would seemingly favor predators as much as chimpanzees. First, the upper canopy may be very near the upper surface of neighboring plateaux, providing easy access to nests by agile predators, such as leopards (*Panthera pardus*). Second, in many areas, this gallery forest type occurs in relatively flat, open areas, where the upper canopy can be rather patchy. A chimpanzee nesting in such a site would seemingly have few escape options which would not culminate in fleeing along the ground. Do chimpanzees nest in *Gilletiodendron* forest groves in such apparently vulnerable locations? There is simply insufficient knowledge of chimpanzee behavior in the BFR area to make any guess about the implications of *Gilletiodendron* forest canopy structure.

Examination of the results presented here on chimpanzee diet shows that identifying links between plant use and plant geography may provide additional sources of evidence on chimpanzee ecological history which have not yet been tapped. This information is most easily and systematically gained by analyzing plant communities individually rather than vegetation as a whole on a landscape scale. For instance, Kortland (1983: 271) found that “chimpanzee population density [in ecologically marginal areas is] not correlated with the local composition of the arboreal flora expressed in terms of percentages of *soudanien* to *guineen* [distribution types]... these apes [are] ecologically as well adapted to the dry forest... as to the rain forest.” Evidence on diet presented by McGrew *et al*. (1988) would appear to support Kortland’s conclusion, if the reader makes the reasonable but unjustified step of equating the authors’ habitat labels “forest” and “woodland” with *guineen* and *soudanien* distribution types: the majority of chimpanzee food plants are called “woodland” species. However, the majority of plants listed are actually Sudano-Guinean in terms of phytogeography, that is, Guinean with Sudanian affinities (Kortland, 1983). Thus, the evidence presented by McGrew *et al*. (1988), as well as that presented here, actually suggest that chimpanzee food plant use may be better adapted to the Sudano-Guinean phytochorion than to the Sudanian. This is contrary to the conclusions of both McGrew *et al.* (1988) and Kortland (1983) that savanna-dwelling chimpanzees are ecologically Sudanian as much as Guinean.

Gilletiodendron forest may be crucial habitat for chimpanzees in the BFR area because this plant community contributes strongly to beta diversity in southwestern Mali (Duvall, 2000). Kortland (1983) found that landscape-scale floral diversity is the most important factor determining the distribution and abundance of chimpanzees in ecologically marginal areas. Few of the species present in *Gilletiodendron* forest, as well as in other gallery forest types in southwestern Mali, southeastern Senegal, and northern Guinea, are abundant in woodland vegetation types in the area (Roberty, 1940; Duong, 1947; Killian & Schnell, 1947; Jaeger, 1956; Schnell, 1960; Aberlin, 1986; Lawesson, 1995; Duvall, 2000). Gallery forests in the Sudanian climate zone may serve as concentrations of floral diversity which enable chimpanzees to flourish because: 1) various Guinean taxa with which chimpanzees have a longer evolutionary history are abundant, 2) there is reduced seasonality in gallery forests due to the constancy of soil moisture content and reflecting the asynchronous phenology of Guinean forests, and 3) diversity in itself enhances the value of a plant community to chimpanzees. While chimpanzee population density may not be tied to the overall local proportion of Guinean to Sudanian plants, chimpanzee distribution in the Sudanian climate zone may correlate to the presence, availability, area, and diversity of Sudano-Guinean gallery forests.

Such forests are abundant in the Manding Plateau, a chain of sandstone hills and mesas in southwestern Mali and southeastern Senegal, where many Sudano-Guinean plant species reach their northern distribution limits. The northern limit of chimpanzee distribution may be linked to gallery forests, which are most abundant in areas with complex topography, due to the important contribution these vegetation types make to local floral diversity. Such a correlation would explain the historic absence of chimpanzees in central southern Mali, on the flat Niger and Bani flood plains (see maps in Kortland, 1983: 234, 244), although the animals occur (or occurred) at approximately the same latitude in hilly parts of neighboring Guinea, Côte d'Ivoire and Burkina Faso, where gallery forests are more abundant (Duong, 1947; Killian & Schnell, 1947; Aubréville, 1950, 1959; Avenard *et al.*, 1974). Gallery forests are more widespread in hilly areas than riparian forests, and would therefore provide more secure (i.e. less likely to become unavailable through the activity of predators or other animals) and less restrictive habitat for chimpanzees. Thus, the type as well as distribution of floral diversity may be an important factor in determining chimpanzee range in ecologically marginal areas.

If true, how could such a correlation affect the understanding of chimpanzee ecological history? Sudano-Guinean gallery forests, including *Gilletiodendron* forest, are relict plant communities, refugia for mesophytes which were more widespread prior to the last glacial maximum. If chimpanzee diet, spatial and temporal distribution, and behavior are as closely linked to Sudano-Guinean plants and habitats as suggested here, it may be that modern chimpanzee populations found in savanna areas are also relicts, and that chimpanzees were originally adapted to the mesic forests which were widespread especially more than 70,000 years ago (Hamilton, 1992; Dupont & Weinelt, 1996).

Finally, from the standpoint of conservation, it is important to acknowledge that the greatest competition between humans and chimpanzees may occur due to human population growth or during famine periods. There is a very high potential for competition between these species, as evidenced by the ethnobotanical data presented here. Previous analyses of potential competition between humans and chimpanzees (e.g. McGrew *et al*., 1982; Sugiyama & Koman, 1992) have not included thorough ethnographic research, and thus have not fully represented the likelihood of direct competition. Although the level of use of wild plants by the Maninka in marginal areas is currently low, population growth will increase the value of resources found in these areas (Weber *et al*., 1996). Relatively simple measures to protect a high number of *Gilletiodendron glandulosum* groves could be combined with ongoing conservation efforts to successfully protect this habitat (Duvall, 2000). Although population growth is likely to continue in the Manantali area (although Pavy [1993] reports a negative demographic trend for the BFR itself), effective protection of marginal areas would likely enable the chimpanzee population to survive (Happold, 1995). The BFR area has a high potential for chimpanzee conservation, and should receive greater attention from primate conservationists, even if other large animals, especially predators, have been extirpated, thus making the area less valuable for some types of research (Moore, 1985).

Plant resources in *Gilletiodendron* forest and other relatively inaccessible plant communities are lightly used by the Maninka except in times of great need. Thus, although the potential for chimpanzee and human competition in the BFR area is high, there appears to be niche separation between the primate species based primarily on topography. Humans prefer relatively flat areas which are easy to cultivate, while chimpanzees favor cliffs, hills and steep slopes (Kortland, 1983; Pavy, 1993). However, preference is not an absolute determinant of behavior, and both species probably utilize most local plant communities to some extent. Further research is required to determine how the two species actually compete for resources. In any case, the importance of support and participation by primate conservationists in monitoring, early intervention and relief efforts associated with human food shortage in areas of marginal chimpanzee habitat should be emphasized.

NOTE

An abridged version of Duvall (2000), which may not be available to many readers, will be published in the Proceedings of the XVIth AETFAT Congress, which was held in Brussels, Belgium from August 27-September 2, 2000.

ACKNOWLEDGEMENTS I thank M. Hamid Ag Mohamed Lamine, Directeur de la Direction National de la Conservation de la Nature du Mali and Dr. Mamadou Diallo Iam, Directeur du Centre Malien de Recherche Scientifique et Technologique, for their permission to conduct research in Mali. The International Primate Protection League and the American Association of Zoos and Aquariums Antelope Taxon Advisory Group have provided funding for the work of Peace Corps Volunteers in the BFR. The Missouri Botanical Garden, San

José State University Department of Biological Sciences, and Peace Corps-Mali provided important material or technical support to the author. I thank G. Klee, R. Myatt, L. Sikkink, M. Kamissoko, B. Niagaté, G. Diallo, J. Dacko, J. Shambaugh, A. Webster, B. Mulley, J. Miller, M. Dionso, F. Dembélé, K. Dembélé, F. Kéïta, N. Suko, J. Kéïta and J. Duvall for their assistance with this research. W. McGrew, J. Moore and an anonymous reviewer provided valuable critical comments on an earlier draft of this paper.

REFERENCES

Aberlin, J.-P. 1986. Recherches phytosociologiques et phytogeographiques au Mali central. Thèse présentée à la faculté des Sciences et Techniques de Saint-Jérôme, Université de Droit, d'Economie, et des Sciences d'Aix-Marseille.

Adam, J.G. 1956. Éléments pour la phytosociologie de l'Afrique occidentale. *Bulletin de la Société Botanique de France*, 103: 12-21.

——— 1962a. Contribution à l'étude de la flore et de la végétation de l'Afrique occidentale. La Basse-Casamance (Sénégal). Deuxième partie. *Bulletin de l'Institut Fondamental d'Afrique Noire*, série A, 24(1): 116-153.

——— 1962b. Une forêt de Copaliers au Sénégal (*Guibourtia copallifera* Benn.). Répartition en Afrique occidentale. *Bulletin de la Société Botanique de France*, 109: 185-191.

——— 1963. Les forêts de *Symmeria-Hunteria* des berges de la Gambi-Koulountou (Sénégal sud-oriental). *Bulletin de l'Institut Fondamental d'Afrique Noire*, série A, 25: 24-37.

——— 1965. Généralités sur la flore et la végétation du Sénégal. *Études Sénégalaises*, 9: 155-214.

——— 1966. Composition floristique des principaux types physionomiques de végétation du Sénégal. *Journal of the West African Science Association*, 11(1-2): 81-97.

——— 1968. La flore et la végétation du Parc National du Niokolo-Koba (Sénégal). *Adansonia*, série 2, 8: 439-459.

Aubréville, A. 1939. Forêts reliques en Afrique Occidentale Française. *Revue Internationale de Botanique Appliquée et d'Agriculture Tropicale*, 19: 479-484.

——— 1950. *Flore Forestière Soudano-Guinéenne: AOF-Cameroun-AEF*. Société d'Éditions Géographiques, Maritimes, et Coloniales, Paris.

——— 1959. *Flore Forestière de la Côte d'Ivoire*. 3 vols. 2d ed. Centre Technique Forestier Tropical, Nogent-sur-Maarne, France.

——— 1962. Savanisation tropicale et glaciations quaternaires. *Adansonia*, 2: 16-84.

Avenard, J.-M., J. Bonvallot, M. Latham, M. Renard-Dugerdil & J. Richard 1974. *Aspects du Contact Forêt-Savane dans le Centre et l'Ouest de la Côte d'Ivoire: Étude Descriptive*. ORSTOM, Paris.

Bailleul, C. 1981. *Petit Dictionnaire Bambara-Français, Français-Bambara*. Avebury, London.

Baldwin, P.J. 1979. The natural history of the chimpanzee (*Pan troglodytes verus*) at Mt. Assirik, Senegal. Unpublished Ph. D. dissertation, Department of Psychology, University of Stirling, Stirling, UK.

Baldwin P.J., W.C. McGrew & C.E.G. Tutin 1982. Wide-ranging chimpanzees at Mt. Assirik, Senegal. *International Journal of Primatology*, 3: 367-385.

Baldwin, P.J., J. Sabater Pí, W.C. McGrew & C.E.G. Tutin 1981. Comparisons of nests made by different populations of chimpanzees (*Pan troglodytes*). *Primates*, 22: 474-486.

Barbour, M.G., J.H. Burk, W.D. Pitts, F.S. Gilliam & M.W. Schwartz 1999. *Terrestrial*

Plant Ecology. Addison Wesley Longman, Menlo Park, USA.

Berhaut, J. 1967. *Flore du Sénégal*. 2d ed. Clairafrique, Dakar.

——— 1971-1979. *Flore Illustrée du Sénégal*. 6 vols. Direction des Eaux et Forêts, Ministère du Développement Rural et d'Hydraulique, Gouvernement du Sénégal, Dakar.

Berlin, B. 1992. *Ethnobiological Classification: Principles of Categorization of Plants and Animals in Traditional Societies*. Princeton University, Princeton, USA.

Bermejo, M., G. Illera & J. Sabater Pí 1989. New observations on the tool-behavior of chimpanzees from Mt. Assirik (Senegal, West Africa). *Primates*, 30: 65-73.

Bird, C.S., ed. 1982. *The Dialects of Mandekan*. Indiana University, Bloomington, USA.

Boudet, G., J.P. Lebrun & R. Demange 1986. *Catalogue des Plantes Vasculaires du Mali*. Institut d'Élevage et de Médecine Vétérinaire des Pays Tropicaux, Maisons Alfort, France.

Cashion, G.A. 1982. Hunters of the Mandé: A behavioral code and worldview derived from the study of their folklore. Unpublished Ph. D. Dissertation, Indiana University, Bloomington, USA.

Cissé, D. 1970. *Structures des Malinké du Kita*. Éditions Populaires, Bamako, Mali.

Clutton-Brock, T.H. & J.B. Gillett 1979. A survey of forest composition in the Gombé National Park. *African Journal of Ecology*, 17: 131-158.

Condit, R., S.P. Hubbell, J.V. Lafrankie, R. Sukumar, N. Manokaran, R.B. Foster & P.S. Ashton 1996. Species-area and species-individual relationships for tropical trees: A comparison of three 50-ha plots. *Journal of Ecology*, 84: 549-562.

Cotton, C.M. 1996. *Ethnobotany: Principles and Applications*. Wiley, Chichester, UK.

Davis, S.D., S.J.M. Droop, P. Gregerson, L. Henson, C.J. Leon, J.L. Villa-Lobos, H. Synge & J. Zantovska 1986. *Plants in Danger: What Do We Know?* IUCN, Gland, Switzerland.

De Bie, S. 1991. Wildlife resources of the West African savanna. *Wageningen Agricultural University Papers*, 91: 1-266.

De Bournonville, D. 1967. Contribution à l'étude du chimpanzé en République de Guinée. *Bulletin de l'Institut Fondamental d'Afrique Noire*, série A, 29: 1188-1269.

Doran, D. 1997. Influence of seasonality on activity patterns, feeding behavior, ranging and grooming patterns in Taï chimpanzees. *International Journal of Primatology*, 18: 183-206.

Duong H.T. 1947. Introduction à l'étude de la végétation du Soudan français. *Conferencia International dos Africanistas Ocidentais, Bissau*, 2: 9-51.

Dupont, L.M. & M. Weinelt 1996. Vegetation history of the savanna corridor between the Guinean and the Congolian rain forest during the last 150,000 years. *Vegetation History and Archaeobotany*, 5: 273-292.

Duvall, C. 2000. Conservation of the tree *Gilletiodendron glandulosum* in Mali, West Africa. Unpublished M.S. thesis, San José State University, San José, USA.

Duvall, C. & B. Niagaté 1997. *Inventaire Préliminaire des Mammifères, Oiseaux, et Reptiles de la Réserve de Faune du Bafing*. Direction Nationale des Ressource Forestières, Fauniques, et Halieutiques, Gouvernement de la République du Mali, Bamako, Mali. TMs (photocopy).

Garmin Corporation 1999. *GPS 12 Personal Navigator Owner's Manual and Reference*. Garmin International, Olathe, USA.

Geerling, C. 1987. *Guide de Terrain des Ligneux Sahélians et Soudano Guinéens*. 2nd ed. Wageningen Agricultural University, Wageningen, The Netherlands.

Guinko, S. 1985. Contribution à l'étude de la végétation et de la flore du Burkina Faso. Les reliques boisées ou bois sacrés. *Bois et Forêts des Tropiques*, 208: 29-36.

Hamilton, A.C. 1992. History of forests and climate. In (J.A. Sayer, C.S. Harcourt & N.M. Collins, eds.) *The Conservation Atlas of Tropical Forests: Africa*, pp. 17-25. IUCN/

Simon & Schuster, New York.

Happold, D. 1995. The interactions between humans and mammals in Africa in relation to conservation: A review. *Biodiversity and Conservation*, 4: 395-414.

Horowitz, M., D. Koenig, C. Grimm & Y. Konaté 1990. *Resettlement at Manantali, Mali: Short-Term Success, Long-Term Problems*. Institute of Development Anthropology, Birmingham, USA.

Hutchinson, J. & J.M. Dalziel 1954-1972. *Flora of West Tropical Africa*, 3 vols. 2d ed. Revised by R.W.J. Keay and edited by F.N. Hepper. Crown Agents for Oversea Governments and Administrations, London.

Izawa, K. 1970. Unit groups of chimpanzees and their nomadism in the savanna woodland. *Primates*, 11: 1-46.

Izawa, K. & J. Itani 1966. Chimpanzees in Kasakati Basin, Tanganyika. (I) Ecological study in the rainy season 1963-1964. *Kyoto University African Studies*, 1: 73-156.

Jaeger, P. 1950. Aperçu sommaire de la végétation du Massif de Kita (Soudan Français). *Revue de Botanique Appliquée et l'Agriculture Tropicale*, 30: 501-506.

———— 1956. Contribution à l'étude des forêts reliques du Soudan occidental. *Bulletin de l'Institut Français d'Afrique Noire,* série A, 18(4): 993-1053.

———— 1959. Les plateaux gréseux du Soudan occidental. Leur importance phytogéographique. *Bulletin de l'Institut Français d'Afrique Noire,* série A, 21(4): 1147-1159.

———— 1966. Sur l'endémisme dans les plateaux soudanais ouest-africains. *Compte Rendu Sommaire des Séances de la Société de Biogéographie,* 368: 38-48.

———— 1968. Mali. *Acta Phytogeographica Suecica*, 54: 51-53.

Jaeger, P. & M. Jarovoy 1952. Les grès de Kita (Soudan occidental): Leur influence sur la répartition du peuplement végétal. *Bulletin de l'Institut Français d'Afrique Noire*, série A, 14(1): 1-18.

Jaeger, P. & E. Lechner 1957. Observations et réflexions au sujet du biotope du Kololo [*Gilletiodendron glandulosum* (Port.) J. Léonard, Césalpinacées]. *Comptes Rendus Hebdomadaires des Séances de l'Academie des Sciences*, 245: 944-946.

Jaeger, P. & D. Winkoun 1962. Premier contact avec la flore et la végétation du plateau de Bandiagara. *Bulletin de l'Institut Fondamental d'Afrique Noire,* série A, 1a: 69-111.

Jürgens, N. 1997. Floristic biodiversity and history of African arid regions. *Biodiversity and Conservation,* 6: 495-514.

Kano, T. 1972. Distribution and adaptation of the chimpanzee on the eastern shore of Lake Tanganyika. *Kyoto University African Studies*, 7: 37-129.

Killian, C. & R. Schnell 1947. Contribution à l'étude des formations végétales et des sols humifères correspondants des massifs du Benna et du Fouta-Djallon (Guinée française). *Revue Canadienne de Biologie*, 6(3): 379-435.

Kortland, A. 1983. Marginal habitats of chimpanzees. *Journal of Human Evolution*, 12: 231-278.

Kortland, A. & E. Holzhaus 1987. New data on the use of stone tools by chimpanzees in Guinea and Liberia. *Primates*, 28: 473-496.

Küchler, A.W. 1988. The classification of vegetation. In (A.W. Küchler & I.S. Zonneveld, eds.) *Vegetation Science*, pp. 67-80. Kluwer, Dordrecht, Germany.

Lawesson, J.E. 1995. Studies of woody flora and vegetation in Senegal. *Opera Botanica*, 125: 1-172.

Lawson, G.W., ed. 1986. *Plant Ecology in West Africa: Systems and Processes*. Wiley, Chichester, UK.

Maley, J. 1987. Fragmentation de la forêt dense humide africaine et extension des biotopes montagnards au Quaternaire récent: Nouvelles données polliniques et chronologiques.

Implications paléoclimatiques et biogéographiques. *Palaeoecology of Africa and the Surrounding Islands*, 18: 307-336.

McBeath, N.M. & W.C. McGrew 1982. Tools used by wild chimpanzees to obtain termites at Mt. Assirik, Senegal: The influence of habitat. *Journal of Human Evolution*, 11: 65-72.

McGrew, W.C., P.J. Baldwin & C.E.G. Tutin 1981. Chimpanzees in a hot, dry and open habitat: Mt. Assirik, Senegal, West Africa. *Journal of Human Evolution*, 10: 227-244.

——— 1982. Observations préliminaires sur les chimpanzés (*Pan troglodytes verus*) du Parc National du Niokolo-Koba. *Mémoires de l'Institut Fondamental d'Afrique Noire*, 92: 333-340.

——— 1988. Diet of wild chimpanzees (*Pan troglodytes verus*) at Mt. Assirik, Senegal: I. Composition. *American Journal of Primatology*, 16: 213-226.

McGrew, W.C., C.E.G. Tutin & P.J. Baldwin 1979. Chimpanzees, tools, and termites: Cross-cultural comparisons of Senegal, Tanzania and Rio Muni. *Man*, 14: 185-214.

McGrew, W.C., M.J. Sharman, P.J. Baldwin & C.E.G. Tutin 1982. On early hominid plant-food niches. *Current Anthropology*, 23: 213-214.

McGrew, W.C., R.M. Ham, L.J.T. White, C.E.G. Tutin & M. Fernandez 1997. Why don't chimpanzees in Gabon crack nuts? *International Journal of Primatology*, 18(3): 353-374.

Michelin 1994. *Afrique Nord et Ouest* [Map]. Michelin, Paris.

Moore, J. 1984. Chimpanzee survey in the Republic of Mali. Summary report to Eaux et Forêts, Mali. TMs (photocopy).

——— 1985. Chimpanzee survey in Mali, West Africa. *Primate Conservation*, 6:59-63.

——— 1992. "Savanna" chimpanzees. In (T. Nishida, W.C. McGrew, P. Marler, M. Pickford & F.B.M. de Waal, eds.) *Topics in Primatology, Vol. 1: Human Origins*, pp. 99-118. University of Tokyo Press, Tokyo.

Moreno-Black, G. 1978. The use of scat samples in primate diet analysis. *Primates*, 19: 215-221.

Nishida, T. & S. Uehara 1983. Natural diet of chimpanzees (*Pan troglodytes schweinfurthii*): Long-term record from the Mahale Mountains, Tanzania. *African Study Monographs*, 3: 109-130.

Pavy, J.-M. 1995. Mali: Chimpanzee census and conservation issues. TMs (photocopy).

Pavy, J.-M. 1993. Mali: Bafing Faunal Reserve: Biodiversity and Human Resource: Survey and Recommendations. TMs (photocopy).

PIRT 1983. *Les Ressources Terrestres au Mali*. Government of Mali/US-AID/TAMS, New York.

Portrères, R. 1939. Quatre légumineuses nouvelles de l'Afrique Occidentale. *Revue Internationale de Botanique Appliquée et l'Agriculture Tropicale*, 20: 785-789.

PREMA (Projet développement rural régional Manantali). 1996. Analyse régionale réduite de la région de Manantali. PREMA, Bamako, Mali. TMs (photocopy).

Projet Inventaire par Télédétection des Ressources Ligneuses et de l'Occupation Agricole des Terres au Mali 1990. *Carte des Formations Végétales: Bafoulabé-Kita*. [Map.] Ministère de l'Environnement et de l'Élévage, Gouvernement de la République du Mali, Bamako, Mali.

Roberty, G. 1940. Contribution à l'étude phytogéographique de l'Afrique Occidentale Française. *Candollea*, 8: 83-137.

Sabater Pí, J. 1979. Feeding behavior and diet of chimpanzees (*Pan troglodytes troglodytes*) in the Okorobiko Mountains of Rio Muni (West Africa). *Zeitschrift fur Tierpsychologie*, 50:265-281.

Sayer, J.A. 1977. Conservation of large mammals in the Republic of Mali. *Biological*

Conservation, 12: 245-263.

Schnell, R. 1960. Notes sur la végétation et la flore des plateaux gréseux de la moyenne Guinée et de leurs abords. *Revue Générale de Botanique*, 67: 325-398.

———— 1976. *Flore et Végétation de l'Afrique Tropicale*. Vol. 1. Gaulthier-Villars, Paris.

Service Géographique d'Afrique Occidentale Française 1958. *Bafoulabé*. [Map]. Service Géographique d'Afrique Occidentale Française, Dakar.

Shafer, M. & C. Cooper 1980. *Mandinko: The Ethnography of a West African Holy Land*. Holt, Rinehart & Winston, New York.

Sowunmi, M.A. 1986. Change of vegetation with time. In (G.W. Lawson, ed.) *Plant Ecology in West Africa: Systems and Processes*, pp. 273-307. Wiley, Chichester, UK.

Spradley, J.P. 1980. *Participant Observation*. Holt, Rinehart & Winston, New York.

Stiling, P.D. 1996. *Ecology: Theories and Applications*. 2d ed. Prentice Hall, Upper Saddle River, USA.

Sugiyama, Y. & J. Koman 1987. A preliminary list of chimpanzees' alimentation at Bossou, Guinea. *Primates*, 28: 133-147.

———— 1992. The flora of Bossou: Its utilization by chimpanzees and humans. *African Study Monographs*, 13: 127-169.

Suzuki, A. 1969. An ecological study of chimpanzees in savanna woodland. *Primates*, 10: 103-148.

Tutin, C.E.G., W.C. McGrew & P.J. Baldwin 1983. Social organization of savanna-dwelling chimpanzees, *Pan troglodytes verus*, at Mt. Assirik, Senegal. *Primates*, 24:154-173.

Warshall, P. 1989. *Mali: Biological Diversity Assessment*. Natural Resources Management Support Project, United States Agency for International Development. AID Project No. 698-0467.

Weber, G., J. Smith & M.V. Manyong 1996. System dynamics and the definition of research domains for the northern Guinea savanna of West Africa. *Agriculture, Ecosystems, and Environment*, 57: 133-148.

White, F. 1979. The Guineo-Congolian Region and its relationships to other phytochoria. *Bulletin du Jardin Botanique National de Belgique*, 49: 11-55.

———— 1983. *The Vegetation of Africa: Maps and Memoir*. UNESCO/AETFAT/ UNSO, Paris.

Whitesides, G.H. 1985. Nut cracking by wild chimpanzees in Sierra Leone, West Africa. *Primates*, 26(1): 91-94.

Yamakoshi, G. 1998. Dietary responses to fruit scarcity of wild chimpanzees at Bossou, Guinea: Possible implications for ecological importance of tool use. *American Journal of Physical Anthropology*, 106: 283-295.

———— Accepted *December 28, 2000*

Author's Name and Address: Chris S. DUVALL, *Department of Geography, University of Wisconsin, Madison, WI53706-1491 U.S.A. E-mail: carwash467@hotmail.com*