2000

Conservation of the tree *Gilletiodendron Glandulosum* in Mali, West Africa

Chris S. Duvall
San Jose State University

Follow this and additional works at: https://scholarworks.sjsu.edu/etd_theses

Recommended Citation

Duvall, Chris S., "Conservation of the tree *Gilletiodendron Glandulosum* in Mali, West Africa" (2000).
Master's Theses. 1987.
DOI: <https://doi.org/10.31979/etd.sy64-t333>
https://scholarworks.sjsu.edu/etd_theses/1987

This Thesis is brought to you for free and open access by the Master's Theses and Graduate Research at SJSU ScholarWorks. It has been accepted for inclusion in Master's Theses by an authorized administrator of SJSU ScholarWorks. For more information, please contact scholarworks@sjsu.edu.

INFORMATION TO USERS

This manuscript has been reproduced from the microfilm master. UMI films the text directly from the original or copy submitted. Thus, some thesis and dissertation copies are in typewriter face, while others may be from any type of computer printer.

The quality of this reproduction is dependent upon the quality of the copy submitted. Broken or indistinct print, colored or poor quality illustrations and photographs, print bleedthrough, substandard margins, and improper alignment can adversely affect reproduction.

In the unlikely event that the author did not send UMI a complete manuscript and there are missing pages, these will be noted. Also, if unauthorized copyright material had to be removed, a note will indicate the deletion.

Oversize materials (e.g., maps, drawings, charts) are reproduced by sectioning the original, beginning at the upper left-hand corner and continuing from left to right in equal sections with small overlaps.

Photographs included in the original manuscript have been reproduced xerographically in this copy. Higher quality 6" x 9" black and white photographic prints are available for any photographs or illustrations appearing in this copy for an additional charge. Contact UMI directly to order.

**Bell & Howell Information and Learning
300 North Zeeb Road, Ann Arbor, MI 48106-1346 USA
800-521-0600**

UMI[®]

CONSERVATION OF THE TREE
GILLETIODENDRON GLANDULOSUM
IN MALI, WEST AFRICA

A Thesis

Presented to

The Faculty of the Department of Environmental Studies
San José State University

In Partial Fulfillment

of the Requirements for the Degree

Master of Science

by

Chris S. Duvall

May 2000

UMI Number: 1399791

UMI Microform 1399791

Copyright 2000 by Bell & Howell Information and Learning Company.

All rights reserved. This microform edition is protected against
unauthorized copying under Title 17, United States Code.

Bell & Howell Information and Learning Company
300 North Zeeb Road
P.O. Box 1346
Ann Arbor, MI 48106-1346

© 2000

Chris S. Duvall

ALL RIGHTS RESERVED

Dr. Gary A. Klee, Committee Chair
Department of Environmental Studies

Dr. Rodney Myatt
Department of Biological Sciences

Dr. Lynn Sikkink
Department of Anthropology

APPROVED FOR THE UNIVERSITY

ABSTRACT

CONSERVATION OF THE TREE GILLETIODENDRON GLANDULOSUM IN MALI, WEST AFRICA

by Chris S. Duvall

The conservation status of the vulnerable endemic tree Gilletiodendron glandulosum (Fabaceae) was assessed in southwestern Mali. Using basic forestry methods, structure and composition of its plant community were analyzed. Additionally, Maninka names and uses of characteristic plants were recorded. Of 126 species collected, 11 are new records for Mali. The vegetation is overwhelmingly dominated by G. glandulosum, although Grewia bicolor (Tiliaceae) and Hippocratea indica (Celastraceae) are also important. Use of characteristic plants is low, although the endangered bush Vepris heterophylla (Rutaceae) appears overharvested. No conservation measures specifically benefit the vegetation, which is passively protected by its marginal place in the Maninka land use system.

ACKNOWLEDGEMENTS

Many people were crucial in the completion of this project. I wish to thank in particular the members of my faculty committee, Gary Klee, Rod Myatt, and Lynn Sikkink, who gave copiously of their time, knowledge, and patience to enable me to undertake this research. Malians are incredibly gracious and hospitable people, and I could not list all the people in Mali who have helped and inspired me. My *jatigi* (host) Djelifili Kéïta, and his wife Narkoukou Dansira, as well as their children, deserve more than I can offer for welcoming me into their family. I thank the *dugutigi* (chief) of Maréna, Karamakanba Kéïta, for his hospitality and support. Bourama Niagaté, Kendefing Kéïta, Djiguiba Kéïta, Brahim Camara, Mahdi Dionsan, Famagan Dembélé, Koundiou Dembélé, Haguimba Kéïta, Saran Sylla, and many others provided valued assistance and friendship. Josh Miller and all the Peace Corps Volunteers in the Manantali area were extremely hospitable and patient, and greatly aided my work.

While in Mali, I received important institutional support from the Direction Nationale de la Conservation de la Nature and the Centre National de la Recherche Scientifique et Technologique. I thank these institutions for allowing me the opportunity to conduct research in Mali. The Missouri Botanical Garden provided valuable material and technical assistance. Finally, the Interlibrary Loan Department at San José State University's Clark Library was crucial in tracking down some obscure references.

And my wife Jen strongly supported me the whole way even though the four months were much harder for her than for me. Thanks, Jen Broidy!

CONTENTS

LIST OF ILLUSTRATIONS	ix
LIST OF TABLES	xi
LIST OF APPENDICES	xii
Chapter	
I. INTRODUCTION	
Motivation	1
Background	3
Comments Regarding Vegetation Terms	3
Pronunciation of Maninkakan Words	5
Available Data on <u>Gilletiodendron</u> Forest	6
Ecological Component of Plant Conservation	11
Ethnobotanical Component of Plant Conservation	13
Maninka Ethnography	15
Summary of Literature Review	21
Thesis Statement and Research Objectives	21
Purpose	21
Objectives	22
II. RESEARCH DESIGN	
Conceptual Framework	24
Overview of Data Collection Strategy	24

Site Description	25
Components of Research	33
Botanical Diversity Assessment	32
Vegetation Composition and Structure	35
Ethnobotanical Research	38
III. RESULTS	
Overview	46
Results from Analyses	46
Botanical Diversity	46
Vegetation Structure and Composition	50
Ethnobotanical Significance of <u>Gilletiodendron</u> Forest	57
Current Conservation Efforts	65
Summary of Main Findings	68
IV. DISCUSSION	
Overview	70
Conclusions	71
Conservation Value of <u>Gilletiodendron</u> Forest	71
Conservation Status of <u>Gilletiodendron</u> Forest	77
Recommendations	83
ILLUSTRATIONS	87
TABLES	125

SOURCES CITED 158

APPENDICES 172

ILLUSTRATIONS

<u>Figure</u>	<u>Page</u>
1. West Africa, Showing International Boundaries and Phytochoria	88
2. Relationship between Precipitation and Vegetation in West Africa	89
3. Map of Western Mali and Surrounding Areas	90
4. Landscape of Manding Plateau Area, Southwestern Mali	91
5. Location of Research Villages and Traditional <i>Kafolu</i>	92
6. Mature <u>Gilletiodendron glandulosum</u> Individual	93
7. <u>Gilletiodendron glandulosum</u> Leaves	94
8. Trunk of Mature <u>Gilletiodendron glandulosum</u> Individual	95
9. <u>Gilletiodendron glandulosum</u> Bark, Showing Color of Slash	96
10. <u>Gilletiodendron glandulosum</u> Fruits	97
11. <u>Gilletiodendron glandulosum</u> Seedlings	98
12. Djiguiba Kéïta and His Daughter Sadio Suko	99
13. Location of Research Sites	100
14. Average Monthly Temperature and Precipitation for Bamako, Mali and Tambacounda, Senegal	101
15. Sudanian Savanna Woodland	102
16. Weathered Sandstone	103
17. Bowal	104
18. Manantali Dam	105

19. Line-intercept Survey Work	106
20. Maninka <i>Birelu</i> (Hangars) in Use	107
21. Components of Maninka Architectural Structures	108
22. Formal Ethnographic Interviews	109
23. Ravine Grove	110
24. Ledge Grove	111
25. Seepage Area	112
26. <u>Gilletiodendron</u> Forest Grove Unprotected from Fire	113
27. Upper Canopy of <u>Gilletiodendron</u> Forest Grove	114
28. Lower Canopy of <u>Gilletiodendron</u> Forest Grove	115
29. Profile of Vegetation in Idealized <u>Gilletiodendron glandulosum</u> Grove	116
30. <u>Hippocratea indica</u> Leaves and Fruit	117
31. Lianas Hanging from <u>Gilletiodendron glandulosum</u> Trunk	118
32. <u>Euphorbia sudanica</u>	119
33. <u>Tephrosia mossiensis</u>	120
34. Shrub-like <u>Gilletiodendron glandulosum</u> Individual	121
35. Ladder Made from <u>Gilletiodendron glandulosum</u> Logs	122
36. <u>Gilletiodendron glandulosum</u> Stump with Sprouts	123
37. Maninka Land Use Pattern	124

TABLES

<u>Table</u>	<u>Page</u>
1. Vegetation Terms Used in this Study.	126
2. Ligneous Plant Species Observed in <u>Gilletiodendron</u> Forest.....	127
3. Species Collected which Represent New Records for Mali.....	135
4. Relative Density Rankings.....	138
5. Relative Cover Dominance Rankings.....	139
6. Relative Basal Dominance Rankings.....	140
7. Relative Frequency Rankings.....	141
8. Importance Value Rankings.....	142
9. Maninka Names for Plants in <u>Gilletiodendron</u> Forest.....	143
10. Maninka Uses of Plants in <u>Gilletiodendron</u> Forest.....	151
11. Preference Ranking of Hardwoods Used for Construction.....	155
12. Actual Use of <u>Gilletiodendron glandulosum</u> in <i>Bire</i> Construction.....	156
13. Chimpanzee Food Plants Occurring in <u>Gilletiodendron</u> Forest.....	157

APPENDICES

<u>Appendix</u>	<u>Page</u>
1. Description of Research Sites.	173
2. Formulae Used in Calculations.	175
3. Complete Results from Biodiversity Index Calculations.	178
4. Complete Results from Point-quarter Survey.	181
5. Complete Results from Line-intercept Survey.	184
6. Complete Results from Quadrat Survey.	188
7. Complete Results for Upper Canopy Cover Dominance.	196
8. Complete Results for Lower Canopy Cover Dominance.	199
9. Research Permits.	201

I. INTRODUCTION

Motivation

Although rain forests occurred in Africa as far north as modern Egypt and Libya as recently as the middle Pleistocene (Maley 1996), climate change and relatively recent human disturbances have greatly modified the landscape. Decreased rainfall and increased wildfire occurrence have favored drought-resistant savanna vegetation which is now dominant throughout West Africa (McIntosh and McIntosh 1981; Dupont and Weinelt 1996; Hamilton 1992; Monnier 1990; Sanford and Isichei 1986). However, even in semi-arid areas, forest remnants endure in isolated pockets where protective topography and subterranean water enable fire- and drought-intolerant plants to survive (Jaeger 1956a).

Relict forests in the West African Sudano-Guinean vegetation zone--the savannas north of the Guineo-Congolian rain forest and south of the semi-arid Sudanian grasslands and woodlands (Figures 1 and 2) (White 1983)--have considerable importance for biodiversity conservation (Lawesson 1995; Jaeger 1968). Biodiversity loss is possibly the greatest threat to the quality of life on Earth, and has been accelerating in recent decades (Wilson 1988). Relict forests are particularly abundant in isolated locations throughout Guinea's Fouta Djallon mountains and their northern foothills, the Manding Plateau--a rugged, inaccessible chain of sandstone mesas in southwestern Mali, southeastern Senegal, and northern Guinea (Figures 3 and 4). Not only are these forests significant reservoirs of biodiversity (Lawesson 1995; Schnell 1976; Adam 1968, 1966; Jaeger 1968, 1966, 1959, 1956a, 1950; Jaeger and Winkoun 1962; Jaeger and Jarovoy 1952; Aubréville 1962, 1949, 1939; Duong 1947), they may also influence the productivity of distant agricultural areas

by moderating the depth and salinity of the water table (Verdcourt 1968, 8). Additionally, these forests provide important habitat to wildlife, particularly the endangered West African chimpanzee subspecies, Pan troglodytes verus Blumenbach (Pavy 1993; Moore 1985; Baldwin, McGrew, and Tutin 1982; Kortland 1983).

Despite their significance, the relict forests of southwestern Mali, which are dominated by the rare endemic tree Gilletiodendron glandulosum (Port.) J. Léonard (Fabaceae-Caesalpinoideae), are poorly known to biologists.¹ Indeed, most of the Manding Plateau has not been surveyed by botanists (Adam 1965), and Mali as a whole is not well known floristically (Davis et al. 1986). Often found in narrow canyons, along cliff ledges, and on rocky slopes, Gilletiodendron forest is poorly known due to its inaccessibility and rarity. In the context of rare plant conservation, much of the information considered most important has not been collected on this tree (see Schemske et al. 1994; Barrett and Kohn 1991; Holsinger and Gottlieb 1991).

Particularly conspicuous is the absence of vegetation structure and composition analysis. Without this analysis, it is impossible to precisely describe the forest as a distinct

¹ In previous works on Gilletiodendron glandulosum, the tree has been given the French common name “kololo”, after its name in the Maninka patois used around Kita and Oualia, Mali. This is the only area where this tree has been studied prior to the current research. However, in the traditional *kafolu* (districts) of Bafing, Bambugu (or Bambouk), Sulun, parts of Gangaran, and probably Mèrètambaya (Figure 5), Gilletiodendron glandulosum is called “sênsão” by the Maninka; the name *kololo* is not recognized, and is often considered, erroneously, to be synonymous with the widely known Maninka plant name *kolokolo* (Pericopsis laxiflora [Benth. ex Bak.] van Meeuwen [Fabaceae-Papilionoideae]). Thus, unlike previous works on Gilletiodendron glandulosum, in the current paper the taxon will be referred to only by its scientific name to avoid confusion with similar Maninka plant names.

plant community or determine its crucial ecological parameters (Lambeck 1997; Ryti 1992; Wright, Murray, and Merrill 1998; Küchler 1988; Daubenmire 1966). Additionally, “comparisons of species lists for individual forests enable particular sites to be identified as priorities for further protection” (Rylands 1990, 240). Information on the ecology of plant communities and on the distribution of rare taxa is vital for evaluating conservation strategies (Patterson 1991; Schemske et al. 1994; Lambeck 1997; Ryti 1992).

The ethnobotany of the Maninka people is poorly known and plants characteristic of Gilletiodendron forest are relatively rare in West Africa. As a result, the ethnobotanical significance of Gilletiodendron forest is virtually unknown, which hinders decision-making on the design and implementation of conservation measures. Knowledge of human use of natural resources is crucial to successful conservation (Schemske et al. 1994; Sayer, Harcourt, and Collins 1992; Holsinger and Gottlieb 1991; Arnould 1990; Koenig, Diarra, and Sow 1998; de Bie 1991). Without better understanding of the floral diversity and ethnobotanical significance of Gilletiodendron forest, Mali’s commendable conservation efforts do not necessarily benefit this valuable relict habitat, which may be a significant reservoir of biodiversity.

Background

Comments Regarding Vegetation Terms

Descriptive terms for vegetation are useful for succinctly summarizing the general ecology of plant communities. However, in West Africa the use of general terms such as ‘dry forest’, ‘gallery forest’, and ‘woodland’ is problematic (Lawesson 1995; Swaine

1992; Kortland 1983). Not only do problems arise in translating between French and English, the most widespread languages used by researchers in Africa, but the technical meaning of terms like ‘forest’, ‘*forêt dense*’, and ‘*forêt claire*’ is often cloudy to begin with (Lawesson 1995; Kortland 1983). While early researchers tended to describe vegetation based on physiognomy, floristic description has gained favor since the late 1940s. However, nearly all sets of terms reflect a varying combination of physiognomic and floristic description, often with adjectives attached to describe climatic, edaphic, and degraded vegetation sub-types. Sub-type description is widespread and particularly confusing due to the wide variety of vegetation types which exist (Swaine 1992). Although White’s (1983) terminology is currently the most widely used in West Africa, it is also unsatisfactory for the above reasons and because it applies only to certain vegetation types, and not to all African vegetation types (Lawesson 1995).

By modifying White’s (1983) terminology to make it more widely applicable, Lawesson (1995) describes vegetation based on clearly defined structural characteristics and analysis of the phytogeographical affinities of the flora. His definitions of vegetation formations and types are not also based on edaphic and climatic criteria, like previous sets of terms (Lawesson 1995, 25). Lawesson’s terms for West African vegetation are favored in the current paper not only due to their clarity and wide applicability, but also because he provides the most recent, complete, and directly comparable data on vegetation near and similar to Gilletiodendron forest. Definitions of vegetation terms used in the current paper are shown in Table 1. Additionally, terms given in quotation marks refer to specific

vegetation formations, types, or sub-types previously described in the literature; reference to the cited authors should be made for exact definitions of these terms.

The phytogeographical affinities of plants are determined from collection records (Hamilton 1974). Within each of the major West African phytochoria (Figures 1 and 2), characteristic plants can be sub-classified depending on which sections of a phytochorion they inhabit, reflecting ecological preferences and vegetation history. Vegetation with similar floral composition is likely to have had similar histories and to have similar modern environmental conditions (Brown and Gibson 1983). Lawesson (1995, 77-85) analyzed the phytogeographical affinities of several hundred woody plants in Senegal while providing a map and clear descriptions of plant distribution types which allow for the classification of other plants. Additionally, Guinko (1985) analyzed the phytogeography of plants in sacred groves in Burkina Faso, including some species not considered by Lawesson. In general, the conclusions of these two authors agree, and are used in the current paper.

Pronunciation of Maninkakan Words

Maninkakan words shown in the text are written following Bailleul's (1981) pronunciation guide, which does not use specialized linguistic symbols as in Bailleul (1996). Underlined letter combinations represent diphthongs. Reference to Bailleul (1981) should be made for proper pronunciation of Maninkakan words.

Available Data on Gilletiodendron Forest

Gilletiodendron glandulosum is a large tree, growing up to 30 m in height (Figure 6) (Jaeger 1956a). Its compound leaves are characteristic of Fabaceae (Figure 7), and are covered with glandular points (Portrères 1939) which give them a shiny appearance. Young leaves are conspicuously red. Trunks often appear fluted (Figure 8) due to the development of small buttresses, from which may sprout dense sucker shoots. Slashing the light grey bark yields a bright orangish red cambium (Figure 9). The fruits are teardrop-shaped pods, covered with glands (thus the specific name, glandulosum). These glands exude a sticky, fragrant resin which seems to defend against predation. The fruits are often abundant in mature trees (Figure 10), and seeds have a remarkably high germination rate (Jaeger 1956a, 1956b). Thus, a dense carpet of seedlings often covers the area beneath crowns of mature Gilletiodendron glandulosum individuals (Figure 11).

Published information on the distribution and composition of Gilletiodendron forest is limited. Jaeger (1966, 1959, 1956a), Jaeger and Lechner (1957), and Jaeger and Jarovoy (1952) provide the most thorough descriptions of the tree's range, a vast triangle with its points at Kita, Bafoulabé, and Kéniéba (Figure 3). However, except for research undertaken on Kita Massif and elsewhere immediately around Kita, Jaeger seems to have estimated the tree's distribution based primarily on observations made from the Dakar-Bamako railway (Jaeger 1956a, 1015), and secondhand reports from the Kéniéba area (Jaeger and Lechner 1957). The majority of this area has not been surveyed for the plant. Geerling's (1987, 171) description including Senegal in the plant's range appears to be an error; no collections of Gilletiodendron glandulosum have been reported from the country,

and both Adam (1968, 456) and Lawesson (1995, 116) state specifically that they did not find it in eastern Senegal in the course of extensive surveys.

The first brief description of Gilletiodendron forest predated the formal taxonomic description of the plant. In a short, primarily anecdotal note, Aubréville (1939) stresses the probable ancient origins and unusual physiognomy of the forest compared with the surrounding savanna vegetation, primarily wooded grassland, grassland, and bare rock with sparse xerophytic cover. He theorizes that Gilletiodendron forest survives only in locations where local topography--characterized by cliffs, canyons, and barren rock flats--provides the tree protection from fire (Aubréville 1939, 480). Duong (1947, 37) supported this theory, adding that the inaccessible location of groves also provides the vegetation protection from cutting. Subsequent research, primarily by the French botanist Paul Jaeger, focused on the same themes identified by Aubréville (Jaeger 1968, 1966, 1959, 1956a, 1950; Jaeger and Lechner 1957; Jaeger and Jarovoy 1952).

Jaeger and Jarovoy (1952) consider the influence of geology on the distribution of plant communities in Mali's rugged Manding Plateau. The authors argue that topographic features which create widely different microclimates are the most significant factors in determining the distribution of plant communities. Although they do not provide quantitative data on vegetation, Jaeger and Jarovoy (1952) show that deep, narrow ravines are important havens for plants more characteristic of wetter climates, such as the trees Cola cordifolia Mast. (Sterculiaceae) and Gyrocarpus americanus Jacq. (Hernandiaceae), which is a pantropical relict of a Tertiary flora (Jaeger and Winkoun 1962; Jaeger 1959). However, in later works, Jaeger argues that the main factor

determining the distribution of Gilletiodendron glandulosum is protection from fire and cutting (Jaeger 1968, 53-54; 1966, 43-44; 1956a, 993). This argument is emphasized as well by subsequent authors (White 1983, 103; Schnell 1976, 273; Adam 1962b, 185).

Despite the agreement of these botanists, their conclusions may reflect colonial natural resource politics in West Africa rather than ecological realities. Fairhead and Leach (1996) have shown that interpretations of vegetation history were used during the colonial period to justify conservation approaches which dispossessed Africans of land ownership and access to natural resources. The political nature of West African forestry in the colonial era is exemplified by Letourneux's (1957) historical review of "Le problème des feux au Soudan français [Mali]." He argues that the traditional "idée de responsabilité [de contrôler les feux semblent] avoir disparu depuis le début du siècle. Les cultivateurs en sont maintenant arrivés à voir brûler avec fatalisme les jachères et, même parfois, leurs propres récoltes [sic]" (Letourneux 1957, 22). At the time, the colonial government of French Sudan was not only attempting to control the incidence of wild fires, but also struggling to make the colony profitable by increasing imports of agricultural products. African residents of French Soudan were not necessarily compliant with French dictates--and had not been since the imposition of French authority around the turn of the century--and were striving to gain independence. The frustration of French officials with their inability to exert political control over colonial subjects in the 1950s is implicitly clear in the contemporary works of botanists--many of them French colonial forestry officers--considering deforestation in West Africa.

While it was not necessarily the intent of individual colonial-era botanists to usurp Africans' rights, forestry science in West Africa from the early nineteenth century to the present has viewed human activities, in particular indigenous agriculture, as the primary factor causing deforestation (Fairhead and Leach 1996). However, widespread deforestation is not necessarily happening in West Africa to the extent argued by botanists and conservationists (Fairhead and Leach 1996; Lawesson 1995), and pre-industrial Africans were probably not capable of causing the scale of land clearing posited by the anthropogenic deforestation argument (Monnier 1990). Some vegetation change has undoubtedly been caused by humans (Hamilton 1992), but other factors, particularly climate change (Maley 1996, 1987; McIntosh and McIntosh 1981) and edaphic conditions (Avenard et al. 1974), have probably been more important in determining the character of vegetation in West Africa. The accomplishments of colonial-era botanists has made it difficult to move past works such as Aubréville (1938, 1962), Jaeger (1956a), Killian and Schnell (1947), Letourneux (1957), and Keay (1959), which represent a long-passed political era but often remain the most complete and current works available on West African botany.

Jaeger (1956a) reports on the systematics, biogeography, and biology of Gilletiodendron glandulosum and also provides data on the ecology of vegetation dominated by this tree. The author's primary assumption is that Gilletiodendron forest represents a vegetation formation he calls "forêts résiduelles soudano-guinéennes" (Jaeger 1956a, 993-996), which has uniquely characteristic structure, composition, and ecology. However, he does not provide quantitative vegetation analysis to support this hypothesis.

Nevertheless, his ecological data seem to show that Gilletiodendron forest is a distinct habitat relative to the surrounding woodlands and wooded grasslands in terms of ambient and soil temperature, relative humidity, evaporation rate, wind speed, and luminosity. The microclimate of the forest tends to be more equable than the surrounding woodland: for instance, daily temperature and humidity variation within groves is less than one-third that in adjacent plant communities (Jaeger 1956a, 1020-1029). Similarly, the information Jaeger provides on biogeography also seems to indicate that this forest is a distinct plant community. Several other plants with limited distributions--such as Gyrocarpus americanus--occur in Gilletiodendron glandulosum forest but not in the surrounding woodland. However, Jaeger (1956a) reports rather than analyzes; his data are not subject to any formal analysis, and are thus inconclusive. Schnell (1976) basically summarizes two of Jaeger's works (1956a, 1968), but usefully places description of Gilletiodendron forest in the context of vegetation throughout Africa.

Despite the lack of thorough data in its support, others have maintained Jaeger's theory that Gilletiodendron forest represents one of only two types of a unique vegetation formation, most widely referred to as "Sudanian dry forest" (White 1983). However, Lawesson (1995, 54-56) and others describe several different "Southern Sudanian forest" types which have vegetation structures and compositions similar to Gilletiodendron forest. Lawesson uses "Southern Sudanian forest" more-or-less synonymously with White's "Sudanian dry forest" (Lawesson 1995, 75). Additionally, Lawesson (1995, 56-59) and others describe several "Sudano-Guinean gallery forest" types which are also quite similar to Gilletiodendron forest.

While many of the species mentioned by Jaeger, Aubréville, Duong, and Portrères as present in Gilletiodendron forest are also present in other vegetation types, and informal descriptions of Gilletiodendron forest structure sound similar to other vegetation types, the actual degree of similarity is unclear. Jaeger (1968, 1966, 1959, 1956a, 1950), Jaeger and Lechner (1957), Jaeger and Jarovoy (1952), Duong (1947), Portrères (1939), and Aubréville (1950, 1949, 1939) offer piecemeal, mostly informal, descriptions of vegetation composition, but do not provide even a species list for the groves they visited. Altogether, at most 68 ligneous and non-ligneous plant species have been reported from Gilletiodendron forest by these authors, a figure which is within the wide range--from ten to ninety species of ligneous plants--recently reported for plant communities which occupy similar habitats in Senegal (Lawesson 1995). However, the accuracy of these data may be limited by the fact that all previous research has been confined almost exclusively to Kita Massif, although Gilletiodendron glandulosum occurs elsewhere in Mali (this has led other authors to conclude erroneously that the tree occurs only near Kita [e.g. Adam 1968; Schnell 1976, 272-273]). No data on vegetation structure in Gilletiodendron forest is available, except anecdotal bits.

Ecological Component of Plant Conservation

The rapid growth of Mali's population threatens the survival of Gilletiodendron glandulosum. The agriculture-based economy in southwestern Mali is in a population-driven expansion phase, which means that the utilization of marginal land and natural resources is increasing, while the availability of land is decreasing (Weber, Smith, and

Manyong 1996). While Gilletiodendron glandulosum habitat is generally not suitable for agriculture or animal husbandry, the hardwood tree is sometimes used for construction (Jaeger 1956a) and Gilletiodendron groves often occur in areas where surface or subterranean water is available (Jaeger and Jarovoy 1952; Jaeger 1956a). As Mali's population grows, the resources represented by Gilletiodendron forest will become increasingly valuable to Mali's impoverished rural population.

Although Gilletiodendron glandulosum is listed as a vulnerable species by the International Union for the Conservation of Nature (IUCN) (WCMC 1998), its actual status is unknown. Both Stebbins (1980) and Rabinowitz (1981) observe that although all threatened or endangered plants are rare, not all rare plants are threatened or endangered. Some species, notably tropical forest trees, are naturally rare and can be considered threatened or endangered only if their genetic diversity is low (Bawa and Ashton 1991; Rabinowitz 1981; Stebbins 1980). However, ecologists point out that certain species have greater ecological significance than others (Lambeck 1997; Schemske et al. 1994; Ryti 1992). These authors stress the importance of understanding the community ecology of rare plants and animals in order to develop conservation priorities. By identifying and protecting several umbrella species--whose habitat requirements encompass those of all others in an ecosystem--greater biodiversity may be preserved than by protecting plant populations based on genetic analysis alone (Lambeck 1997; Ryti 1992). Schemske et al. (1994) also point out that although an inordinate amount of research has focused on the genetics of rare and endangered plants, there is no empirical evidence that a population's persistence is directly linked to its genetic diversity.

Jaeger (1956a) indicates that Gilletiodendron glandulosum is the key component of the vegetation it dominates because it forms the canopy which creates and maintains the distinct microclimate required by the plant community. Indeed, conservation of Gilletiodendron forest has focused on the tree since before the species was described (Aubréville 1939). However, Lambeck (1997) argues that simplistic approaches to ecosystem management which focus on one umbrella species are unlikely to meet the widely different needs of all species in a community. The use of multiple umbrella species for various habitat parameters is more likely to encompass the crucial parameters of the threatened community (Lambeck 1997; Ryti 1992). Without knowing which plants occur in a plant community, nor in what abundance, identifying potential umbrella species is impossible.

Finally, even if Gilletiodendron glandulosum is an appropriate focus for conservation efforts for this plant community, it is not specifically protected under Malian law (Assemblée Nationale 1996; République du Mali 1987). The consequences of this oversight are unclear, but certainly do not contribute to the protection of the species.

Ethnobotanical Component of Plant Conservation

An important component of Gilletiodendron forest ecology which also requires attention is the significance of the forest's plants for the indigenous human population. From an ecological standpoint, Aubréville (1939), Jaeger and Jarovoy (1952), and Jaeger (1956a, 1968) all note the enormous, probably fatal, influence humans could have on Gilletiodendron glandulosum if logging or burning increased unchecked. Although Malian

government forestry agents actively work to limit illegal burning or logging in the area, these workers often do not have sufficient information to devise and implement successful management policies (Duvall, pers. obs.). Social science research is vital to the success of rare plant conservation projects (Schemske et al. 1994; Sayer, Harcourt, and Collins 1992; Holsinger and Gottlieb 1991). Arnould (1990) showed that successful natural resource management projects in the West African Sahel have respected indigenous resource needs and incorporated indigenous opinions in project design. Similarly, Koenig, Diarra, and Sow (1998) found that agricultural development and natural resource management projects which incorporate local participation and indigenous knowledge have proved most successful. De Bie (1991, 2) found that, in Mali, “conservation should take the needs of the local population into account because conservation inevitably affects... traditional rights of hunting, grazing, and gathering.” Unfortunately, the economic significance of wild plants to Maninka in the area where Gilletiodendron glandulosum occurs is virtually unknown (Detwyler 1999; Grimm 1999).

Additionally, several authors have shown that traditional protection of “sacred groves” by indigenous people is an important means of preserving biodiversity in West Africa (Decher 1997; Sayer, Harcourt, and Collins 1992; Guinko 1985). These groves are protected to preserve rare plants and animals in order to expand the range of locally available natural raw materials (Decher 1997; Fairhead and Leach 1996). While there is evidence that the Bamanan people maintain protected groves elsewhere in Mali (Malgras 1992) and that the Maninka do too in southern Guinea (Fairhead and Leach 1996), there is no indication that this practice exists in the area where Gilletiodendron glandulosum

occurs. Identification of indigenous conservation techniques which effect Gilletiodendron forest is vital in considering how to preserve this rare plant community.

Maninka Ethnography

The area where Gilletiodendron glandulosum occurs is inhabited predominantly by the Maninka (or Mandinka, Mandingo, or Malinké) ethnic group, which is part of the broader Manding (or Mandé or Manden) group of peoples (Figure 12) (Dalby 1971). Although Manding peoples have been present in central West Africa for at least 8,000 years (McCall 1971), the Maninka trace their origins to the establishment of the Mali Empire by the historic leader Sundiata Kéita in the fourteenth century (Dalby 1971; Cashion 1982). Sundiata, who mustered an army comprised largely of hunters, remains a well-known and popular Maninka hero (Cashion 1982).

Recognition of descent from Sundiata's kingdom distinguishes the Maninka from the Bamanan (or Bambara)--Mali's dominant ethnic group--who instead claim descent from the brothers Barama and Nia N'golo Kulibali who led resistance against the Songhai empire in the early seventeenth century (Levtzion 1975, 174). Otherwise, the Maninka and Bamanan, like other Manding ethnic groups, are culturally similar, and their languages are mutually intelligible (Bird 1982). As a result, ethnographers often use data collected on one Manding ethnic group in order to understand unstudied aspects of other Manding groups. Thus, some of the literature cited below refers to other ethnic groups than the Maninka but is considered to be representative of Manding culture in general.

Largely restricted to the inaccessible Manding Plateau (Figure 3), the Maninka homeland has been generally less strongly affected by French colonial and independent Malian development and political processes than elsewhere in southern Mali (Koenig, Diarra, and Sow 1998; Kéïta 1972). The Manding Plateau area in southwestern Mali is among the poorest parts of the country, and has at best skeletal transportation, government-funded education, market, administrative, and government-funded health infrastructures (Koenig, Diarra, and Sow 1998; Pavy 1993; Kéïta 1972).

The Maninka are subsistence farmers and hunters with extensive cultural knowledge of the natural resources of the area. For instance, farmers make decisions on land use based on the presence of indicator plant species (Grigsby 1990, 1996; Jones 1970), hunters stalk their quarry and harness spiritual powers based on thorough knowledge of plant life (Cashion 1982; Cissé 1964), and various medical practitioners treat illnesses using herbal medicines (Imperato 1974, 1977; Hielscher and Sommerfeld 1985). Additionally, Dalziel (1955), Malgras (1992), Fairhead and Leach (1996), and several other authors provide Maninka names for over one thousand wild and domesticated plants, as well as several hundred additional names in other Manding languages. Bailleul (1996, 1981) provides terms for plants, plant parts, and vegetation in Bamanankan, the language of the Bamanan people.

The emphasis in ethnological research on the Maninka has focused not on the relationship between culture and environment, but instead on the structures and functions of social institutions. These ethnographic sources are helpful in understanding Maninka culture and indicate, in general terms, how plants are used by the Maninka at some place

in their homeland, as well as social classes which may have specialized knowledge of plants. However, due to the high ecological diversity of the Maninka homeland, it is difficult to accurately generalize about a singular Maninka economic ethnobotany. For instance, most wild plants which occur in the southern portion of the Maninka homeland do not also occur in its north, while the numerous microhabitats characteristic of the Fouta Djallon and the Manding Plateau contribute to a pattern of sparsely scattered and highly localized plant populations. Similarly, continuity of material culture, and thus use of plant raw materials, is not uniform throughout the Maninka homeland due in part to the informal maintenance of Sundiata's administrative structure, which rested on politically separate *kafolu* (districts). The people of each *kafo* have maintained a separate sub-cultural identity, and there is generally an uninhabited gap between villages in neighboring *kafolu* (Duvall, pers. obs.). Thus, most information on Maninka uses of plants is of limited value in understanding the economic significance of Gilletiodendron forest.

Jaeger (1956a) provides the only direct observations of Maninka use of plants in Gilletiodendron forest. He reports that the only use of Gilletiodendron glandulosum by the Maninka is as a construction hardwood. Although he alleges that overexploitation of this tree has destroyed groves found in easily accessible areas (Jaeger 1956a, 996), he provides no evidence for actual methods or levels of use for any plant in Gilletiodendron forest.

Many sources hint of the uses Maninka professional classes have for plants. Cissé (1964) and Cashion (1982) both explore the structure and significance of Maninka

hunters' associations. Both authors argue that *donsolu* (hunters) exercise remarkable individual influence because they may harness magical power through knowledge of wildlife, plants, and spirits which inhabit the bush. Although it is not their purpose, these authors clearly indicate that Maninka hunters' knowledge of vegetation and plants is complex and profound. Similarly, Duvall and Niagaté (1997) show that Maninka hunters often locate game by seeking plant communities or plant species favored by their prey. Hopkins (1971) briefly discusses other professional classes in Maninka society. Although he does not discuss these groups in detail, it is clear from his descriptions that they may have specialized botanical knowledge. *Numuw* (blacksmiths) use particular trees in making different implements and in heating their forges; *garankéw* (leatherworkers) tan and dye leather using various plant products; and *finaw* (musicians or mimes) use plant materials to make musical instruments.

Some literature on Manding agriculture comes from the perspective of economic development and focuses on the importance of financial, rather than natural, resource inputs. Jones (1970) analyzes the economy of the village Ba Dugu Djoliba in order to understand the significance and distribution of development aid. In his general discussion of Maninka agriculture, however, he implies that land is classified for agricultural potential based on the presence of unspecified plants which indicate soil fertility (Jones 1970, 286-295). Similarly, Grigsby (1990, 1996) seems to show that indicator species are important to the Bamanan in the categorization of land use. The plants he identifies, *Vitellaria paradoxa* Gaertn. (Sapotaceae), the shea nut tree, and *Parkia biglobosa* (Jacq.) Benth. (Mimosaceae), the locust bean or *nèrè* tree, show the suitability of a certain parcel for

female cultivators because collection of their fruits is considered a woman's task (Grigsby 1990, 1996). However, neither Jones (1970) nor Grigsby (1990, 1996) explicitly states that indicator plant species are used by the Maninka to classify vegetation. Similarly, Rondeau (1987) and Lekan (1992) consider plant use from the standpoint of community development. These authors show that women's and children's collection of wild foods makes an important nutritional and economic contribution to Bamanan society during the yearly hungry season, although their purposes are to analyze the sociological and economic effects of annual food shortages.

Fairhead and Leach (1996) more clearly show the importance of natural resource inputs in Maninka economies. By providing a thorough critique of the traditional view of deforestation held by conservationists in Guinea, these authors show that "relict" forest groves away from the main body of the rain forest are not so likely remnants of a once more widespread vegetation as they are anthropogenic plant reserves. Similarly, Malgras (1992) writes that Bamanan sacred groves are important reservoirs of biodiversity in southern Mali. Fairhead and Leach's (1996) analysis of Maninka land use, agriculture, and use of wild and semi-domesticated plants, as well as historical data, clearly show the wide range of knowledge the Maninka have of plants. However, the wild plants discussed by Fairhead and Leach (1996) are nearly all Sudano-Guinean or Guinean species which do not occur as far north as Gilletiodendron forest. Additionally, it is uncertain if plant use in their research area, southern Guinea, would be similar to that in Mali's Bafing Valley. There is not adequate research on Maninka ethnobotany to argue one way or the other about any but the most salient, widespread plants, such as Vitellaria paradoxa, Parkia

biglobosa, and Adansonia digitata L. (Bombaceae), which are used in similar manners by nearly all ethnic groups between the rain forest and the Sahel.

This situation also limits the applicability of the works specifically on plant use in West Africa. Dalziel (1955), Malgras (1992), Baumer (1995), Maydall (1992), Portrères (1965, 1966), and Schnell (1950) show that hundreds if not thousands of wild plant species may be used by the Maninka, but generally provide little information on the geographical distribution of cited uses, quantities used, periods of harvest, or even the ethnic group responsible. Additionally, few of the plants characteristic of Gilletiodendron forest are mentioned by these authors; most research on Maninka plant use has been in southern Guinea, in the Sudano-Guinean vegetation zone.

Research on Bamanan medical institutions and beliefs offers little insight on the problem of Maninka use of wild plants. Imperato (1977) provides an extensive description of Bamanan beliefs on health and sickness, including a thorough discussion of herbal medicines and beliefs regarding the causes of their efficacy. His analysis focuses on perceptions of health, however, rather than on the nature of plant medicines. Imperato (1974, 1977) and Hielscher and Sommerfeld (1985) describe the roles of various traditional medical practitioners. *Furabòlaw* (herbalists), *diyòsònaw* (magicians), *gòlònfilaw*, *soubakaw*, and *tiyèndòlaw* (diviners or magicians), *maniamaga mussow* (midwives), and *marabuw* (Islamic clerics) treat (or, in some instances, cause) illnesses by using herbal medicines. Clearly, there is knowledge of herbal medicines in Maninka society, but these authors do not indicate which plants may be used, nor how. Malgras (1992) and Dalziel (1955) show that hundreds of plants may be used medicinally by the

Maninka, but provide very little information on geographic distribution of usage, or on the quantities required for treatment.

Summary of Literature Review

A review of available literature on Gilletiodendron forest shows that this rare habitat may be a significant reservoir of floral diversity. Apparently, the complex topography of the Manding Plateau allows atypical vegetation to survive by protecting plants from fire. The conservation of Gilletiodendron forest is hampered by a lack of information on its vegetation structure and composition and its sociocultural significance. Without understanding the floral composition of this plant community, natural resource managers can not assess its significance to regional biological diversity. Similarly, without knowledge of traditional conservation measures or of the economic significance of plants to the indigenous Maninka, conservationists can not balance human needs with conservation priorities.

Thesis Statement and Research Objectives

Purpose

The purpose of the present research is to determine the overall need for more rigorous conservation measures to protect a poorly known, rare plant community. Currently, insufficient data exist on Gilletiodendron forest to assess the appropriateness of possible conservation measures. Three categories of information are pertinent to understanding both the value of Gilletiodendron forest to biodiversity conservation as well

as the level of exploitation to which this vegetation type is subject. Specifically, data is presented in the following subject areas: (1) structure and composition of Gilletiodendron forest vegetation; (2) naming and use of characteristic plants by the Maninka people; and (3) conservation measures which affect Gilletiodendron forest. Analysis of this information will allow assessment of the conservation value and status of Gilletiodendron forest.

Objectives

By analyzing data which answer a specific set of research questions, the conservation value and status of Gilletiodendron forest may be assessed. These questions, developed prior to field research had begun, are implicit in the three information categories listed above and provided a framework which helped determine the methods and analyses used. Research questions were designed specifically to limit the scope of work and exclude data which do not pertain to floral diversity, vegetation structure or human use of Gilletiodendron forest. The questions adopted are summarized in the following outline:

- 1) Structure and composition of Gilletiodendron forest vegetation
 - a) What ligneous plant species are present?
 - b) What is the general structure of the vegetation?
 - c) What is the relative contribution of the most common ligneous species to total canopy cover?

- d) What is the relative contribution of the most common ligneous species to total basal cover?
 - e) What is the density of ligneous plants?
 - f) What is the level of floral diversity?
- 2) Naming and use of characteristic plants by the Maninka people
- a) What are Maninka names for plants occurring in Gilletiodendron forest?
 - b) What are Maninka uses of these plants?
 - c) What is the current level of use by the Maninka of these plants?
- 3) Indigenous conservation measures which affect Gilletiodendron forest
- a) What measures do the Maninka take to conserve wild plants?
 - b) Are there any social or cultural restrictions on the use of plants occurring in Gilletiodendron forest?
 - c) What legal measures have been taken to protect these plants?

II. RESEARCH DESIGN

Conceptual Framework

Overview of Data Collection Strategy

The main problem addressed by this research is the paucity of basic information on Gilletiodendron forest which hinders the assessment of conservation needs of the vegetation type. As a result, field methodology was designed to collect a wide yet well-defined range of descriptive data, as indicated by the research questions listed above. Basic forestry techniques were used in order to collect data on the structure and composition of the plant community, while basic ethnographical methods were used to determine the use of plants by Maninka informants. Since comparison of original data to previously published material can provide valuable insights on the significance of Gilletiodendron forest to biodiversity conservation relative to other vegetation types, the botanical methods adopted have been widely used by other authors working in broadly similar vegetation types.

The different botanical data collection methods used--point-quarter, line intercept, and quadrat sampling--provide similar data, although each of the three methods is different in terms of sampling procedure. Thus, each yields a slightly different summary of the vegetation sampled. By definition, no sampling method gives an exact description of the population sampled. The use of several different methods to analyze a single problem offers a means to gain a balanced view of the problem. However, these three methods are not entirely duplicative; each provides a type of data the others do not. Similarly, the ethnographic methods used--participant observation and ethnographic interviews--yield

similar but complementary data. Participant observation is less structured and more informal and can pick up nuances that verbal responses may lack. However, interviews can provide more precise information. The ways in which these various data collection methods work together is described in the appropriate subsections below.

Ethnographic and botanical data collection methods do not overlap, but provide complementary data which enhance understanding of the entire data set. For instance, by using quadrat sampling the density and frequency of plant species was estimated, while informal and semi-formal interviews determined the potential and actual use of plant species. Comparison of the two types of data identified plant species whose levels of use may not be sustainable due to the low abundance of the species. Thus, the data collected provide two different but complementary viewpoints on the problem of Gilletiodendron forest conservation.

Site Description

Mali is a landlocked country in West Africa which straddles the semi-arid Sahel, with the Sahara in the north and Sudano-Guinean wooded savanna in the south (Figures 1 and 2). As a result, annual rainfall for the nation varies greatly from virtually none in the extreme north (25° 10' N) to over 1600 millimeters in the south (10° 10' S) (White 1983). Its total surface area is 1.24 million square kilometers (Pavy 1993, 1), about the size of California and Texas combined. Mali's population in 1991 was approximately 8.3 million, growing annually at a rate of 3% (Stockman 1993).

Botanical research took place at sixteen Gilletiodendron glandulosum groves and 6 villages in the Bafing and Sulun traditional *kafolu* (districts), in the Bafoulabé district of the Kayes administrative region (Figure 13). Rainfall in this area generally comes during the period June to October, and probably averages about 1000 mm per year (Kortland 1983). Variance is high, however, with annual rainfall usually falling in the range 900 to 1500 mm (PREMA 1996; Pavy 1993). Potential evapotranspiration is high through a significant part of the year, while during the rainy season there is a surplus of moisture (Figure 14). Favored by a relatively low population density, the natural resources in this area remain relatively well-preserved especially compared with the rest of southern Mali, which is more heavily populated.

Southwestern Mali contains the country's largest remaining area of intact "Sudano-Guinean savanna woodland" (Warshall 1989, 11). West African savanna woodland has been described in general by several authors since the late nineteenth century, most recently by Lawesson (1995) and Frederiksen and Lawesson (1992) in Senegal. Duong (1947) and Projet Inventaire (1990) provide brief descriptions of the floral composition of Mali's savanna woodland (Figure 15). The floral resources of Mali are poorly surveyed, and the condition and distribution of valuable habitat, including Gilletiodendron forest, is basically unknown (Warshall 1989, 8). There have been no vegetation surveys of southwestern Mali (Boudet, Lebrun, and Demange 1986; Lawesson 1995) except for a large-scale remote sensing project in the 1980's which produced a vegetation map with resolution too coarse to show individual Gilletiodendron forest groves (Projet Inventaire 1990). Casual observation shows that although population

growth has led to increased demand for plant resources, natural vegetation in the study area remains largely undisturbed, perhaps because commercial exploitation and large-scale agriculture are not practical without better transportation. Additionally, the last significant populations of large wild animals in Mali occur in this area, although, with the exception of the chimpanzee population, no wild animals occur in internationally significant numbers (Chardonnet et al. n.d. [1999], Duvall and Niagaté 1997; Pavy 1993).

Floral diversity in the study area is closely tied to topography (Jaeger 1966, 1959, 1956a; Jaeger and Jarovoy 1952). The Manding Plateau presents a magnificent landscape dominated by towering sandstone cliffs and mesas (Figure 4). These hills, which rise to nearly 800 meters in elevation (Service Géographique d'A.O.F. 1958), are a northern spur of Guinea's Fouta Djallon Mountains (Figure 3). The diverse topography of the cliffs and mesas creates numerous microclimates which accommodate a wide range of plant communities despite relatively poor soil quality (Lawesson 1995; Jaeger and Jarovoy 1952; Jaeger 1959, 1956a). The characteristic sandstone dates from the Palaeozoic era, and overlays Precambrian gneisses and schists (Figure 16) (Jaeger and Jarovoy 1952; Jaeger 1959). Bowals--rocky laterite formations formed of hardened, iron-rich soils which are unsuitable for agriculture and characteristic of tropical climates--are common throughout the area (Figure 17). Flat lowland areas have thin clayey and sandy topsoils which originate from erosion and sedimentation and are poor for agriculture (Pavy 1993, 7; PREMA 1996, 27). Most settlements in the area are located in lowland areas and rely on these soils for agriculture. The inaccessible cliffs and mesas are marginal land, and not heavily used. However, proximity to cliffs has been valued historically because rugged

topography has provided the Maninka refuge from invaders (Cissé 1970, 54; Jaeger 1950). Currently, due to increasing population pressures, location near the hills is desirable also for better access to wild natural resources and additional agricultural land; the plateaux are becoming more valuable as need for the resources they hold increases.

Mali is amongst the five poorest nations on Earth as estimated by Gross Domestic Product (GDP). This measure of wealth does not account for several important components of Mali's economy--such as domestic production, unpaid labor, and harvesting of wild products--but is commonly used for comparative purposes (Goodstein 1999, 82-83). Mali's per capita income was estimated at \$300 in 1991 (Stockman 1993). This figure indicates that availability of and access to monetary resources is low, and that highly productive components of the economy--such as transportation and manufacturing--are poorly developed. Over 50% of the GDP is accounted for by the agricultural sector, which employs over 75% of the workforce (Stockman 1993).

According to the U.S. Department of State, only 15% of Malian adults are literate (Stockman 1993). Rural adult literacy in southwestern Mali is extremely low, perhaps less than 7% for males and less than 2% for females (Duvall, pers. obs.). Many boys attend one to several years of government-funded, French-language formal schooling, while most girls do not attend school; the national average for primary school attendance is 21% (Stockman 1993). Those children who do not attend school are economically productive, providing services for their extended families including agricultural labor, domestic labor, child care, and, rarely, income generation through paid labor or market commerce. Successful execution of these tasks is based on complex and sophisticated cultural

knowledge; individuals in Mali undergo formalized training and skills acquisition through various cultural and social institutions even if they do not attend government-funded schools.

Southwestern Mali is amongst the poorest areas in the nation primarily due to a lack of transportation infrastructure. The combined influence of rugged topography and relatively high rainfall has discouraged road construction, and thus the area has benefited less from economic development than other parts of Mali (Koenig, Diarra, and Sow 1998; Horowitz et al. 1990; Kéïta 1972). Although the Dakar-Bamako Railway remains one of Mali's two primary links to the sea, political factors have limited development of transportation options in the region. Virtually every all-season road in the area is essentially a lengthy cul-de-sac, designed to transport materials from the railway to a specific large-scale project. Although road construction has increased since 1996, and an all-season road now exists between Bamako and Koundian, much of the research area is inaccessible by automobile during the rainy season. Due to the lack of motorized transportation, government-funded schools, health facilities, administrative posts, and technical stations, as well as national and international non-governmental organizations, are rare in the study area. Consequently, the local economy is primarily subsistence-oriented, with a significant portion of food coming from secure, non-market sources, such as wild plants and animals, and semi-domesticated crops (Horowitz et al. 1990).

The area immediately downstream from the Manantali Dam has been the focus of development efforts since the mid-1980's, when construction of the dam led to the involuntary resettlement of over 10,000 people (Figure 18). However, this area was and

still is marginal to the national economy; copious development funding has not resulted in significant gains in the standard of living for the local population (Horowitz et al. 1990). Indeed, having lost established orchards and gardens to the reservoir, the nutritional quality of the local diet has deteriorated since resettlement. Additionally, the expansion of a cash economy has made labor a commodity, and has increased the prestige value of purchased products, including food and medicine. As a result, use of wild plants has decreased in the area of study since the construction of Manantali Dam (Horowitz et al. 1990). Finally, although there is a forestry agent in Manantali responsible for the enforcement of resource protection laws in the area and in the nearby Bafing Faunal Reserve, natural resource management law enforcement is sporadic and localized, and seems to alter people's choice of wild plant products only near Manantali (Duvall, pers. obs.).

Ethnographic research was conducted in and around the town of Manantali and in the villages Nantéla, Woundiamba, Maréna, Makadugu, and old Sollo (Figure 13). Except for Manantali, which has a large population of temporary and transient workers from throughout Mali and West Africa, these villages are virtually exclusively Maninka in ethnic composition. Maréna is the only village which was resettled as part of the dam construction project, although Nantéla, Manantali, Woundiamba, and Sollo were directly affected by resettlement. Maréna was moved approximately 40 km from its original location, although several farming hamlets near the original site remain seasonally occupied.

While the resettlement has not been easy for the people of Maréna, the village is fortunate to have a new site away from the main area of resettlement, so that population pressures on natural resources are lower relative to other resettled villages. Socially and economically, Maréna, like the original host villages in the resettlement zone, including Manantali, Nantéla, and Woundiamba, has been greatly affected by dam construction. The town of Manantali is emblematic of the changes that have occurred. The information which follows is compiled from Grimm (1991) and from the author's personal notes. In 1982, Manantali was a tiny, one-family hamlet. By 1985, it had a population of around 10,000, including European engineers, European and African administrators and managers, and thousands of transient job seekers from throughout Mali and West Africa. Many local residents from affected villages found their first salaried positions at this time, and dived into the cash economy. By 1991, construction was complete and the first boom had ended; Manantali's population declined to its present level of about 5,000 people, and the resettled and original host villages had begun the long period of adjustment to new geographic and economic realities. As the site of a major international project, several subsequent infrastructure development projects have come and gone in Manantali: in 1994, repairs to the dam brought hundreds of jobs, thousands of job seekers, and lots of aid money; in 1996, a road construction project brought more of the same; the next boom came in 1999, when construction of the dam's hydroelectric plant began. The impact of this boom cycle on the local resident population has been an intractable inclusion in the national cash economy; reliance on wild natural resources has declined due to the spread

of competing, usually imported, manufactured products (Horowitz et al. 1990).

In contrast, the people of old Sollo and Makadugu have maintained varied use of wild natural resources because they remain largely independent of the cash economy which has developed in the resettlement zone. Sollo, one of the three oldest villages in the Bafing, is more than 250 years old, and was visited by the first European to travel to the interior of modern Mali, the Englishman Mungo Park, in 1798 (Park 1896). Sollo was resettled due to dam construction, but it was not actually destroyed by the waters; the only road which reached the village at the time was flooded. After two disappointing farming seasons in the poorly situated new site, many residents returned to old Sollo, and cut a new road over difficult terrain to Manantali. Despite this connection, as well as intermittent boat transportation on the reservoir, old Sollo is rather isolated from Manantali and the resettlement zone. People--mainly males--travel to Manantali only during the dry season. Makadugu, in the Sulun *kafo*, was not directly affected by dam construction. Although some males travel to Manantali to seek work and to trade during the dry season, Makadugu is over 80 km away by path, and the route is often impassable from late July to early October. Thus, the people of Makadugu are quite self-sufficient, and maintain traditional handicrafts and trades which are now rare elsewhere in Mali.

Components of Research

Botanical Diversity Assessment

Individual Gillettiodendron glandulosum groves near Maréna, Manantali, Makadugu,

Nantéla, and Sollo were located by asking Maninka farmers and hunters about local vegetation and by surveying likely locations based on topographical maps. Each of the sixteen groves located in this way was considered a single research site (Appendix 1). The latitude and longitude of each site was recorded using a hand-held Garmin GPS-12 receiver, which has an accuracy of 15 m (Garmin 1999) (Figure 13). Site altitude was estimated to the nearest 20 m based on the topographic map of the Service Géographique d'A.O.F. (1958).

At each site, all ligneous plant species were collected and preserved in a plant press following the methods described by Liesner (1991). Plants were identified using pertinent floras and botanical field guides (Geerling 1987; Hutchinson and Dalziel 1954, 1958, 1963, 1968, 1972; Boudet, Lebrun, and Demange 1986; Aubréville 1959a, 1959b, 1959c, 1950; Berhaut 1967, 1971, 1974, 1975a, 1975b, 1976, 1979). Specimens were deposited and are available for review at the Missouri Botanical Garden in St. Louis, Missouri. All sites were visited at least twice, usually 5-10 times, over the course of 2-10 days. Since all groves except Site 16 were small enough in area to be completely surveyed in the amount of time available, no effort was made to confirm quantitatively through species-area estimation that the majority of plant species were observed in each site.

Additionally, two widely used indices of biological diversity were calculated for Gilletiodendron forest. The Simpson diversity measure calculates, as a weighted average of abundance, the number of occurrences of a species in a data set (Stiling 1996). The index, normally used in its reciprocal form, is expressed by the formula

$$N_2 = \sum \left(\frac{n(n-1)}{N(N-1)} \right) \quad \text{where: } N = \text{total number of individuals of all species} \\ n = \text{number of individuals of a species.}$$

The Simpson index increases from a value of 1.0 for a sample containing a single species to infinity for a sample in which each individual belongs to a different species (Cox 1985).

However, this measure is heavily weighted toward the most abundant species, and undervalues the contribution of rare species to diversity (Stiling 1996). Thus, it is not a good indicator of floral diversity in Gilletiodendron forest, which is heavily dominated by Gilletiodendron glandulosum, Hippocratea indica Willd. (Celastraceae), and Grewia bicolor Juss. (Tiliaceae). The Simpson index is used here primarily in order to compare results with Lawesson (1995).

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). Since Gilletiodendron forest is dominated by a small number of species, this index seems to be better suited for this vegetation type. The Shannon index calculates the degree of uncertainty in predicting the species of an individual randomly chosen from a sample; uncertainty increases as the number of species increases and as the number of individuals per species becomes more equitable (Cox 1985). The formula used is

$$H = -\sum p_i (\ln p_i) \quad \text{where: } p_i = \text{the proportion of individuals in the } i\text{th species}$$

This value for this index increases from 0 for a sample containing a single species to high values for samples containing many species with a small number of individuals per species (Cox 1985). A drawback to this index is that it assumes that all species present in a

community are represented in the sample, a condition which is rarely met (Stiling 1996). However, as the proportion of species represented in the sample increases, error caused by failure to meet this condition decreases. Additionally, Condit et al. (1996) find that for sample sizes >1000 stems, a condition which is met by the present data set (total stems = 3158), the Shannon index is acceptably accurate. Both diversity indices were calculated using data from 10 m x 10 m quadrat samples (described below).

Vegetation Composition and Structure

Four commonly measured quantitative vegetation 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 plant by combining its density, dominance, and frequency values relative to other plants in the vegetation. For the precise formulae used, see appendix 2.

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 the vegetation may be inaccurately low. Since many of the species characteristic of cliff faces and wet slopes are relatively rare (such as Vepris heterophylla [Engl.] R. Let. [Rutaceae] and Smeathmannia laevigata Soland. [Passifloraceae]), this source of bias may cause estimates of the floral diversity of

Gilletiodendron forest to be low. More thorough surveying, particularly in the dry season with climbing gear, are necessary to clarify the actual level of botanical diversity in Gilletiodendron forest.

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, 234-235). The point-to-plant distance and basal area of each plant is measured, and from this data frequency, density, and basal dominance values for each species can be determined (Cox 1985). For the present research, only plants ≥ 10 cm diameter at breast height (DBH) were sampled. In most instances, point-to-plant distances were measured to the nearest 0.1 m 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 0.5 m. Basal area was calculated from measurement of trunk circumference. Sample points were located at the ends of randomly placed transect lines (see below), and were generally 10 m apart unless greater distance was necessary to avoid sampling an individual more than once. Bamboo (Oxytenanthera abyssinica [A. Rich] Munro [Poaceae]) was not included in this survey.

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. From these data, standard measures of vegetation composition can be calculated. For the present research, two different canopy levels were sampled separately, the lower being ≤ 8 m high, the upper greater than this height (Figure 19). This designation agrees with

Lawesson's (1995, 24) 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 0.25 m using lines marked at meter intervals.

Consecutive 10 m transects 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, 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.

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 10 m x 10 m (100 m²) or rarely 5 m x 20 m 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 total number of species relative to other quadrat shapes (Condit et al. 1996). In each quadrat, DBH and height of every plant taller than 1 m was measured, as well as the number of individuals belonging to each species. This was the most thorough sampling method used, because individuals of all ages except seedlings were recorded. As a result, the estimates of density and frequency collected through this method are higher relative to those collected through the other methods, while the basal dominance estimate is lower relative to that of the point-quarter method. Also based on this survey, the average height of each species was calculated for all individuals and for all individuals ≥ 10 cm DBH. 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.

Ethnobotanical Research

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, and helps make both informants and the researcher more comfortable with the other party (Spradley 1980). Additionally, it can help the researcher better understand the meaning and accuracy of responses to formal, structured questions. Ethnographic interviews, whether formal or informal, have the advantage of precision: informants can be asked very specific questions and can offer very specific responses. However, responses can sometimes be inaccurate or misleading for various

reasons; participant observation can help clarify responses because the researcher can learn rather than just hear about the nature of cultural phenomena.

Participant observation. Participant observation is a widely used and effective 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 (Spradley 1980). Participatory observation has been used successfully in research on the Maninka and other Manding peoples (e.g. Fairhead and Leach 1996; Cashion 1982; Shafer and Cooper 1980).

As a Peace Corps Volunteer, the author lived in the village of Maréna from 1995 to 1997, and worked in several nearby villages, including Manantali, Nantéla, Woundiamba, Makadugu, and Sollo. The Peace Corps-Mali training program emphasizes participant observation, although not necessarily in such terms; Volunteers are encouraged to work alongside host country nationals and learn to do typical Malian jobs by watching, asking, and doing. During his service, the author worked primarily with hunters and farmers and learned how to cultivate peanuts, collect fire wood, build houses, and identify game. He also built close relationships with many highly knowledgeable individuals. From a research standpoint, after two years of participant observation the author left Mali with a considerable network of valuable informants.

When the author returned to Mali in August, 1999, these people were pleased to welcome him back into their homes, and continued to be patient with his questions. However, it was determined beforehand that it would be preferable to ease back into the

more demanding aspects of ethnographic research, such as interviewing, for two reasons. First, the period from July to late September is a stressful, busy time for the Maninka, when food supplies are low and crops, nearing ripeness, require much attention. Demanding time to ask what were to informants somewhat silly questions would be undue on the part of the author. Second, it seemed better for informants and the author to reacquaint before semiformal and formal interviewing began. Thus, for nearly a month the author lived with his Maninka hosts, Djelifili Kéïta and Narkoukou Dansira, while catching up on news, hiking with hunters, especially Mahdi Dionsan and Famagan Dembélé, and working with farmers, especially Djiguiba Kéïta, Haganda Kéïta, and Kendeing Kéïta, and collecting botanical data. After beginning ethnographic interviews, the author continued to live with his hosts, and participated in daily life while conducting botanical research.

Ethnographic interviews. During the initial phase of ethnographic research, 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 ye kuru to” (the trees found on the rocky parts of the hills) rather than something to do with *sênsão* (Gilletiodendron glandulosum) itself. 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 endemic status of

Gilletiodendron glandulosum and the interest the tree holds for Western-trained 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 Maninkakan or Bamanankan, a related Manding language. Previous experience interviewing Maninka in the Bafing area showed that the use of either writing instruments or a hand-held tape recorder was distracting, and seemed to deprive informants of spontaneity in their responses. 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 specific, preconceived questions asked as they fit comfortably into the conversation. Usually no more than four or five preconceived questions were asked in the course of a semiformal interview. Responses were memorized by the researcher, and written as soon as possible afterwards, usually no longer than five to ten minutes.

To determine preferred uses of Gilletiodendron glandulosum, informants were asked “Sensão nafa ye mun ni mun ti?” (What are the uses of the Gilletiodendron tree?). This question format is similar to that used in other ethnobotanical studies, including Berlin, Breedlove, and Raven (1974) and Conklin (1954), and is recommended by Cotton (1996). Based on previous questioning and published information (especially Jaeger 1956a), it was expected that Gilletiodendron glandulosum would have few uses by the Maninka, so no attempt was made to quantify ranking of different uses. Indeed, the only

use of Gilletiodendron reported by informants was as a construction hardwood used primarily for *tarumalu* (support posts) and *salalu* (cross beams) in *birelu* (hangars, i.e. open-sided outdoor shelters), *kulukululu* (granaries), *garèkalu* (outdoor beds), and other structures (Figures 20 and 21).

Once the use of Gilletiodendron glandulosum was determined, a preference ranking of trees used for construction was prepared as described by Cotton (1996). Informants were asked to list the trees they preferred for use as *tarumalu* (posts) and *salalu* (cross beams), and the order of each informant's preferences was recorded. It was determined beforehand that informants would be questioned specifically about wood used to make *birelu* (hangars, i.e. open-sided outdoor shelters) rather than other structures because wood is visible in a *bire* and thus examination of the trees actually used would be easier. This is not likely to bias results because several informants stated that there is no different system of preference in choosing construction wood if making a *bire*, *kulukulu* (granary), *garèka* (outdoor bed), or other structure. Thus, the specific question used in Maninkakan was “Yiro jumen ni jumen yè kè bire taruma/sala ti?” (Which trees become hangar posts/cross beams?). This question is similar in form to questions used in other economic ethnobotanical studies, including Berlin, Breedlove, and Raven (1974) and Conklin (1954), and is recommended by Cotton (1996).

After several interviews, it became apparent that asking about both *tarumalu* and *salalu* was not only tedious for the informants, but also tended to bias the second data set of each informant's response. That is, after thinking about which trees were best for the first purpose, informants tended to repeat the same list of trees when asked about the

second purpose regardless of whether they were questioned first about *tarumalu* or *salalu*. While the two uses are similar, they are not identical. According to informants, a ground-borne *taruma* must withstand termites and moisture better than an aerial *sala*. It is also more difficult to replace a *taruma*. Thus, builders generally seek the most durable wood possible when installing a *taruma*, while less durable wood is acceptable as a *sala*. It was decided to limit preference ranking questions to the making of *tarumalu*, as this would provide the clearest reflection of hardwoods preferred for *kendeya* (durability), which is the most valuable trait of construction wood for the Maninka. In only two cases did this strategy seem to introduce any bias. Both *sênsão* (*Gilletiodendron glandulosum*) and *sibo* (*Borassus aethiopium* Mart. [Arecaceae]) are preferred to serve as *salalu* rather than *tarumalu*. In the case of *sibo*, this is a marked difference; many informants stated that this palm is the best or second best material for making *salalu*, while it is a rather poor choice for *tarumalu* because it deteriorates quickly in soil moisture. However, in the case of *sênsão*, the difference in preference seems minimal. All informants praised the durability of the tree, but said that it lasted considerably longer if not exposed to soil moisture. Be that as it may, *Gilletiodendron* was tied with *kèrèkèto* (*Anogeissus leiocarpus*) as the second most preferred *taruma* material.

To determine the actual use of *Gilletiodendron* as *bire tarumalu* (hangar support posts), *tarumalu* in actual use in the main Manantali market, four family compounds in Maréna, and two compounds each in Woundiamba, Makadugu, and old Sollo were surveyed. *Gilletiodendron glandulosum* logs are fairly easy to identify due to their fluted appearance (Figure 8); other aged construction hardwoods are not reliably identifiable.

All Gilletiodendron *bire tarumalu* were identified so that the frequency of use could be determined.

Semi-formal interviews were also used to a limited extent to learn the names of and uses for other plants. During hikes with hunters or time spent working in the fields, informants were asked to identify nearby plants with the question “wo ye yiro jumen ti?” (Which tree is that?). To elicit descriptions of plant uses, informants were asked “wo nafa ye mun ti?” (What is its use?) either after a nearby plant had been indicated or after an informant confirmed that they knew of a certain plant which was not necessarily immediately present.

Formal interviews were more commonly used to elicit names and uses of plants. Usually in the course of preparing specimens, informants were shown fresh plant specimens and asked to identify these by name and explain their uses (Figure 22), as described by Cotton (1996), Berlin (1992), and Berlin, Breedlove, and Raven (1974). Responses were written at the time of the interview. 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 repetitiveness of this technique was valuable for eliminating erroneous identifications and identifying knowledgeable informants, although it was often tedious to informants, who tended to remember which plant species they had seen before (although they did not always give the same name on different occasions). The knowledge 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 which came up most often by the most knowledgeable informants was determined to be correct. In some instances a knowledgeable informant, especially Famagan Dembélé or Mahdi Dionsan, was able to guess why certain erroneous identifications were given repeatedly by other informants, and then give the proper name for the plant species in question. Rarely, when it was uncertain if a given name or use 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 a 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.

III. RESULTS

Overview

In this section, the results of data analyses are reported. These results are not presented per data collection method, but rather per topic. For instance, in the sub-section *Vegetation Structure and Composition*, the density results from all three sampling methods are reported together under a single heading, Density. Additionally, a summary of main findings follows the main body of this section.

Results from Analyses

Botanical Diversity

One hundred twenty-six species of woody plants belonging to at least 42 families were observed and collected in 16 different stands of Gilletiodendron forest (Table 2). Nearly half of these plants are of Lawesson's (1995) Sudano-Guinean distribution type. This total includes 11 species previously unreported from Mali (Table 3). While none of the families represented by these species are new for Mali, the new records represent significant northward or eastward extensions of the ranges of the taxa. Most of these plants are rather rare in Gilletiodendron forest with only one or a few individuals having been observed. However, several are relatively common (such as Anthocleista nobilis and Cordia africana), their lack of record from Mali evidently due to the fact that this vegetation type has not been previously surveyed.

Many riparian species were collected--such as Cola laurifolia, Pterocarpus santalinoides, Sarcocephalus latifolius, and Garcinia livingstonei--reflecting the mesic

conditions characteristic of the forest type. Gilletiodendron glandulosum forest is found along ledges and ravines--seasonal drainage channels--in sandstone cliffs, geologic conditions which contribute to high soil humidity (Jaeger and Jarovoy 1952). Greater floral diversity and lower dominance by Gilletiodendron glandulosum was observed in groves found at least partially in ravines (Figure 23), which were generally more mesic sites than cliff ledges (Figure 24).

Additionally, certain plants which are common in previously described "Southern Sudanian forest" types (Lawesson 1995)--such as Bombax costatum, Combretum micranthum, and Ficus glumosa--were most abundant in cliff ledge rather than ravine sites. Other plants highly characteristic of "Southern Sudanian forest"--such as Pterocarpus erinaceus, Hexalobus monopetalus, and Anogeissus leiocarpus--comprise only a negligible part of Gilletiodendron forest vegetation. As in other "Sudano-Guinean gallery forest" types (Lawesson 1995), the following species are common in Gilletiodendron forest: Diospyros mespiliformis, Sarcocephalus latifolius, Saba senegalensis, Cissus quadrangularis, Spondias mombin, Malacantha alnifolia, and Cissus populnea. Additionally, several plants which are only (or primarily) reported from gallery forests in the Sudano-Guinean phytochorion are present in Gilletiodendron forest, such as Anthocleista nobilis, Christiana africana, Leptactina senegambica, Ficus asperifolia, Erythrophleum guineensis, and Pachystela brevipes. It may prove possible using floristic data to describe two distinct forest types--using the terminology of Lawesson (1995), a less mesic "Southern Sudanian forest" and a more mesic "Sudano-Guinean gallery forest"--reflecting differences between ravine and cliff ledge Gilletiodendron forest

vegetation, but the number ($n = 4$) of purely or mainly cliff-ledge groves studied is insufficient for such generalization. In any case, the total area of Gilletiodendron forest vegetation in ravine sites seems to be greater than that found in cliff ledge sites.

Gilletiodendron forest vegetation most commonly occurs in places where surface and subterranean water is abundant (Jaeger 1956a). Although surface water in Gilletiodendron groves is not usually permanent nor deep, occurring mainly during the period July to December when run-off is abundant, topography and geology, as well as the shading effects of the canopy, ensure that the soil remains moist throughout the year (Jaeger 1956a). In many groves, an important source of soil moisture appears to be seepage from between sedimentary layers of sandstone (Figure 25), in addition to seasonal drainage. Soil humidity enables a variety of mesophytic and riparian species to survive, as in similar locations in the sandstone plateaux of eastern Senegal (Adam 1966). Although not strictly riparian, survival of this vegetation appears to depend at least as much on soil moisture as on protection from fire, which Jaeger (1956a, 1966, 1968), Aubréville (1939), and Duong (1947) cite as the most important environmental variable determining its distribution. Indeed, Site 7 and parts of Sites 9, 11, 15, and 17 occur along seasonal drainage channels or semi-permanent creeks in flat, unprotected areas surrounded by grasses and fire-prone wooded grassland (Figure 26). Sites 7, 9, and 11 are particularly interesting, as the lower edges of these groves lie within meters of actively cultivated fields which are burned yearly to clear crop residue. Several charred, but otherwise healthy, Gilletiodendron individuals were observed on the edge of Sites 7 and 11, but the vegetation seemed otherwise unaffected.

Gilletiodendron forest vegetation contains more Sudano-Guinean than Sudanian floral elements. Of 122 species characteristic of Gilletiodendron forest which are reported by Lawesson (1995), Guinko (1985), or White (1979), or whose distribution type can be readily deduced from Lawesson's map and descriptions (1995, 77-85), 58 (46.0%) are of Sudano-Guinean distribution types, 40 (31.7%) are widespread species, and 23 (18.3%) are Sudanian type plants. Many of the Sudano-Guinean plants are of the western Guinean distribution type, which are most abundant in Senegal in the lower Casamance, and also occur sparsely in relict populations in eastern Senegal (Adam 1968, 1965, 1962a, 1962b; Lawesson 1995). Many of the Sudanian plants are endemic to West Africa and have distributions limited to southeastern Senegal, southwestern Mali, Guinea, and Sierra Leone.

Although the majority of plant species observed were sampled in the course of the vegetation structure survey (96 of 126), most species were relatively uncommon as a consequence of the overwhelming dominance of Gilletiodendron glandulosum, Grewia bicolor, and Hippocratea indica (see *Vegetation Structure and Composition*, below). The dominance of these three species contributes to the relatively low inverse Simpson diversity index score, 8.26 (Appendix 3). This score is considerably lower than that of other "Sudano-Guinean gallery forest" and "Southern Sudanian forest" types reported by Lawesson (1995, 89), which are in the range 17.96-60.94. None of the vegetation types examined by Lawesson, though, were as heavily dominated by a single species as Gilletiodendron forest, and the Simpson index is rather insensitive to the addition of rare species (Stiling 1996). However, the Shannon index score is also relatively low, 2.96.

Again the overwhelming dominance of Gilletiodendron glandulosum, Hippocratea indica, and Grewia bicolor explains this score.

Tropical forests in dry climate zones, particularly gallery forests, are poorly known and not widely researched (Janzen 1988). The only comparable published data may be that of Parthasarathy and Kathikeyan (1997) from southeastern India. In their study of “tropical dry evergreen forest” remnants which are floristically similar to Gilletiodendron forest to the generic level, they calculated Shannon indices of 2.36 and 2.57, while the inverses of their Simpson indices are 5.77 and 7.99 (Parthasarathy and Kathikeyan 1997, 1067). The calculated biodiversity indices for Gilletiodendron forest are slightly higher than these figures, which is perhaps due to the fact that Parthasarathy and Kathikeyan’s study sites are very isolated and small (1 ha each) remnants of a once more widespread vegetation, while the present research sites are larger in total area, less isolated, and part of a much larger archipelago of habitat isolates.

Vegetation Structure and Composition

Gilletiodendron forest is overwhelmingly dominated by Gilletiodendron glandulosum, Grewia bicolor, and Hippocratea indica in all structural characteristics examined. However, data on vegetation structure fails to indicate the importance of this vegetation for the conservation of rare plants--such as Anthocleista nobilis, Smeathmannia laevigata, and Christiana africana--which are uncommon and characterized by patchy distributions. Additionally, these plants tend to be most common in the most inaccessible locations--particularly cliff faces, moss-covered slopes with seepage areas, and along

waterfalls--and were thus undersampled relative to plants found in more accessible locations.

Canopy structure. Structurally, Gilletiodendron forest has two canopy levels, the upper level greater than 8 m in height, the lower level less than this. The upper canopy is more continuous than the lower, though the latter can be more dense (Figures 27 and 28). 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 topography characteristic of Gilletiodendron groves. In an idealized grove (Figure 29), 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. These plants may be more fire-tolerant than other characteristic plants, as they are also common in fire-prone woodland and wooded grassland vegetation. Various lianas, especially Hippocratea indica (Figure 30), form a connection between lower canopy shrubs and bushes and upper canopy trees on the downslope edge of the grove (Figure 30). On the upslope edge, 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. Often, small trees--such as Stereospermum kunthianum and Xeroderris stühlmannii--are common on the upslope edge. On some edges of the grove, depending on topography, trees more characteristic of woodland, wooded grassland, and “Southern Sudanian forest” types (Lawesson 1995) are present. Within the grove, the lower canopy is especially dense along seasonal drainage channels and around seepage areas which occur in rocky upslope portions of the grove, at the junction of sedimentary layers.

Seepage areas along steep boundary slopes are often rich in uncommon species. Locally, Gilletiodendron sucker sprouts less than 8 m high can form dense patches. Xerophytes--such as Euphorbia sudanica (Figure 32) and Tephrosia mossiensis (Figure 33)--are present along the dry upper edge of the grove.

While the lower canopy is consistently between 3 and 7 m, 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 25-30 m. Such sites are very well shaded and have virtually no lower canopy or herbaceous vegetation, although lianas may be present in the upper branches of trees. Often, shorter saxicolous trees--such as Ficus glumosa, Ficus cordata, and Gyrocarpus americanus--form part of the high canopy although rooted along the rock face of the bordering cliff (Figure 25). In parts of groves found along cliff edges, rock ridges, or relatively open, flat areas, upper canopy trees tend to be lower, between 8 and 12 m 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 10-12 m. In these locations, which tend to have relatively lower soil humidity than other Gilletiodendron forest locations and are also somewhat more accessible, Gilletiodendron glandulosum may occur as a multi-stemmed shrub, and may occupy the lower canopy edge species niche or occur in rocky savanna areas away from the main body of the grove (Figure 34). It is unclear if this uncommon form of the plant is due to ecological factors or to abundant sprout growth following repeated cutting by humans. However, similar plasticity in habit is also known of the relict

tree Guibourtia copallifera Benn. (Fabaceae-Caesalpinoideae) which occurs elsewhere in Mali and West Africa (Jaeger 1956a; Léonard 1951). In locations where the upper canopy is below 12 m in height, it also tends to be rather patchy, while the lower canopy is often rather dense.

Density. The density of ligneous plants in Gilletiodendron forest vegetation is relatively high, with approximately 3289.30 stems of all sizes per hectare based on the quadrat sampling survey, which yielded data comparable to that of Lawesson (1995). This value is similar only to the “Ampelocissus leonensis-Pentaclethra macrophylla gallery forest” vegetation type described by Lawesson, which has a density of 3300 ± 800 for two sites sampled (1995, 71). All other vegetation types reported by Lawesson have lower densities. This value is considerably higher than those reported for two 1-ha plots in “tropical dry evergreen forest” in southeastern India, 1367 and 974 stems per ha (Parthasarathy and Kathikeyan 1997, 1067).

The density of individuals ≥ 10 cm DBH is 492.75 stems per ha based on the quadrat survey, or 438.31 based on the point-quarter survey. These figures are in the median range for lowland tropical forest and tropical riparian forest sites worldwide reported by Meave and Kellman (1994, 126-127). Figures cited by these authors, however, are all from sites with higher precipitation than in Gilletiodendron forest, often much more so (mean = $3082.07 \text{ mm} \pm 1200.40$). This implies that Gilletiodendron forest vegetation has a relatively high density for its level of precipitation.

Line transect sampling yielded a density measurement lower than quadrat sampling and higher than measures for individuals ≥ 10 cm DBH because this technique samples both large, mature individuals and smaller individuals. All of these three measures show that Gilletiodendron forest vegetation is much denser than the surrounding woodland, and that the vegetation is dominated by Gilletiodendron glandulosum, Grewia bicolor, and Hippocratea indica (Table 4).

Based on the point-quarter survey data (Table 4, Appendix 4), no plant has a relative density greater than 4% other than Gilletiodendron glandulosum and Grewia bicolor. The Gilletiodendron has a relative density of 53.44%, while the Grewia has a relative density of 15.47%. Based on the line-intercept survey data (Table 4, Appendix 5), Hippocratea indica, Grewia bicolor, and Gilletiodendron glandulosum have the greatest relative densities of all plants sampled, although they are not overwhelmingly dominant in this measurement. There is a steady decline in relative density, with no major jumps from one plant to the next (Table 4). Finally, based on the quadrat survey data (Table 4, Appendix 6), Gilletiodendron and Hippocratea indica are strongly dominant, with Grewia bicolor and a variety of other plants also important.

Cover dominance. Cover dominance is shown by the line intercept survey data (Table 5, Appendices 7 and 8). Based on Lawesson's (1995, 24) definition, the vegetation studied is clearly a forest (rather than woodland) formation, having total upper canopy cover of 79.78% (1659.5 m of 2080 m total transect length). There is minimal overlap of individuals in the upper canopy, so this figure is near the actual percent of upper canopy cover. Gilletiodendron glandulosum is overwhelmingly dominant in the upper canopy

layer (Appendix 7). Its dominance, expressed as percent of total upper canopy cover is 47.55% (relative upper canopy cover dominance 59.60%), while the next most dominant upper-canopy tree, Spondias mombin, has a dominance of just 4.10% (5.14% relative). The liana Hippocratea indica is the second most dominant component of the upper canopy, reflecting its overall importance to the composition of Gilletiodendron forest vegetation.

The lower canopy of Gilletiodendron forest is more diverse than the upper canopy and also more dense with 95.76% total cover (Appendix 8). (Ground without woody plant cover accounts for only 0.08% of total cover.) However, this figure is somewhat misleading because the lower canopy is very patchy. On the edges of groves, in seasonal drainage channels, and near openings in the upper canopy, the lower canopy is almost impenetrably dense, with numerous individuals of many different species tangled and overlapping. Actual lower canopy cover is probably less than 60%, with much of the area under dense upper canopy sections virtually devoid of lower canopy cover.

Unfortunately, the data collected are based on cover dominance per species rather than canopy level per se, so calculation of actual lower canopy cover is not possible with these data. Grewia bicolor (23.02% dominance, 24.04% relative dominance) and Hippocratea indica (16.74% dominance, 17.48% relative dominance) are co-dominant, with Gilletiodendron glandulosum and Combretum micranthum also major components.

Basal dominance. Gilletiodendron glandulosum is overwhelmingly dominant in terms of basal dominance as shown by the point-quarter and quadrat sampling surveys (Table 6). In the point-quarter survey, the dominance of Gilletiodendron stems ≥ 10 cm

DBH is 18.19 m² per hectare, a relative dominance of 59.6%. With the score of 9.90%, the plant with the nearest relative dominance value is Adansonia digitata, the baobab, which has such a high value because of the tree's characteristically high diameter: only two individuals were sampled. Even greater is the dominance of all sizes of Gilletiodendron stems, as indicated by the quadrat sampling data. Basal dominance of the plant is 28.62 m² per hectare, or 83.15% relative dominance. The next most dominant plant in this survey is Grewia bicolor, with merely 3.31% relative dominance.

Total basal dominance for all individuals in Gilletiodendron forest is 32.48 m² per ha based on quadrat sampling, or 30.52 m² per ha for individuals ≥10 cm DBH based on point-quarter sampling. The point-quarter figure is somewhat lower because only individuals ≥10 cm DBH were sampled. These figures fall in the lower range of values for lowland tropical forest and tropical riparian forest sites worldwide as reported by Meave and Kellman (1994, 126), and are higher than measurements in two 1-ha plots in "tropical dry evergreen forest" in India (15.44 and 29.48 m² per ha) (Parthasarathy and Karthikeyan 1997, 1067).

Frequency. The plants which occur with the greatest frequency in Gilletiodendron forest vegetation are the triumvirate of Hippocratea indica, Gilletiodendron glandulosum, and Grewia bicolor (Table 7). In the point-quarter survey, the Gilletiodendron, the Grewia, and Ficus cordata were strongly dominant. Respectively, these plants had relative frequency values of 31.56%, 15.25 %, and 13.48% while the next most frequent plant, Spondias mombin, had a value of just 4.61%. In the quadrat and line intercept surveys, the three plants were not so strongly dominant, but were clearly the

most frequently encountered plants. Hippocratea indica was strongly dominant in the line intercept survey, while the three plants were co-dominant in the quadrat survey.

Importance value. Finally, the summary importance values of the three survey data sets show the major importance of Hippocratea indica, Gilletiodendron glandulosum, and Grewia bicolor in the composition of the vegetation studied (Table 8). In the point-quarter survey, Gilletiodendron is overwhelmingly dominant, having an average importance value of 48.20%, followed by Grewia bicolor (11.65%) and Ficus cordata (4.98%). In considering total cover in the line intercept survey, Gilletiodendron glandulosum, Hippocratea indica, and Grewia bicolor were the three most important plants, although several others were nearly as important overall, particularly Combretum micranthum and Diospyros abyssinica. The quadrat survey also showed that the three main plants were the most important.

Ethnobotanical Significance of Gilletiodendron Forest

Maninka plant names. Ethnographic interviews elicited 104 different Maninka names for 98 scientific botanical taxa (Table 9). Most plants observed in Gilletiodendron forest were salient and recognizable at least to hunters--which are traditionally the class of individuals most familiar with wild plants in Maninka society (Cashion 1982)--while many plants were easily recognizable by most individuals questioned. However, some plants were not or only poorly recognized even by hunters, reflecting either their rarity or lack of known use. Names for plants listed in table 9 having a very poor recognition rate should be interpreted as educated guesses--based on the plant's habitat, and form, smell, or

taste--by one or a few Maninka hunters speaking the Bafing-area patois. The names listed as such do not correspond with published names for the scientific taxon in question nor any other taxa, and may prove incorrect. All other names listed are correct for the Maninka patois spoken in the Bafing, Bambugu, and Sulun traditional *kafolu*, unless otherwise noted.

Less than half of these names (47 of 104) correspond even roughly with published plant names in Maninkakan or other Manding languages. While many of the names listed in table 9 are somewhat tentative due to low saliency of some plants and thus very poor recognition by informants, the names which fail to correspond with published sources are not necessarily wrong. Instead, this variance reflects both the unique vocabulary and pronunciation of the Maninka patois spoken in the research area (which is not represented in any published source), as well as the rarity of many of the plants considered. For instance, Maninka names for *Tephrosia mossiensis* and *Gyrocarpus americanus*, both rare and localized in West Africa, are unreported in published sources, although these plants are common and, in the recent past, were commonly used in the Bafing area. Most of the names listed in table 9 are new to the published Manding vocabulary.

These plant names clearly reflect common patterns of Maninka plant nomenclature. Most plants have abstract, irreducible names, such as *sènsão* (*Gilletiodendron glandulosum*). Some names are reducible and derived from plant physical or habitat characteristics as perceived by the Maninka. For instance, *tun su ma* (*Feretia apodanthera*), meaning 'found at termite mounds', describes a common habitat of this plant. The name *kònòding dolo* (*Combretum paniculatum*), meaning 'little bird's beer',

refers to the drop of nectar found at the base of each flower which is drunk by sunbirds (Nectariniidae). Other descriptive names refer to uses of the plant. For example, *sòsò ngani* (*Asparagus flagellaris*), which roughly means ‘troublesome or annoying to mosquitoes’, is used as an insecticide, while a branch of *jègè bòrò* (*Leptactina senegambica*), meaning ‘fish sack’, can be used as a fish stringer. Many plants have specific names, with various, usually paired modifiers used with irreducible generic names. The most common modifiers are the pairs *ke* and *muso* (male and female), *ge* and *fing* or *hing* (white and black), and *nunko* and *nganya* (smooth and rough, generally used in describing leaves). For instance, there are *sambe fing* (*Grewia bicolor*) and *sambe ge* (*Grewia lasiodiscus*), a distinction based on the pubescence of the leaves (that of *sambe fing* is denser, thus darker to the Maninka); *hego nunko* (*Lannea microcarpa*) and *hego nganya* (*Lannea velutina*), because the leaves of *hego nganya* are pubescent, while those of *hego nunko* are glabrous; and *jambakatan ke* (*Combretum glutinosum*) and *jambakatan muso* (*Combretum collinum*), a distinction which appears to be abstract. Often, the more salient or common member of such pairs is referred to only by the generic name unless more precise locution is desired. Thus, *jambakatan ke*, a common tree and valuable source of firewood, is usually referred to simply as *jambakatan*, while *jambakatan muso*, an uncommon tree, is inevitably referred to as such. Finally, some names consist of compound descriptive modifiers used with irreducible generic names. Two examples of this type of name are *hara to se* (*Manilkara multinervis*), meaning ‘the type of *se*

(*Vitellaria paradoxa*) which is found in rice fields', and *dèn ba toro* (*Ficus sur*), which means 'the type of *toro* (*Ficus*) with large fruit'.¹

It is also important to note that table 9 lists names without generalized descriptive modifiers which are often attached to plant names in common speech. Although the nouns *yiro* (tree), *nòmbo* (liana), *yiridiyō* (shrub or herb), and *juo* (meaning something close to 'stem' or 'an individual tree') are often used in close combination with proper plant names, they are generally not properly part of a plant name. Thus, although the baobab (*Adansonia digitata*) may be referred to as *sitojuo* (a baobab tree), the name of the tree itself is *sito* (baobab). There are a few exceptions to this rule. For instance, *karinòmbo* is the proper name for *Combretum tomentosum*, while the proper name for *Gardenia imperialis* is *kumbukambajuo*. Similarly, the name for parasitic plants, particularly the Loranthaceae, may include the name of the host tree in which an individual plant is found, although the use of such a modifier is confusing in general speech. Thus *Tapinanthus dodoneaefolius* is called *yiro la don* (forces the tree open), although the individual specimen collected from a *Ficus cordata* was referred to as *seko la don* (forces the *seko* [*Ficus*] open).

Additionally, in Maninkakan, plants whose proper names are not known are often referred to with general terms. Names such as *nòmbo*, *nòmboliyō* (non-ligneous vine), and *yiridiyō*, often modified by a noun or adjective describing a plant's appearance, do not refer to specific plants but are general terms like 'weed' or 'flower' in English. Thus,

¹ Although figs are not technically fruit from a botanical standpoint, the Maninka do not make such a distinction. Thus, the Maninka word *dèn* is translated as 'fruit', not 'fig'.

published names such as “nambo” for Baissea multiflora (Berhaut 1971, 367), or “sala nombole” or “sala nombo” (crossbeam vine, i.e. vine used to tie crossbeams in construction) for Baissea multiflora, Strophanthus sarmentosus (Dalziel 1955, 367, 381), and Combretum tomentosum (Berhaut 1975a, 371) are not proper Maninka plant names. Thus, although many plants characteristic of Gilletiodendron forest were referred to repeatedly with such general names, this data is not reported here because use of such terms reflects the low saliency of a particular species rather than its proper name.

Maninka plant use. The most important characteristic of Maninka plant names for understanding the economic significance of Gilletiodendron forest becomes evident when comparing the list of names with the list of uses (Table 10). Plants which have a commonly known use are easily recognized, although not all easily recognized plants have a commonly known use. It is important to note that most reported uses were not observed in practice, and that many informants stated that reliance on wild plant products has declined significantly since construction of the Manantali Dam and the associated involuntary resettlement in the mid- to late-1980s. This decline has also been noted by development anthropologists monitoring the resettlement project (Horowitz et al. 1990). Thus, although many plants in Gilletiodendron forest may have known uses, this does not necessarily mean they are regularly used in any quantity.

Most wild food plants tend only to be used in times of famine (e.g. the seeds of *jagungo* [Pterocarpus santalinoides]), while those that are used annually during the period of food shortage before harvest are planted or husbanded near town (e.g. the leaves of *sinamu* [Crateva adansonii]). Although most adults know many plants used as famine

foods, many children and teenagers are not familiar with these, perhaps because there has not been widespread famine in the area since the early 1980s. Several wild fruits are appreciated but not widely harvested except as snacks by children--such as the fruits of *minkòn* (*Spondias mombin*), *batio* (*Sarcocephalus latifolius*), and *hego nunko* (*Lannea microcarpa*). Only *saba* fruit (*Saba senegalensis*) is regularly sold in local markets. A few plants are greatly appreciated and commonly harvested--such as the leaves of *sito* (*Adansonia digitata*), *sinamu* (*Crateva adansonii*), and *haro* (*Piliostigma thonningii*). Such harvesting seems to have minimal impact on the plant populations affected because the quantity collected is relatively quite small, and because harvests are infrequent and rely on a large number of plants. Also, as discussed below, these plants are uncommon in Gilletiodendron forest, and individuals in more accessible locations tend to be harvested much more often.

Medicinal plants, with one significant exception, seem to have lost nearly all value to pharmaceuticals or introduced ornamental plants, especially eucalyptus (*Eucalyptus camaldulensis* Dehnhardt [Myrtaceae]) and neem (*Azadiracta indica* A. Juss. [Meliaceae]). Although there appears to be a renewal of interest in “traditional” medicine amongst urban Malians, the quantities used are quite small, and the market seems limited. For instance, when Daouda Kulibali, a “master” of “traditional medicine” from Bamako, stopped his a brightly painted automobile in Maréna to advertise his goods with a loudspeaker, the response to the herbalist’s pitches was clearly anemic. Several curious children approached, but no customers were observed during several hours. However, a similar herbalist was observed to have a brisk business in Bamako, and a Chinese expatriate even

opened an herbal medicine stand in downtown Bamako in early December, 1999. On the other hand, twice, in the course of conversations with different hunters and farmers, when asked which *hito* (medicine or leaf) should be taken for an infected insect bite and for mild dysentery, informants offered Chinese-made mentholatum rub and French-made antibiotic pills. These are better than Maninka medicines, was the explanation. Most manufactured pharmaceuticals which are available are very inexpensive in local markets, generally less than 100 CFA francs (\$0.16) per dose. Use of herbal medicine by those who most commonly rely on it, Mali's rural population, seems to be declining.

The exception to this trend is the case of *gèngèliba* (*Vepris heterophylla*), a shrub endemic to West Africa whose leaves have proven biochemical effectiveness as a medicine for stomach pains and gastrointestinal ailments (Paris and Etchepare 1968). This plant is listed as endangered by IUCN (WCMC 1998). This plant is prized and popular, and fetches 2000 CFA francs (approximately \$3.30) per kilogram in the Bamako and Kita markets. It is also widely used by rural people. In Maréna, Djiguiba Kéïta prepared *gèngèliba* for his wife Sayon each morning for a week after she had given birth in October, 1999, to ease stomach pains. As a result of this popularity, it is heavily harvested in some areas and has been extirpated where transportation to larger markets is reliable. People around Manantali tell of entire hillsides of *gèngèliba* being killed by harvesters from Bamako and Kita after dam construction began, and it is still common to see 50 kg sacks of leaves in trucks bound for Kita and Bamako. While populations of the plant appear large and healthy in more remote areas, those near larger towns (especially Kita and Bamako, but also Manantali) are seriously threatened if not already wiped out.

The situation of *sênsão* (*Gilletiodendron glandulosum*) is similar, though not as serious. The tree is a highly valued and extremely durable hardwood, used mainly for construction. Its most favored use is as a *sala* (load-bearing crossbeam), although it is also commonly used as a *taruma* (support post) (Table 11; Figures 21 and 35). However, in sparsely populated areas, it is uncommon to see *Gilletiodendron* wood in use, even if there is a grove nearby (Table 12). This is because other trees with similar uses--especially *gèlèyo* (*Prosopis africana*), *kèrèkèto* (*Anogeissus leiocarpus*), and *kosio* (*Burkea africana*)--are generally more easily accessible than *Gilletiodendron glandulosum*. However, in areas where the human population is higher, or the populations of other trees with similar uses have been depleted, or law enforcement against illegal cutting of well-known hardwoods has increased, use of *Gilletiodendron glandulosum* is intensified.

Based on the survey of actual use of *Gilletiodendron* logs in *bire* construction, the tree has a level of use much lower than its preference ranking would predict (Tables 11 and 12). When asked why *Gilletiodendron* was not used more often relative to less favorable trees such as *wòlò* (*Terminalia macroptera*), informants stated that it was easier to harvest trees found near villages and not in the hills. In remote areas, there is virtually no evidence of human disturbance in *Gilletiodendron glandulosum* groves. Around Manantali, where there is a relatively high human population, a high demand for materials to construct *birelu* (hangars) in the thriving daily market and workers' village, and relatively vigorous enforcement of laws banning unlicensed cutting of *gèlèyo* (*Prosopis africana*), *kèrèkèto* (*Anogeissus leiocarpus*), and *genu* (*Pterocarpus erinaceus*), there were 47 *Gilletiodendron* stumps per 422 uncut trees in sites 1, 2, 3, 4/5, 6, 7, and 8. While the

current level of exploitation around Manantali does not appear to be less than sustainable--especially because the tree sprouts vigorously after cutting (Figure 36)--it represents a trend that would predict a growing level of exploitation of Gilletiodendron glandulosum as population growth continues and transportation options expand in the Bafing Valley and surrounding areas. The overwhelming cover dominance of Gilletiodendron glandulosum means that overexploitation of the tree spells death for many of the other plants in a grove which rely on a dense upper canopy for appropriate habitat (Jaeger 1956a).

Current Conservation Efforts

Non-legislative measures. No Gilletiodendron glandulosum grove identified during this research can be classified as a “sacred grove” such as described by Fairhead and Leach (1996), Decher (1997), Guinko (1985), or Malgras (1992). Indeed, no social or cultural structure was identified analogous to the practice of protecting sacred groves known elsewhere in West Africa.

Wild plant conservation is not specifically nor consciously practiced by the Maninka in the research area. However, land use patterns tend to protect plants found in marginal or inaccessible areas, particularly steep slopes, cliffs, and the tops of plateaux (Figure 37). Cultivation takes place in flat, lowland areas, which are easily accessible and near to villages. Many valued wild trees are maintained in fields to provide shade, food, or other products, and some non-native fruit trees may also be planted. While only a small portion of the lowland area may be cultivated in any one farming season, a much larger area of fallow land is an integral part of the farming system. Historically, the fallow cycle

has been 7-14 years (Cashion 1982; Grigsby 1990), although the increasing population which requires more land to produce food has caused the fallow cycle to decrease to around 3 years in the Bafing Valley. The fallow land is dominated by grasses. Large individuals of valued tree species which were maintained when the fallow land was under cultivation dominate the ligneous vegetation, although younger individuals belonging to different species may become increasingly important as the length of the fallow period increases. Fallow land is an important reservoir of wild plant species useful to the Maninka, and the fallow cycle helps stimulate overall diversity by creating disturbance through fire and clearing, which many plants require to germinate and grow.

Beyond the fallow fields, usually in areas where edaphic or topographic factors make farming impossible, is marginal land which is not intensively used by the Maninka. Gilletiodendron forest generally occurs in such marginal areas. Some marginal areas are more actively used by the Maninka, such as slopes dominated by bamboo (Oxytenanthera abyssinica), which is a valuable construction material. However, sites which are difficult to access due to topography are seldom used by the Maninka because the plant resources they hold are not worth the risk or difficulty associated with their harvest. Most Gilletiodendron groves occur in such locations, and are thus seldom visited by the Maninka. Thus, Gilletiodendron forest is passively accorded some protection in the Maninka land use system on account of the inaccessible location of most groves. However, Gilletiodendron glandulosum nor any other plant abundant in Gilletiodendron forest is given any special protection by the Maninka.

Legislative measures. Although Gilletiodendron glandulosum is recognized as a vulnerable species by IUCN (WCMC 1998), this status does not provide the tree any legal protection under the Convention on International Trade in Endangered Species (CITES) nor any other international agreement. International awareness of this tree is low, and most efforts to legally protect rare plant species are directed toward areas which have greater levels of biodiversity or are more seriously threatened with destruction in the short term.

Mali's national laws provide protection for plants which have a high "intérêt économique, socio-culturel, ou scientifique" (Assemblée Nationale 1996, Article 16). Additionally, "versants montagneux", "abords des cours d'eau permanents, et semi-permanents", and "zones de naissance des cours d'eau et leur bassin de reception" are protected throughout the country (Assemblée Nationale 1996, Art. 10). However, the only plants specifically protected by law (Assemblée Nationale 1996, Art. 17) are widespread, well-known species which are commonly used for various purposes. No rare species--including Gilletiodendron glandulosum and Vepris heterophylla--are specifically protected under Malian law.

Compounding this is the near complete lack of awareness of Gilletiodendron glandulosum by conservationists working in Mali. The tree was not included in any surveys or inventories of biodiversity specific to Mali since the publication of Jaeger (1968), other than in the one-page summary of rare plants by Davis et al. (1986). Instead, Warshall (1989) and Projet Inventaire (1990) stress the importance of another rare tree, Guibourtia copallifera, which occurs in similar habitats near Bamako. However, this tree

is not endemic to Mali and is relatively common elsewhere in West Africa. Of approximately 15 people interviewed in Mali, no forestry agent, conservationist, resource manager, professor, or other professional, whether Malian or not, knew of Gilletiodendron glandulosum, *kololo*, or *sensão*. Thus, no effort is currently underway on any administrative level to protect the plant resources of Gilletiodendron forest.

Summary of Main Findings

Gilletiodendron forest is dominated by Gilletiodendron glandulosum, Hippocratea indica, and Grewia bicolor. These three plants are the most important components of all vegetation structural characteristics surveyed. However, there is a large number of rare plant species which also occur in Gilletiodendron forest that are characteristic of more humid Sudano-Guinean forests further to the south. Since Gilletiodendron forest is so overwhelmingly dominated by a small number of species, indices of floral diversity for the vegetation type are relatively low.

Use of plants occurring in Gilletiodendron forest by the Maninka people is low, although most plants have known names and uses. This is because Gilletiodendron forest often occurs in inaccessible locations which hinder the collection and transport of plant materials. Thus, this vegetation type is not currently heavily exploited. However, Gilletiodendron glandulosum and Vepris heterophylla both have the potential to be overexploited because of their high value. This is especially evident in areas with high human populations, where demand for wild plant products is high.

Unfortunately, no plants which are common in Gilletiodendron forest (except the widespread trees Bombax costatum, Pterocarpus erinaceus, and Anogeissus leiocarpus) are specifically protected under Malian law. This is particularly problematic in the case of Gilletiodendron glandulosum and Vepris heterophylla. Additionally, there are no indigenous, non-legislative conservation measures which protect Gilletiodendron forest. However, since this vegetation type generally occurs in marginal areas within the Maninka land use system, it benefits from passive protection.

IV. DISCUSSION

Overview

The results of this project help answer three important questions about the conservation of Gilletiodendron glandulosum. First, what is the botanical significance of Gilletiodendron forest? This vegetation is a unique type of Sudano-Guinean gallery forest which holds remarkable botanical diversity considering its northerly geographic location. As such, it is highly valuable to Mali for the maintenance of national biodiversity, and internationally important for the rare genetic and ecological information it holds. Additionally, Gilletiodendron forest provides valuable habitat for various frugivores, including the endangered western chimpanzee (Pan troglodytes verus). Continued monitoring of and research on this vegetation type should be undertaken.

What are conservation priorities for plants in Gilletiodendron forest? Although many plants in Gilletiodendron forest have uses to the Maninka people, actual use of these plants is low. Except for Gilletiodendron glandulosum and Vepris heterophylla, no plants appear to be particularly vulnerable to destructive harvesting. Gilletiodendron glandulosum is not currently harvested at unsustainable levels in the areas surveyed, although Vepris heterophylla may be. Improved legal protection of these plants is vital.

What steps should be taken to improve conservation of Gilletiodendron forest? While Gilletiodendron forest has survived without the benefit of any real conservation efforts, estimates of population growth in Mali dictate that conservation measures should be planned now to protect this rare plant community for the long-term future.

Conclusions

Conservation Value of Gilletiodendron Forest

In the past, the conservation value of Gilletiodendron forest has been evaluated based on analysis of its origins as well as on descriptions of its floral diversity. These two aspects are considered below in light of the evidence presented here.

Origins of Gilletiodendron forest. Gilletiodendron forest has usually been described as a type of “Southern Sudanian forest” (Lawesson 1995) or “Sudanian dry forest” (White 1983; Schnell 1976; Jaeger 1956a). However, its floral composition is more similar to previously described “Sudano-Guinean gallery forest” types (Lawesson’s [1995] term; for vegetation descriptions see also Adam 1968, 1966, 1965, 1963, 1962a, 1962b; Aubréville 1949; Jaeger and Winkoun 1962; Duong 1947; Roberty 1940). The variety and abundance of mesophytic and riparian species in Gilletiodendron forest clearly distinguishes this vegetation from other “Southern Sudanian forest” (Lawesson 1995) or “Sudanian dry forest” types (White 1983). Also, humid soil conditions and location along seasonal or semi-permanent waterways characteristic of Gilletiodendron forest distinguish this vegetation type from “Southern Sudanian forest” types, which characteristically occur on deep soils in flat areas (Lawesson 1995). The distinctions between similar vegetation types and even formations is not absolute (Lawesson 1995, 56-57), which is the case in considering Gilletiodendron forest and other forest and gallery forest types in the area.

While quibbling over the use of a vegetation general term to describe vegetation may seem trifling, implications of the distinction between ‘dry forest’ and ‘gallery forest’ are significant. Gallery forests are edaphic vegetation types; their distribution is

determined by soil and ground moisture factors. On the other hand, in West Africa, dry forests are considered to be climatic vegetation types; their distribution is determined by climate. The fact that dry forests occur in areas which otherwise currently support only grasslands or woodlands--such as most of southern Mali--has long been interpreted to mean that dry forest is the aboriginal climax vegetation of the Sudanian and Sudano-Guinean climate zones (Aubréville 1938, 1962, 1949; Duong 1947; Schnell 1960, 1976; Jaeger 1956a, 1966; Adam 1956). In particular, Jaeger (1956a, 1966, 1968) has argued that Gilletiodendron forest is one of only two types of vegetation which survive in West Africa from the period before the increased incidence of fire due to agriculture favored the expansion of savanna vegetation. However, his data were not thorough and did not include floristic analysis. Based on the floristic evidence reported here, it appears that Gilletiodendron forest is an edaphic, rather than climatic, vegetation type.

Additionally, the location of several research sites indicates that edaphic conditions are important in determining the distribution of Gilletiodendron forest groves. Site 7 and parts of Sites 9, 11, 15, and 17 occur along seasonal drainage channels or semi-permanent creeks in relatively flat, unprotected areas surrounded by grasses and fire-prone wooded grassland (Figure 26). Sites 7, 9, and 11 are particularly interesting because the lower edges of these groves lie within meters of actively cultivated fields which are burned yearly to clear crop residue. Several charred, but otherwise healthy, Gilletiodendron individuals were observed on the edges of Sites 7 and 11, but the vegetation seemed otherwise unaffected. These locations belie the accuracy of statements such as “[l’arbre] ne peut s’étendre en savane [à cause des feux]” (Schnell 1976, 298), and discredit theories that

nearly miraculous topography (see Duong 1947, 38-39) is the only thing saving Gilletiodendron glandulosum from extinction. Certain species in Gilletiodendron forest are undoubtedly quite sensitive to fire--such as Gyrocarpus americanus--and groves could certainly be destroyed by fire, but the importance of fire in determining the distribution of this vegetation may have been overestimated by earlier researchers. Lechner's observation of the death of Gilletiodendron glandulosum saplings and seedlings growing away from the cliffs following a wildfire is repeatedly cited as proof that the tree is highly susceptible to fire (Jaeger and Lechner 1957; Jaeger 1956a, 1966; Schnell 1976). However, in dry forest in Ghana saplings and seedlings, whether the adults are fire-tolerant or not, are most sensitive to fire (Swaine 1992). Gilletiodendron glandulosum seedlings are not likely different. Also, Swaine (1992) has shown that larger individual trees in Ghanaian dry forests are more susceptible to drought than to fire.

This is not to say that the tree is highly fire tolerant. Its bark is thin and it occurs in a vegetation type which does not burn regularly. Instead, it may be possible that Gilletiodendron glandulosum has a relatively high but narrow tolerance for soil moisture, and that river bank locations may exceed its tolerance while areas away from seasonal drainage channels and seepage areas may not have sufficient soil moisture. Few locations other than ravines and cliff ledges have relatively high soil moisture in the rugged Manding Hills (Jaeger 1956a, 1966; Jaeger and Jarovoy 1952; Jaeger and Lechner 1957; Duong 1947; Schnell 1976; Killian and Schnell 1947), and these locations also tend to be protected from fire by topography. Additionally, Avenard et al. (1974) show that in the Sudano-Guinean savannas of central Côte d'Ivoire edaphic factors are paramount in

determining the distribution of plant communities; anthropic factors are not not significant. The importance of soil humidity over fire protection would also explain the absence of Gilletiodendron glandulosum in similar ravine vegetation in central Mali's Bandiagara Plateau (Jaeger and Winkoun 1962), which is drier than the Manding Plateau (Monnier 1990) (though possibly also less fire-prone [Ehrlich, Lambin, and Malingreau 1997]). Both environmental factors undoubtedly influence the distribution of Gilletiodendron forest to a certain degree, but earlier emphasis on the destructive influence of anthropogenic fire may reflect the natural resource politics of the colonial era more than ecological realities (Fairhead and Leach 1996).

Based on floristic evidence, it is likely that Gilletiodendron forest is a relict vegetation type. From a phytogeographical standpoint, the combination of species present in Gilletiodendron forest is significant. Many of the species collected are endemic to Mali (i.e. Gilletiodendron glandulosum) or West Africa (e.g. Leptactina senegambica, Smeathmannia laevigata, Tephrosia mossiensis). Many of these plants have disjunct populations scattered throughout West Africa, and since such plants do not generally have long-distance dispersal methods, it is likely that their disjunct populations were once more-or-less continuous (Brown and Gibson 1983). Similarly, many genera are more characteristic of the Guineo-Congolian (e.g. Gilletiodendron, Cola, Dialium) or Sudano-Guinean (e.g. Leptactina, Anthocleista, Detarium) phytochoria rather than the Sudanian, which indicates an affinity between Gilletiodendron forest and more southerly phytochoria (Figure 1). These phytochoria were more widespread to the north more than 25,000 years before present (BP), before the onset of the last major world glacial period which resulted

in drier conditions throughout northern Africa and lasted until about 12,000 years BP (Hamilton 1992, 1974). Once the climate became moist again, Guineo-Congolian forests may have reached as far as 13° N between 6000-8000 years BP (McIntosh and McIntosh 1981). Other species are sparsely dispersed pantropicals (e.g. Gyrocarpus americanus, Lepisanthes senegalensis), or are present both in West Africa and South America (e.g. Spondias mombin, Christiana africana). The presence of such species indicates that Gilletiodendron forest may be quite ancient, since plants with trans-Atlantic distributions probably represent remnants of vegetation more than two million years old (Smith 1973). In Central America, riparian and gallery forests in drier climate zones have been shown to be refugia for species characteristic of wetter climates during periods of climatic desiccation (Meave and Kellman 1994), and it is likely that Gilletiodendron forest plays a similar role in Mali's savannas.

Additionally, the overwhelming dominance of Gilletiodendron glandulosum in the vegetation is likely what would result from the fragmentation of a once more widespread habitat. Species which survive and continue to flourish after permanent habitat fragmentation are likely to reproduce rapidly and abundantly, and to become strongly dominant (McKinney 1997; Patterson 1987). Gilletiodendron glandulosum has an extremely high germination rate approaching 100% (Jaeger 1966, 1959, 1956a), and produces great numbers of seeds each year with a regularity that is somewhat uncommon among tropical trees (Jaeger 1956b). Its seedlings are also remarkably hardy and are abundant throughout Gilletiodendron glandulosum groves (Figure 11) (Jaeger 1956a).

Floral diversity. Gilletiodendron forest is not characterized by a remarkably high level of floral diversity. However, it contributes significantly to beta biological diversity in the Manding Plateau area. First, it is important to emphasize that Gilletiodendron glandulosum does not occur elsewhere on Earth. Unlike all other ligneous plants endemic to Mali, this tree is unquestionably a distinct species and not a possible subspecies of a more widespread plant (Léonard 1951; Boudet, Lebrun, and Demange 1986). It is a remarkable species based on form, economic potential, and probable relict status and deserves protection in its own right. Second, many of the plants found in Gilletiodendron forest are either extremely rare or not found in other Sudanian vegetation types--such as Xylopia elliotii, Gyrocarpus americanus, and Vepris heterophylla. Finally, many of the plants characteristic of the Sudano-Guinean phytochorion are rare even further to the south--such as Leptactina senegambica, Smeathmannia laevigata, and Anthocleista nobilis. If Gilletiodendron forest were destroyed, Mali would lose at least 12 plant species from its total inventory of 1740 (Boudet, Lebrun, and Demange 1986), and its stock of many other rare plants would decline greatly. As a habitat for numerous rare plant species, and as the sole known habitat for nearly 1% of Mali's total inventory of plants despite its limited area, Gilletiodendron forest has a high conservation value.

Additionally, tropical forests with relatively low species diversity are poorly known in general and are not frequently studied due to a preference in the scientific community to research species-rich communities (Parthasarathy and Karthikeyan 1997; Janzen 1988). There is relatively little published data on plant communities which can be reasonably compared with Gilletiodendron forest. Thus, although the absolute level of floral diversity

of Gilletiodendron forest can be estimated, the relative meaning of this value is difficult to determine. Further research must focus on other riparian and gallery forests in relatively dry climate zones throughout the tropics in order to more completely understand the relative value to biodiversity conservation represented by Gilletiodendron forest.

Conservation Status of Gilletiodendron Forest

The status of Gilletiodendron forest in terms of conservation is assessed based on the current and likely future levels of human impact on this vegetation type, as well as on the types of conservation measures currently enacted for its protection. While Gilletiodendron forest is not currently threatened with destruction, high population growth and the lack of appropriate conservation measures mean that long-term survival of the vegetation type is not assured.

Human impact. For the most part, humans currently have little direct impact on Gilletiodendron forest. The physical difficulty in getting to Gilletiodendron glandulosum groves has kept this type of forest as yet relatively unaffected by human activities. Many of the most commonly used plants which occur in Gilletiodendron forest--such as Cissus populnea, Pterocarpus erinaceus, and Anogeissus leiocarpus--are commonly used only because they are abundant outside of Gilletiodendron groves, in more easily accessible locations. It is physically demanding if not dangerous to access most Gilletiodendron forest stands, which are often found along sheer cliffs or at the summit of very steep, rocky slopes. It is so much more difficult returning from these locations while carrying a large load of wood, fresh leaves, or roots. However, wood is fuel, and the growing

fuelwood problem, present even in some relatively remote areas, is increasing the attractiveness of the plant resources of Gilletiodendron glandulosum groves for women seeking to decrease the amount of time required daily to collect wood. Although fuel is not currently a significant product of Gilletiodendron forest in the Bafing area, it will probably be one in the near future as more accessible wood stocks are depleted.

The likelihood of this trend is exemplified by Gilletiodendron glandulosum itself. In remote areas where human population growth has not yet depleted stocks of plant resources found in easily accessible locations such as fallow fields, use of the Gilletiodendron is very low. However, around Manantali, where population growth has been tremendous in the last twenty years, use of Gilletiodendron glandulosum is common, and groves in this area show much evidence of human disturbance, particularly logging. As population growth proceeds in Mali by as much as 3% per year (Stockman 1993) and demand for wild plant resources consequently increases, the value of the natural resources present in Gilletiodendron forest will increase and harvesting will proceed.

Although the kinds of uses many characteristic plants have demand little of the plant populations in question, the overwhelming importance of Gilletiodendron glandulosum means that consideration of appropriate use levels should be confined to the Gilletiodendron itself. For instance, *karinòmbo* (Combretum tomentosum) is used to make the *kòtò*, which is either the uppermost support ring in a conical thatch roof, or the ring of fiber used to hold a drum head on a drum. The demand for these objects is very low, and the quantity of *karinòmbo* required to make them is also quite low. Similarly, even regular use of *sabarô* (Gyrocarpus americanus) seeds to make beads would seem to

have little impact on the plant's population. Prayer bead chains--the most common use of *sabarõ* beads--require about 50 to 70 seeds, while a mature tree produces thousands of single-seeded fruit yearly. Even relatively heavy use of these and many other plants characteristic of Gilletiodendron forest would not seem to have a major direct impact on the vegetation. However, harvesting enough Gilletiodendron glandulosum lumber for three or four *birelu* (hangars) could be devastating to a grove because such use could create major canopy openings and expose surviving plants to unsuitable environmental conditions.

Additionally, it should be noted that only direct effects of plant use on plant populations have been considered above. Non-proximate causes such as climate change could be devastating on Gilletiodendron forest if there is significant drying of the climate in West Africa. However, the possible effects of climate change in the tropics are far from clear (Hartshorn 1992; Dixon et al. 1996). The indirect effects of plant use on Gilletiodendron forest are currently rather low because the use of plants in Gilletiodendron groves is low. Indirect effects such as erosion, disruption of wildlife habitat, and spread of introduced plants could significantly increase with only small increases in the actual use of Gilletiodendron forest plant resources.

From the standpoint of biodiversity conservation, disruption of wildlife habitat may be the most significant indirect effect because Gilletiodendron forest appears to be important habitat for the endangered western chimpanzee (*Pan troglodytes verus*). The wild animals of western Mali are considerably more endangered than the plants, and habitat loss has been the main cause of the decline of wildlife populations in West Africa

(Decher 1997). Fresh chimpanzee nests were observed in or near all Gilletiodendron groves surveyed within current chimpanzee distribution ($n = 5$), and the abundance of fruit trees and surface water makes this vegetation type important habitat for these animals. Also, the only researchers who have studied chimpanzees in Mali have referred to the importance of “isolated forest patches on the steep slopes” as habitat for chimpanzee (Moore 1985, 60; Pavy 1993). However, Moore and Pavy did minimal research on vegetation, and apparently did not visit Gilletiodendron forest, although a photograph by Moore (1985, 60) clearly depicts this vegetation type. In Niokolo-Koba National Park, Senegal, and in northern Guinea, gallery forest is also important chimpanzee habitat (Kortland 1983; Baldwin, McGrew, and Tutin 1982; Dupuy 1970; de Bournonville 1967).

Many plants in Gilletiodendron forest have been recorded as chimpanzee foods (Table 13). Additionally, several woody plants characteristic of Gilletiodendron forest have fruits which are edible by humans, and are thus likely eaten by chimpanzee too (e.g. Diospyros mespiliformis, Celtis integrifolia, Ziziphus mucronata, Cola laurifolia). The overall abundance, density, and diversity of chimpanzee food plants, as well as the availability of surface water makes Gilletiodendron forest highly valuable habitat for this animal. While the total quantity of these plants harvested for human consumption is generally quite small, a potential effect of wild plant collection compounded by ongoing population growth may be the reduction of suitable habitat for diurnal frugivores in southwestern Mali.

Mali's Bafing Faunal Reserve may harbor the second-largest protected sub-population of the western chimpanzee sub-species (based on figures from Pavy [1993] and

McGrew [1989]). Increased human presence in Gilletiodendron glandulosum groves may make the habitat unsuitable for chimpanzee even if the vegetation is not, as a whole, strongly affected by increased use. Improved knowledge of the ecology of Mali's chimpanzees is necessary in order to clarify the relationship between Gilletiodendron glandulosum and Pan troglodytes verus and improve conservation of these two rare species.

Conservation measures. Currently, Gilletiodendron glandulosum is not widely used in construction by the Maninka because other trees with the same use are more easily accessible and often more abundant. In general, plants which occur in marginal areas in terms of Maninka land use benefit from their relative isolation and are not regularly harvested. However, this is passive conservation at best, and Gilletiodendron glandulosum is not accorded any special protected status by the Maninka. In more populous areas where the demand for construction hardwood is higher, use of the tree increases. Thus, there are currently no indigenous, non-legislative conservation measures in place to protect Gilletiodendron glandulosum or any other plant commonly found in Gilletiodendron forest.

On the contrary, in more populous areas the enforcement of national forestry laws is more vigorous, which means that its use may be encouraged because it is not legally protected in Mali. On account of its "intérêt... scientifique," Gilletiodendron glandulosum meets a condition established for determining which species are to be protected under Article 16 of Law 95-004, "Fixant les conditions de gestion des ressources forestières" (Assemblée Nationale 1996). However, it is not mentioned in Article 17 of this law,

which lists 11 species specifically given protection, including Pterocarpus erinaceus, Anogeissus leiocarpus, and Borassus aethiopium, all used as construction hardwoods. Additionally, Prosopis africana is protected under the *Code Domaniale et Foncier*, which establishes penalties and additional protection statutes (République du Mali 1987).

Rural Malian farmers, hunters, carpenters, and blacksmiths generally know which wild plants and animals are legally protected and avoid harvesting them if it is possible that doing so will result in a fine. Although forestry law enforcement in Mali can be spotty and tainted with bribery, it does modify people's behaviors to the extent that ways to avoid fines are sought. Often this means that alternative raw materials become more desirable if natural resource law enforcement increases. In the Manantali area, Gilletiodendron glandulosum is an attractive alternative source of construction hardwood when more commonly used trees are unavailable due to law enforcement. Vepris heterophylla is also unprotected despite its "intérêt économique, socio-culturel, et scientifique" (Assemblée Nationale 1996, Art. 16). While plants with uses similar to *gèngèliba* are also unprotected, lack of legal status overlooks the value of the plant to Mali and Malians, and allows, if not encourages, wasteful harvesting practices. Although Malian Law 95-004 should provide protection to Gilletiodendron glandulosum, Vepris heterophylla, and Gilletiodendron forest, no protection is given to these resources because they are not mentioned specifically by name.

Additionally, although vegetation occurring along seasonal waterways, seepage areas, and waterfalls is protected under Malian law (Assemblée Nationale 1996, Art. 10), it is virtually unknown for forestry agents in the Manantali area to fine people based on the

provenance of wood they have collected, whether the species collected are legal or not (Duvall, pers. obs.). Vegetation in such areas is highly vulnerable to destruction caused by overharvesting because loss of vegetative cover can irrevocably alter soil moisture and nutrient content (Barbour et al. 1999). All Gilletiodendron forest stands visited for the current research are eligible for protection under Article 10 of Law 95-004, and forestry agents should extend their surveillance based on this article since no common plant species in Gilletiodendron forest are specifically protected. These legal oversights undervalue the importance of the natural resources represented by Gilletiodendron forest, and without better awareness of this natural resource on the part of Malian conservationists, the long-term survival of this relict habitat is uncertain.

Recommendations

Currently, knowledge of Gilletiodendron glandulosum is very low among professional Malian conservationists, and simple measures such as raising awareness about the tree and including it in the national forestry code would improve current conservation efforts. No professionally trained Malian conservationist or forestry agent interviewed was aware of the existence, let alone endemic status, of this tree. This includes forestry agents in Manantali and Kita, who should have the most direct role in its conservation. Foreign conservationists working in Mali are also ignorant of this tree. Warshall (1989) fails to mention it in his biodiversity assessment of the nation, although he underscores the value of Guibourtia copallifera, a widespread relict tree not endemic to Mali which occurs near Bamako. Similarly, the Projet Inventaire (1990) map for the Bafing Valley mentions

Guibourtia copallifera forest instead of Gilletiodendron forest, although the former species does not occur in the area. Simple measures, such as the dissemination of descriptions of the tree including its Maninka names and endemic status to forestry agents in the Kayes region would help rectify this situation.

While the tree should be given legal protection by the Malian Direction Nationale de la Conservation de Nature and the Assemblée Nationale, a complete prohibition of cutting should not be promulgated nor enforced. At current and reasonably foreseeable levels of use the tree does not need such drastic protection. Additionally, such an action could alienate rural Maninka who not only rely on wild plant products, including Gilletiodendron glandulosum, but also whose knowledge and support is necessary for the success of any conservation efforts in the research area (de Bie 1991; Pavy 1993; Duvall and Niagaté 1997).

Efforts should be made to fully protect many Gilletiodendron groves in order to conserve national biological diversity. Ideally, large Gilletiodendron groves within the Bafing Faunal Reserve area and forest reserves near Oualia and Kita should be located, demarcated, specifically protected, and monitored to prevent disturbance. The effort should be made to protect as many groves as possible rather than aiming at a certain quantity of surface area in order to include the highest number of species possible (Quinn and Harrison 1988). Groves protected in these areas, particularly around the Bafing Faunal Reserve, would benefit from ongoing conservation efforts if local residents were involved in the planning process. By marking groves and announcing their legal and scientific status as part of an environmental education program already led by Peace Corps

Volunteers in the Manantali area, protected groves around the Bafing Faunal Reserve would likely remain undisturbed. The Jidiba grove (Site 16), just north of old Sollo, should be protected not only because of its high floral diversity, but also because it is clearly important habitat for chimpanzees, which are abundant in this area (Moore 1985; Pavy 1993; Duvall and Niagaté 1997). The Bandinkoto (Site 14) and Banfora-Goungouto (Site 11) groves are also rich in floral diversity. Bandinkoto grove is also within current chimpanzee range, and nests were observed in it.

Further measures should be taken to improve knowledge of the distribution, abundance, and floral composition of Gilletiodendron forest in western Mali. The research area for this project is in the northern portion of the Manding Plateau. Sites further to the south likely have greater floral diversity (Lawesson 1995), and probably harbor other rare plants. Better knowledge of the distribution of rare or threatened resources is vital to determining conservation strategies and priorities (Patterson 1991). Additionally, botanical exploration of the southern distribution limit of Gilletiodendron glandulosum may provide further insight into the natural history of the tree, and thus on vegetation and climate history in West Africa. Research on the distribution of plants in Gilletiodendron forest may provide insight on plant response to climate change through biogeographic analysis (Kodric-Brown and Brown 1993; McDonald and Brown 1992; Cutler 1991). The possible effects of climate change on tropical plants is very poorly known (Tausch, Wigand, and Burkhardt 1993), although climate change is a significant threat to biodiversity in the next century (Pimm et al. 1995).

Finally, use of Gillettiodendron forest by chimpanzees is a remarkable biogeographical occurrence: a relict animal population (Kortland 1983; Warshall 1989; McGrew 1989) relying on a relict plant community. Better understanding of this relationship is not only crucial to conserving Mali's remaining chimpanzees, but it may also provide valuable insight on the ecology of savanna chimpanzees and thus refine models for the evolution of early hominids (Suzuki 1969; Baldwin, McGrew, and Tutin 1982).

ILLUSTRATIONS

Figure 1. West Africa, Showing International Boundaries and Phytochoria. Phytochoria: 1, Saharan; 2, Sahelian; 3, Sudanian; 4, Sudano-Guinean; 5, Guinea-Congolian. Star (★) indicates research site for the current study. After White (1983, 1979), Geerling (1987), Adam (1965), and Lawesson (1995).

Figure 2. Relationship between Precipitation and Vegetation in West Africa. After Adam (1965).

Figure 3. Map of Western Mali and Surrounding Areas.

Figure 4. Landscape of Manding Plateau Area, Southwestern Mali. The area shown is sparsely populated. As a result, the savanna woodland vegetation visible in the center of the photo is unusually dense.

Figure 5. Location of Research Villages and Traditional *Kafolu*.

Figure 6. Mature Gilletiodendron glandulosum Individual. Tree is around 10 m high. The dark foliage and light-colored bark are characteristic of the species and make it easily visible from some distance.

Figure 7. Gilletiodendron glandulosum Leaves. Young leaves are usually red in color, and the surface of all leaves is characteristically shiny.

Figure 8. Trunk of Mature Gilletiodendron glandulosum Individual. Fluting caused by ridge-like buttresses is characteristic of the species. Sucker sprouts (smaller stems on right and center left of photo) growing from the base of buttresses is also common.

Figure 9. Gilletiodendron glandulosum Bark, Showing Color of Slash

Figure 10. Gilletiodendron glandulosum Fruits. The fruits, often extremely abundant in the tops of the crowns of mature individuals, ripen in the period September-November.

Figure 11. *Gilletiodendron glandulosum* Seedlings. Seedlings are often the most abundant species in the herbaceous layer of *Gilletiodendron* forest. Pocket knife shown for scale. This photograph was taken under a dense canopy at mid-day, showing the characteristic density of upper canopy cover.

Figure 12. Djiguiba Kéïta and His Daughter Sadio Suko. Djiguiba is wearing an open-sided traditional Maninka tunic over his western-style shirt. Sadio was one month old at the time of this picture.

Figure 13. Location of Research Sites.

Figure 14. Average Monthly Temperature and Precipitation for Bamako, Mali and Tambacounda, Senegal.

Figure 15. Sudanian Savanna Woodland. Photo taken in October, 1999, the end of the rainy season, this shows the high dominance of grasses in this plant community. The large tree is Adansonia digitata, the baobab, highly characteristic of West African savannas.

Figure 16. Weathered Sandstone. The golden color with black mineral stains is characteristic.

Figure 17. Bowal. Characterized by infertile lateritic soil, bowé (plural of bowal, a word in the Pulaar language) are dominated by sparse short grass communities. This bowal is unusually bounded by a sandstone formation. The dark foliage of Gillettiodendron glandulosum is clearly visible in the right of the photograph.

Figure 18. Manantali Dam. Over 1 km wide and 50 m high, this dam was completed in 1988 and blocks the Bafing River just south of the town of Manantali. The reservoir, over 400 km², flooded the historic Bafing *kafo* (district) and led to the resettlement of over 10,000 people. Although enhanced fishing, hydroelectric power generation, large-scale irrigation perimeters, and improved downstream navigation were promoted as reasons to build the dam, none of these schemes has been realized.

Figure 19. Line-intercept Survey Work. This survey was conducted simultaneously with other surveys. The white plastic bag contains fresh plant specimens, and the measuring tape was used to measure the circumference of trees in the point-quarter survey. Raingear, food, water, and emergency supplies filled the backpack. The terrain presented a constant challenge.

Figure 20. Maninka *Birelu* (Hangars) in Use. Hangars (i.e. open-sided outdoor shelters) are used not only as shelter from sun and light rain, but also to store construction materials and food and to dry food. Wood is selected for durability to serve as *tarumalu* (support posts) and *salalu* (cross beams). The girls are Mbakourou and Ninsondi Suko and Fanta Demba, from Maréna.

Figure 21. Components of Maninka Architectural Structures.

Figure 22. Formal Ethnographic Interviews. After having collected specimens, the researcher asked Maninka informants to identify and describe uses for plants. Farnagan Dembélé of Makadugu, shown here, is especially knowledgeable of Maninka plant names and uses.

Figure 23. Ravine Grove. Most Gilletiodendron forest groves are found in seasonal drainage channels along cliff edges, rather than merely in rocky areas protected from fire by topography. This is research Site 16, called Jidiba by the people of old Sollo. This grove lies along a semi-permanent stream, and also holds a large seepage area at the base of the upper sediment layer.

Figure 24. Ledge Grove. A stand of *Gilletiodendron glandulosum* is visible in the center right of this photograph. Many *Gilletiodendron* groves are found along cliff ledges, where seepage areas provide moist soil conditions. These groves tend to be smaller in area than ravine groves and less diverse floristically. The rock face in this photograph is approximately 80 m high.

Figure 25. Seepage Area. This photograph, taken outside of any Gilletiodendron forest grove, shows the abundance of water available to plants at the junction of sedimentary layers. The shine on the sandstone is water, which has stained the rock black. Note on the left the sandstone of the upper sedimentary layer, which is unstained. The tree is Ficus cordata, which is characteristic of cliff faces in Gilletiodendron forest.

Figure 26. Gilletiodendron Forest Grove Unprotected from Fire. Site 7 occurs along a semi-permanent stream in a rocky area dominated by grasses. Under the canopy there is only a sparse herbaceous layer, but the grove is surrounded at close proximity by grasses in an area which is regularly burnt for agricultural purposes.

Figure 27. Upper Canopy of Gilletiodendron Forest Grove. This photograph was taken from the same point as that in figure 15, but looking in the opposite direction. Comparison of the two photos shows the relative density of the upper canopy of Gilletiodendron forest compared with savanna woodland. The upper canopy of Gilletiodendron forest groves are often easy to examine from the edge of boundary cliffs; in this photograph, the researcher is standing on the edge of a 15 m high cliff.

Figure 28. Lower Canopy of Gilletiodendron Forest Grove. The lower canopy is often very dense, with a high degree of overlap between various plant species. This is the edge of Site 1, showing a low but dense lower canopy, without abundant lianas (see Fig. 31).

Figure 29. Profile of Vegetation in Idealized Gilletiodendron glandulosum Grove

Figure 30. Hippocratea indica Leaves and Fruit. This liana is abundant in both the lower and upper canopy of Gilletiodendron forest. Its leaves are characteristically shiny, and except for their opposite arrangement is easily confused with the leaves of Diospyros abyssinica, a common small tree. Its fruit (center) is distinctive, consisting of three lobed capsules.

Figure 31. Lianas Hanging from Gilletiodendron glandulosum Trunk. Lianas often form an important connection between the lower and upper canopy levels on the edge of Gilletiodendron forest groves, and may be a locally important component of the upper canopy. Cissus quadrangularis and Hippocratea indica are most abundant in this photo.

Figure 32. Euphorbia sudanica. This cactiform succulent is common on sandstone formations in the Bafing area. It is a common xerophytic element of Gilletiodendron forest, occurring on the dry upslope edge of groves.

Figure 33. Tephrosia mossiensis. This small shrub, endemic to West Africa, is common on sandstone formations in the Bafing area. It is an upslope xerophytic element of Gilletiodendron forest. The collections made for the present research may represent a new sub-specific taxon; all previously collected specimens have “deep red” flowers (Hutchinson and Dalziel 1958, 530).

Figure 34. Shrub-like Gilletiodendron glandulosum Individual. In dry, rocky locations, Gilletiodendron glandulosum may adopt a shrub-like habit, although it is uncertain if this is caused by environmental factors or repeated cutting. A similar habit has been reported for another relict tree in Mali, Guibourtia copallifera.

Figure 35. Ladder Made from Gilletiodendron glandulosum Logs. This ladder was used to collect honey from a wild hive found in a rock crevice. Gilletiodendron glandulosum is favored as a load-bearing material, especially in construction, due to its remarkable *kendeya* (durability).

Figure 36. Gilletiodendron glandulosum Stump with Sprouts. This tree was felled probably 9-12 months prior to this photo. Most stumps sprout vigorously, although few large trees (≥ 10 cm DBH) were observed which were originally stump sprouts. This may indicate the relative novelty of heavy use of Gilletiodendron glandulosum in the research area.

Figure 37. Maninka Land Use Pattern. In the extreme foreground an unharvested millet field is visible, while the large cleared area is a peanut field. In the center, the light green area is fallow land, which has been farmed in the past but is not currently under cultivation. Note the increased density of trees in this area. Beyond the fallow land is marginal land which is not heavily used by the Maninka. Marginal land is often defined by topography; in this photo, a stream running along the base of a steep slope provides a natural geographic boundary. Gilletiodendron forest generally occurs in marginal land such as the steep slope in this view, although no groves are visible.

TABLES

Table 1. Vegetation Terms Used in this Study

Term	Definition
dry forest:	Forest which is not part of the Guineo-Congolian phytochorion.
forest:	"A continuous stand of trees, with a closed upper canopy at least 8 m 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).
<u>Gilletiodendron</u> forest:	The plant community dominated by <u>Gilletiodendron glandulosum</u> .
grassland:	"Land covered with herbs, either without woody plants or the latter not with more than 10% cover of the ground" (Lawesson 1995, 24).
grove:	A single, isolated stand of trees usually dominated by a single species.
phytochorion: (<i>pl.</i> , phytochoria)	The largest unit of vegetation description used in this study. "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).
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:	The smallest unit of vegetation description used in this study. 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. A vegetation type is a component of a vegetation formation.
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 8 m tall and with a canopy of 40% or more. The field layer is usually dominated by grasses" (Lawesson 1995, 24).

Table 2. Ligneous Plant Species Observed in Gilletiodendron Forest

Species	Species Name Abbreviation	Family	Plant Distribution Type (see p. 134)	Collection Numbers
<u>Acacia ataxacantha</u> DC.	Ac. at.	Fabaceae- Mimosoideae	W [1]	--
<u>Acacia polyacantha</u> Willd. ssp. <u>campylacantha</u> (Hochst. ex A. Rich.) Brenan	Ac. po.	Fabaceae- Mimosoideae	G1 [1]	340
<u>Acridocarpus chevalierii</u> Sprague	Ac. ch.	Malpighiaceae	SU2 [4]	51, 94, 121, 249
<u>Adansonia digitata</u> L.	Ad. di.	Bombacaceae	W [1]	--
<u>Albizia zygia</u> (DC.) J.F. Macbr.	Al. zy.	Fabaceae- Mimosoideae	SZ [2]	203
<u>Allophylus cobbe</u> (L.) Raeusch	Al. co.	Sapindaceae	GW [1]	181, 196, 231
<u>Anogeissus leiocarpus</u> (DC.) Guill. & Perr.	An. le.	Combretaceae	W [1]	155, 165
<u>Anthocleista nobilis</u> G. Don	An. no.	Loganiaceae	G1 [1]	372
<u>Asparagus flagellaris</u> (Kunth) Bak.	As. pa.	Liliaceae	SU2 [4]	45
<u>Baïssa multiflora</u> A.DC.	Ba. mu.	Apocynaceae	GW [4]	182, 365
<u>Berlinia grandiflora</u> (Vahl.) Hutch. & Dalz.	Be. gr.	Fabaceae- Caesalpinioideae	GW [4]	289
<u>Bombax costatum</u> Pellegr. & Vuillet	Bo. co.	Bombaceae	W2 [1]	80
<u>Boscia angustifolia</u> A. Rich.	Bo. an.	Capparaceae	W [1]	150, 198, 357
<u>Boscia salicifolia</u> Oliv.	Bo. sa.	Capparaceae	SU2 [1]	--
<u>Bridelia ferruginea</u> Benth.	Br. fe.	Euphorbiaceae	W [4]	171, 267
<u>Burkea africana</u> Hook. f.	Bu. af.	Fabaceae- Caesalpinioideae	SZ [2]	241
<u>Canthium</u> sp.?	--	Rubiaceae		306
<u>Canthium venosum</u> (Oliv.) Hiern.	Ca. ve.	Rubiaceae- Vanguerieae	W [4]	378

Table 2—Continued

Species	Species Name Abbreviation	Family	Plant Distribution Type*	Collection Numbers
<u>Celtis integrifolia</u> Lam.	Ce. in.	Ulmaceae	W [1]	70, 283
<u>Chaetacme aristata</u> Planch.	Ch. ar.	Ulmaceae	G2 [4]	326
<u>Christiana africana</u> DC.	Ch. af.	Tiliaceae	GW [4]	390
<u>Cissus populnea</u> Guill. & Perr.	Ci. po.	Vitaceae	SU2 [1]	60, 252
<u>Cissus quadrangularis</u> L.	Ci. qu.	Vitaceae	W [4]	71, 87, 97,
<u>Coccinia grandis</u> (L.) J.C. Voigt	Co. gr.	Cucurbitaceae	W [4]	67, 130
<u>Cola cordifolia</u> (Cav.) R. Br.	Col. co.	Sterculiaceae	GW [1]	384
<u>Cola laurifolia</u> Mast.	Co. la.	Sterculiaceae	GW [4]	292
<u>Combretum collinum</u> Fresen. ssp. <u>hypopilinum</u> (Diels) Okafor	Com. co.	Combretaceae	GW [1]	262
<u>Combretum glutinosum</u> Perr. ex DC.	Co. gl.	Combretaceae	W [1]	153
<u>Combretum micranthum</u> G. Don	Co. mi.	Combretaceae	W [1]	43, 65, 75, 117, 142, 144
<u>Combretum nigricans</u> Lepr. ex Guill. & Perr.	Co. ni.	Combretaceae	W [1]	180, 230, 294
<u>Combretum paniculatum</u> Vent.	Co. pa.	Combretaceae	W2 [1]	119
<u>Combretum tomentosum</u> G. Don	Co. to.	Combretaceae	SU2 [1]	170, 175, 202, 211, 373
<u>Cordia africana</u> Lam.	Co. af.	Boraginaceae	SU2 [4]	308
<u>Cordia myxa</u> L.	Co. my.	Boraginaceae	W [4]	285
<u>Crateva adansonii</u> DC. ssp. <u>adansonii</u>	Cr. ad.	Capparaceae	W2 [1]	224
<u>Crotalaria pallida</u> Ait.	Cr. pa.	Fabaceae- Papilionoideae	GW [1]	314
<u>Croton</u> sp.?	--	Euphorbiaceae		240
<u>Cryptolepis sanguinolenta</u> (Lindl.) Schltr.	Cr. sa.	Asclepiadiaceae	G2 [4]	358

Table 2—Continued

Species	Species Name Abbreviation	Family	Plant Distribution Type (see p. 134)	Collection Numbers
<u>Desmodium velutinum</u> (Willd.) DC.	De. ve.	Fabaceae- Papilionoideae	W [4]	381
<u>Detarium microcarpum</u> Guill. & Perr.	De. mi.	Fabaceae- Caesalpinoideae	GW [1]	322
<u>Detarium senegalense</u> J.F. Gmel.	De. se.	Fabaceae- Caesalpinoideae	GI [1]	334
<u>Dialium guineense</u> Willd.	Di. gu.	Fabaceae- Caesalpinoideae	GW [1]	332
<u>Dichrostachys cinerea</u> (L.) Wight & Arn. ssp. <u>africana</u> Brenan & Brummit	Di. ci.	Fabaceae- Mimosoideae	W [1]	328
<u>Diospyros abyssinica</u> (Hiern) F. White	Di. ab.	Ebenaceae	SU2 [4]	44, 69, 164, 354
<u>Diospyros mespiliformis</u> Hochst ex A.DC.	Di. me.	Ebenaceae	W2 [1]	39, 133, 160, 188, 207, 210, 342
<u>Erythrina senegalensis</u> DC.	Er. se.	Fabaceae- Papilionoideae	SU2 [1]	336
<u>Erythrophleum guineense</u> G. Don	Er. gu.	Fabaceae- Caesalpinoideae	GW [4]	385
<u>Eugenia</u> sp. ?	Eu.	Myrtaceae		377
<u>Euphorbia sudanica</u> A. Chev.	Eu. su.	Euphorbiaceae	SU2 [4]	66
<u>Feretia apodanthera</u> Del. ssp. <u>apodanthera</u>	Fe. ap.	Rubiaceae-Ixoreae	W [1]	41, 76, 120, 141, 176, 178, 185, 222, 242
<u>Ficus abutilifolia</u> (Miq.) Miq.	Fi. ab.	Moraceae	GI [1]	68, 217
<u>Ficus asperifolia</u> Miq.	Fi. as.	Moraceae	G2 [4]	379

Table 2—Continued

Species	Species Name Abbreviation	Family	Plant Distribution Type*	Collection Numbers
<u>Ficus cordata</u> Thunb.	Fi. co.	Moraceae	SU2 [1]	47, 86, 115, 173
<u>Ficus glumosa</u> Del.	Fi. gl.	Moraceae	GW [1]	136, 254
<u>Ficus ingens</u> (Miq.) Miq.	Fi. in.	Moraceae	SU2 [1]	174
<u>Ficus sur</u> Forssk.	Fi. su.	Moraceae	W2 [1]	276, 312, 313
<u>Ficus sycomorus</u> L. ssp. <u>gnaphakocarpa</u> (Miq.) C.C. Berg.	Fi. sy.	Moraceae	GW [1]	271
<u>Ficus thonningii</u> Blume	Fi. th.	Moraceae	W2 [1]	226
<u>Garcinia livingstonei</u> T. Anders.	Ga. li.	Clusiaceae	SU2 [1]	299
<u>Gardenia imperialis</u> K. Schum.	Ga. im.	Rubiaceae- Gardenieae	GW [4]	368
<u>Gardenia sokotensis</u> Hutch.	Ga. so.	Rubiaceae- Gardenieae	SU2 [1]	74, 84, 88, 114, 195
<u>Gilletiodendron glandulosum</u> (Port.) J. Léonard	Gi. gl.	Fabaceae- Caesalpinoideae	SU2 [4]	53, 57, 58, 82, 110
<u>Grewia bicolor</u> Juss.	Gr. bi.	Tiliaceae	W [1]	38, 55, 64, 81
<u>Grewia flavescens</u> Juss.	Gr. fl.	Tiliaceae	GW [4]	177, 186
<u>Grewia lasiodiscus</u> K. Schum.	Gr. la.	Tiliaceae	SU2 [4]	91, 154, 256
<u>Gyrocarpus americanus</u> Jacq.	Gy. am.	Hernandiaceae	SU2-Pt [4]	48, 128,
<u>Hexalobus monopetalus</u> (A. Rich.) Engl. & Diels.	He. mo.	Annonaceae	GW [1]	138, 228
<u>Hibiscus sterculiifolius</u> (Guill. & Perr.) Steud.	Hi. st.	Malvaceae	G2 [4]	304, 374
<u>Hippocratea africana</u> (Willd.) Loes. ex Engl.	Hi. af.	Celastraceae	W [4]	152, 291

Table 2—Continued

Species	Species Name Abbreviation	Family	Plant Distribution Type (see p. 134)	Collection Numbers
<u>Hippocratea indica</u> Willd.	Hi. in.	Celastraceae	W [4]	37, 52, 56, 108, 344, 364
<u>Indigofera arrecta</u> Hochst.	In. ar.	Fabaceae- Papilionoideae	W [4]	243, 260, 345
<u>Ixora brachypoda</u> DC.	Ix. ra.	Rubiaceae-Ixoreae	SZ [2]	370
<u>Khaya senegalensis</u> (Desr.) A. Juss.	Kh. se.	Meliaceae	GW [1]	318
<u>Kigelia africana</u> (Lam.) Benth.	Ki. af.	Bignoniaceae	W2 [1]	330
<u>Lannea microcarpa</u> Engl. & K. Krause	La. mi.	Anacardiaceae	GW [1]	278, 281
<u>Lannea nigritana</u> (Sc. Elliot) Keay	La. ni.	Anacardiaceae	GW [1]	116
<u>Lannea velutina</u> A. Rich.	La. ve.	Anacardiaceae	W2 [1]	382
<u>Lepisanthes senegalensis</u> (Juss. ex Poir) Leenh.	Lepi. se.	Sapindaceae	GW [1]	320
<u>Leptactina senegambica</u> Hook. f.	Lept. se.	Rubiaceae- Pavetteae	SU2 [1]	213
<u>Leptadenia hastata</u> (Pers.) Decne.	Le. ha.	Asclepidiaceae	SU2 [4]	205
<u>Lonchocarpus laxiflorus</u> Guill. & Perr.	Lon. la.	Fabaceae- Papilionoideae	G1 [1]	--
<u>Lophira lanceolata</u> Van Tiegh. ex Keay	Lop. la.	Ochnaceae	G1 [1]	149, 239
<u>Malacantha alnifolia</u> (Bak.) Pierre	Ma. al.	Sapotaceae	G1 [1]	63, 280
<u>Manilkara multinervis</u> (Bak.) Dubard	Ma. mu.	Sapotaceae	G1 [1]	208, 218, 258
<u>Maytenus senegalensis</u> (Lam.) Exell.	Ma. se.	Celastraceae	W [1]	233
<u>Opilia celtidifolia</u> (Guill. & Perr.) Endl. ex Walp.	Op. ce.	Opiaceae	W [1]	179, 316
<u>Oxytenanthera abyssinica</u> (A. Rich.) Munro.	Ox. ab.	Poaceae	W2 [1]	166
<u>Pachystela brevipes</u> (Bak.) Baill. ex Engl.	Pa. br.	Sapotaceae	G1 [1]	287

Table 2—Continued

Species	Species Name Abbreviation	Family	Plant Distribution Type*	Collection Numbers
<u>Paullinia pinnata</u> L.	Pa. pi.	Sapindaceae	G1 [1]	296
<u>Piliostigma thonningii</u> (Schum.) Milne-Redhead	Pi. th.	Fabaceae- Papilionoideae	GW [1]	263, 351
<u>Pseudocedrela kotschy</u> (Schweinf.) Harms	Ps. ko.	Meliaceae	GW [4]	386
<u>Psychotria psychotrioides</u> (DC.) Roberty	Ps. ps.	Rubiaceae- Psychotrieae	SG [3]	375
<u>Pterocarpus erinaceus</u> Poir.	Pt. er.	Fabaceae- Papilionoideae	W [1]	79, 310
<u>Pterocarpus lucens</u> Lepr. ex Guill. & Perr.	Pt. lu.	Fabaceae- Papilionoideae	W [1]	124
<u>Pterocarpus santalinoides</u> L'Hér. ex DC.	Pt. sa.	Fabaceae- Papilionoideae	GW [1]	273, 302
<u>Raphia sudanica</u> A. Chev.	Ra. su.	Arecaceae	GW [4]	--
<u>Saba senegalensis</u> (A.DC.) Pichon	Sa. se.	Apocynaceae	GW [1]	61, 268
<u>Sarcocephalus latifolius</u> (Smith) Bruce	Sa. la.	Rubiaceae- Naucleaeae	GW [1]	95, 191
<u>Securinega virosa</u> (Roxb. & Willd.) Baill.	Se. vi.	Euphorbiaceae	W [4]	77, 265
<u>Smeathmannia laevigata</u> Soland.	Sm. la.	Passifloraceae	G2 [4]	388
<u>Solanum dasyphyllum</u> Schum. & Thonn.	So. da.	Solanaceae	G1 [4]	146
<u>Spondias mombin</u> L.	Sp. mo.	Anacardiaceae	SU2 [1]	50, 159
<u>Stereospermum kunthianum</u> Cham.	St. ku.	Bignoniaceae	W2 [1]	107, 127, 168, 190, 220, 245, 247, 248, 387

Table 2—Continued

Species	Species Name Abbreviation	Family	Plant Distribution Type (see p. 134)	Collection Numbers
<u>Strophanthus sarmentosus</u> DC.	St. sa.	Apocynaceae	GW [1]	102, 189
<u>Syzgium guineense</u> (Willd.) DC. ssp. <u>guineense</u>	Sy. gu.	Myrtaceae	GW [1]	369
<u>Tamarindus indica</u> L.	Ta. in.	Fabaceae- Caesalpinoideae	Pt [2]	383
<u>Tapinanthus dodoneaeifolius</u> (DC.) Danzer	Ta. do.	Loranthaceae	SU2 [4]	125
<u>Tephrosia mossiensis</u> A. Chev.	Te. mo.	Fabaceae- Papilionoideae	SU2 [4]	112, 158, 361
<u>Terminalia macroptera</u> Guill. & Perr.	Te. ma.	Combretaceae	W2 [1]	200
<u>Trema orientalis</u> (L.) Blume	Tr. or.	Ulmaceae	W [1]	104, 134, 162
<u>Trichilia emetica</u> Vahl.	Tr. em.	Meliaceae	GW [1]	235
Unknown #1	--	Asteraceae		376
Unknown #2	--	Rubiaceae		389
<u>Uvaria chamae</u> P. de Beauv.	Uv. ch.	Annonaceae	GW [1]	324
<u>Vepris heterophylla</u> (Engl.) R. Let.	Ve. he.	Rutaceae	SU2 [4]	90, 223, 348
<u>Vernonia colorata</u> (Willd.) Drake	Ve. co.	Asteraceae	SZ [2]	274
<u>Vitex doniana</u> Sweet	Vi. do.	Verbenaceae	W2 [1]	380
<u>Xeroderris stühlmannii</u> (Taub.) Mendonça & E.P. Sousa	Xe. st.	Fabaceae- Papilionoideae	W2 [1]	106
<u>Xylopia elliptica</u> Engl. & Diels	Xy. el.	Annonaceae	G2 [4]	371
<u>Zanha golungensis</u> Hiern	Za. go.	Sapindaceae	SU2 [1]	193
<u>Ziziphus mucronata</u> Willd. ssp. <u>mucronata</u>	Zi. mu.	Rhamnaceae	GW [1]	161

* Sources: [1] Lawesson (1995); [2] Guinko (1985); [3] White 1979; [4] deduced from Lawesson (1995) and Hutchinson and Dalziel (1954, 1958, 1963, 1968, 1972).

Plant distribution type abbreviations (Lawesson 1995, 81):

- G1: Western Guinea-Congolia/Sudanian Regional Transition Zone
- G2: Continental Guinea-Congolia/Sudanian Regional Transition Zone
- GW: Widespread Guinea-Congolia/Sudanian Regional Transition Zone
- SU2: Southern Sudanian Regional Center of Endemism
- W: Widespread Widely Distributed
- W2: Southern Widely Distributed

Plant distribution type abbreviations (Guinko 1985):

- SZ: Sudano-Zambezian (i.e. Sudano-Guinean)

- Pt: Panropical

Plant distribution type abbreviation (White 1979):

- SG: Sudano-Guinean

Table 3. Species Collected which Represent New Records for Mali

Species	Family	Remarks
<u>Anthocleista nobilis</u> G. Don	Loganiaceae	<i>Duvall</i> 372: Previously known from the Casamance region in southern Senegal, where it occurs in gallery forests and near marshy areas (Adam 1962a, Berhaut 1979). Only a related species, <u>Anthocleista djalonenensis</u> A. Chev., has been reported from eastern Senegal (Lawesson 995, 113). <u>A. nobilis</u> has also been reported from central Guinea, Sierra Leone, Liberia, and eastward to Nigeria (Berhaut 1979; Schnell 1960; Hutchinson and Dalziel 1963, 35). A very distinctive tree, it is widely known by the Maninka, and apparently occurs in humid riparian microhabitats nearly as far north as Manantali. Several individuals observed growing along semi-permanent creeks in Sites 14 and 16.
<u>Chaetacme aristata</u> Planch.	Ulmaceae	<i>Duvall</i> 326: Single individual observed in Site 11. Present in Guineo-Congolian secondary forest from Côte d'Ivoire eastward (Hutchinson and Dalziel 1958, 593). This is apparently the first record of this plant from west of Côte d'Ivoire.
<u>Christiana africana</u> DC.	Tiliaceae	<i>Duvall</i> 390: Previously known from Senegal, where it is present on humid creek banks in Niokolo-Koba National Park (Adam 1968, 1963) and in gallery forests in the Casamance (Adam 1962a; Hutchinson and Dalziel 1958). The plant is also present to the south in evergreen Sudano-Guinean forests in Guinea, Sierra Leone, Côte d'Ivoire, and Ghana (Adam 1968; Hutchinson and Dalziel 1958). Several individuals observed in Site 16, growing on steep wet slope below seepage area.
<u>Cordia africana</u> Lam.	Boraginaceae	<i>Duvall</i> 308: This plant has been collected in Guinea and Nigeria, and it is common in central Africa (Hutchinson and Dalziel 1963, 320). Abundant in Sites 11 and 14.
<u>Cryptolepis sanguinolenta</u> (Lindl.) Schltr.	Asclepiadaceae	<i>Duvall</i> 358: A rare component of gallery forests from Guinea to the Central African Republic (Geerling 1987, 74; Hutchinson and Dalziel 1963, 83). Berhaut (1971, 517) reports that this plant is "assez commun au Sénégal, à proximité des galeries forestières". Several individuals observed in Site 13.

Table 3—Continued

Species	Family	Remarks
<u>Detarium senegalense</u> J.F. Gmel.	Fabaceae- Caesalpinoi- deae	<i>Duvall</i> 334: A young specimen apparently belonging to this species was collected by Roberty near Bandiagara, but its determination is uncertain (Boudet, Lebrun, and Demange 1986, 126). The species was also mentioned as a component of gallery forest vegetation near Kita by Portrères (1939). Present in gallery and dry forests in southern Senegal, from the Casamance (Adam 1962a) to Niokolo-Koba (Adam 1968; Lawesson 1995; Berhaut 1975), and in central Guinea and eastward (Hutchinson and Dalziel 1958). Two very large individuals observed in Sites 11 and 16, one on edge of semi-permanent creek, the other on a steep, wet hillside below a seepage area.
<u>Erythrophileum guineense</u> G. Don	Fabaceae- Caesalpinoi- deae	<i>Duvall</i> 385: Known from dry forests and galleries in the Casamance, southern Senegal (Adam 1962a), and elsewhere in moist places throughout southern Senegal (Berhaut 1975b; Adam 1963). Although it is not reported from Mali by Boudet, Lebrun, and Demange (1986), Hutchinson and Dalziel (1958, 484) cite a specimen from Kita, and it is mentioned as occurring in <u>Gilletiodendron</u> forest by Jaeger (1956, 1150). Several individuals observed in Site 16.
<u>Ficus asperifolia</u> Miq.	Moraceae	<i>Duvall</i> 379: This shrub occurs along creeks in southern Senegal, Guinea-Bissau, Guinea, Sierra Leone, Liberia, and eastward (Hutchinson and Dalziel 1958; Schnell 1950). Berhaut (1979, 425) states that it is widespread in Senegal, along creeks and in moist locations. Single individual observed in Site 14.
<u>Smeathmannia laevigata</u> Soland.	Passiflora- ceae	<i>Duvall</i> 388: Although this species is not listed for Mali by Boudet, Lebrun, and Demange (1986), Hutchinson and Dalziel (1954, 200) report a single specimen of the var. <u>nigrica</u> A. Chev. ex Hutch. and Dalz. from the country. Known from the Casamance, southern Senegal, where it is found in gallery forests, littoral sand dunes, and secondary Guineo-Congolian forest areas (Adam 1962a). This genus is endemic to Africa West of the Congo basin (Hepper 1965). Several individuals observed in Site 16, growing on a steep, wet slope below a seepage area.

Table 3—Continued

Species	Family	Remarks
<u>Solanum dasyphyllum</u> Schum. & Thonn.	Solanaceae	<i>Davall 146</i> : This plant has been collected in The Gambia, Senegal, Guinea-Bissau, Sierra Leone, Liberia, Côte d'Ivoire, and other countries eastward (Hutchinson and Dalziel 1954, 334). A single individual observed in Site 6.
<u>Xylopia elliotii</u> Engl. & Diels	Annonaceae	<i>Davall 371</i> : This plant is otherwise known only from central Guinea and Sierra Leone (Hutchinson and Dalziel 1954, 42). Several individuals observed along semi-permanent stream in Site 14.

Table 4. Relative density rankings. Data based on line intercept, point-quarter, and quadrat surveys.

Line intercept survey			Point-quarter survey			Quadrat survey		
Species	Density (#/ha)	Relative Density	Species	Density (#/ha)	Relative Density	Species	Density (#/ha)	Relative Density
Hi. in.	192.81	12.06	Gi. gl.	236.46	53.44	Hi. in.	886.33	26.75
Gr. bi.	165.96	10.38	Gr. bi.	68.45	15.47	Gi. gl.	600.00	18.11
Gi. gl.	131.44	8.22	Gy. am.	16.59	3.75	Gr. bi.	287.77	8.69
Di. ab.	127.63	7.98	Sp. mo.	15.21	3.44	Di. ab.	153.96	4.65
Co. mi.	123.36	7.71	Co. mi.	12.45	2.81	Co. mi.	107.91	3.26
Ga. so.	81.36	5.09	Bo. co.	8.99	2.03	Di. me.	84.89	2.56
Sp. mo.	67.88	4.24	Di. ab.	5.53	1.25	Ga. so.	71.94	2.17
Co. to.	43.75	3.01	Di. me.	5.53	1.25	Sp. mo.	71.94	2.17
Ac. ch.	49.21	3.08	Ma. mu.	4.84	1.09	Sa. la.	63.31	1.91
Fe. ap.	40.07	2.51	Bo. an.	4.15	0.94	Gy. am.	53.24	1.61
Totals for all species	1599.13			438.31			3289.30	

Table 5. Relative cover dominance rankings. Data based on line intercept survey. Dominance equals percent of total ground cover or percent of canopy level cover.

Total Cover			Upper Canopy			Lower Canopy		
Species	Dom.	Relative Dom.	Species	Dom.	Relative Dom.	Species	Dom.	Relative Dom.
Gi. gl.	59.40	33.76	Gi. gl.	47.55	59.60	Gr. bi.	23.02	24.04
Hi. in.	25.76	14.64	Hi. in.	9.01	11.30	Hi. in.	16.74	17.48
Gr. bi.	23.02	13.08	Sp. mo.	4.10	5.14	Gi. gl.	11.85	12.38
Co. mi.	10.55	6.00	Gy. am.	3.44	4.31	Co. mi.	10.55	11.02
Sp. mo.	5.12	2.91	La. mi.	2.18	2.73	Di. ab.	4.29	4.48
Di. ab.	4.29	2.44	Ma. mu.	1.50	1.88	Sa. la.	2.16	2.26
Gy. am.	3.62	2.06	Bo. co.	1.30	1.63	Ci. po.	1.73	1.81
Ci. po.	2.67	1.52	Di. me.	1.15	1.45	Sa. se.	1.68	1.76
Sa. se.	2.58	1.47	Ci. po.	0.94	1.18	Co. to.	1.56	1.63
La. mi.	2.56	1.46	Sa. se.	0.90	1.13	Ox. ab.	1.51	1.58
Totals for all species	175.48			79.78			95.70	

Table 6. Relative basal dominance rankings. Data based on point-quarter and quadrat surveys.

Point-quarter survey			Quadrat survey		
Species	Dom. (m ² /ha)	Relative Dom.	Species	Dom. (m ² /ha)	Relative Dom.
Gi. gl.	18.19	59.60	Gi. gl.	28.62	83.15
Ad. di.	3.02	9.90	Ox. ab.	2.16	6.28
Gr. bi.	1.29	4.23	Gr. bi.	1.14	3.31
De. se.	1.11	3.64	Hi. in.	1.00	2.91
Sp. mo.	1.08	3.54	Sp. mo.	0.55	1.60
Kh. se.	0.89	2.92	Gy. am.	0.25	0.73
Gy. am.	0.78	2.56	Bo. co.	0.14	0.41
La. mi.	0.57	1.87	Ma. al.	0.12	0.35
Di. me.	0.48	1.57	Di. ab.	0.096	0.28
Bo. co.	0.38	1.25	Co. mi.	0.064	0.19
Totals for all species	30.52			32.48	

Table 7. Relative frequency rankings. Data based on line intercept, point-quarter, and quadrat surveys.

Species	Line intercept survey		Point-quarter survey		Quadrat survey	
	Freq.	Weighted Freq.	Relative Freq.	Sp.	Freq.	Relative Freq.
Hi. in.	58.17	147.05	21.17	Gi. gl.	0.89	12.20
Gr. bi.	56.25	100.97	14.53	Gr. bi.	0.43	10.64
Gi. gl.	85.58	99.32	14.30	Fi. co.	0.38	9.65
Co. mi.	30.29	57.73	8.31	Sp. mo.	0.13	6.10
Ga. so.	7.21	36.26	5.22	Ad. di.	0.01	5.11
Fe. ap.	5.77	14.29	2.06	Gy. am.	0.11	2.98
Ci. po.	10.10	10.11	1.46	Co. mi.	0.09	2.98
Hi. af.	3.85	8.28	1.19	Bo. co.	0.07	2.84
Co. to.	11.06	7.84	1.13	Di. me.	0.04	2.55
Te. mo.	1.92	7.56	1.07	La. mi.	0.04	2.55

Table 8. Importance value rankings. Data based on line intercept, point-quarter, and quadrat survey.

Line intercept survey			Point-quarter survey			Quadrat survey		
Species	Imp. Value (sum)	Imp. Value (avg.)	Species	Imp. Value (sum)	Imp. Value (avg.)	Species	Imp. Value (sum)	Imp. Value (avg.)
Gi. gl.	56.28	18.74	Gi. gl.	144.60	48.20	Hi. in.	40.30	13.43
Hi. in.	47.87	15.96	Gr. bi.	34.95	11.65	Gr. bi.	21.65	7.22
Gr. bi.	37.99	12.66	Fi. co.	14.94	4.98	Di. ab.	10.04	3.35
Co. mi.	22.02	7.34	Sp. mo.	11.59	3.86	Co. mi.	9.55	3.18
Di. ab.	18.06	6.02	Ad. di.	10.56	3.52	Ox. ab.	9.03	3.01
Ga. so.	10.62	3.54	Gy. am.	10.21	3.40	Sp. mo.	6.75	2.25
Sp. mo.	9.86	3.29	Co. mi.	6.39	2.13	Ac. ch.	4.01	1.34
Ac. ch.	6.05	2.02	Bo. co.	5.76	1.92	Sa. la.	3.80	1.27
Co. to.	5.34	1.78	Di. me.	4.24	1.41	Co. to.	3.75	1.25
Ci. po.	5.30	1.77	La. mi.	4.23	1.41	Ma. al.	3.73	1.24

Table 9. Maninka names for plants in Gilletiodendron forest. Pronunciation follows Bailleul (1981).

Scientific Name	Maninka Name	Degree of Recognition by Informants	Similar Citations
<u>Acacia ataxacantha</u>	<i>wandindinwariso</i>	very strong recognition	Malgras 1992
<u>Acacia polyacantha</u>	<i>dènba wara si</i>	very poor recognition	
<u>Adansonia digitata</u>	<i>sito</i>	very strong recognition	Aubréville 1950; Berhaut 1974; Dalziel 1955; Shafer and Cooper 1980
<u>Albizia zygia</u>	<i>jakola</i>	strong recognition	
<u>Allophyllus cobbe</u>	<i>kada</i>	very poor recognition	
<u>Anogeissus leiocarpus</u>	<i>kèrèkèto</i>	very strong recognition	Malgras 1992; Dalziel 1955; Aubréville 1950; Berhaut 1974
<u>Anthocleista nobilis</u>	<i>dèn ba yiro</i>	very strong recognition; name means 'large child tree'	Berhaut 1979; Aubréville 1959c
<u>Anthocleista nobilis</u>	<i>dèn ba hito</i>	very strong recognition; name means 'large child leaf'	
<u>Asparagus flagellaris</u>	<i>sòsò ngani</i>	very strong recognition; name means 'troublesome to mosquitoes'	
<u>Asparagus flagellaris</u>	<i>nyina ngani</i>	poor recognition; name means 'troublesome to mice'	
<u>Baissea multiflora</u>	<i>kulu saba nòmbo</i>	poor recognition; name translates as 'three hill vine'	Berhaut 1971
<u>Baissea multiflora</u>	<i>balimbo</i>	very poor recognition	
<u>Bombax costatum</u>	<i>bunkun</i>	very strong recognition	Berhaut 1974
<u>Boscia angustifolia</u>	<i>jaba nginjão</i>	good recognition	Aubréville 1950; Berhaut 1974
<u>Boscia salicifolia</u>	<i>jaba nginjão</i>	strong recognition	
<u>Bridelia ferruginea</u>	<i>dahing</i>	very strong recognition	Malgras 1992

Table 9--Continued

Scientific Name	Maninka Name	Degree of Recognition by Informants	Similar Citations
<u>Burkea africana</u>	<i>kòsio</i>	strong recognition	Berhaut 1975a, 290; Adam 1965
<u>Canthium venosum</u>	<i>wara sa kamã</i>	very poor recognition	
<u>Celtis integrifolia</u>	<i>kaman yã</i>	good recognition	Aubréville 1950; Malgras 1992
<u>Chaetacme aristata</u>	<i>sage</i>	poor recognition	
<u>Cissus populnea</u>	<i>goumbão</i>	very strong recognition	Berhaut 1971
<u>Cissus quadrangularis</u>	<i>wulujòlòkò</i>	poor recognition	Dalziel 1955; Bailleul 1996; Berhaut 1971, 1967
<u>Cola cordifolia</u>	<i>tabo</i>	good recognition	Bailleul 1996; Dalziel 1955; Malgras 1992; Berhaut 1967; Aubréville 1950; Shafer and Cooper 1980
<u>Cola laurifolia</u>	<i>bakan lè</i>	good recognition	
<u>Croton</u> sp.?	<i>koromòndiyon</i>	strong recognition; this is the name used in the Bafing traditional canton	
<u>Croton</u> sp.?	<i>korokòlò</i>	strong recognition; this is the name used in the Bambugu and Sulun traditional cantons	
<u>Canthium</u> sp.?	<i>kalani</i>	poor recognition	
<u>Combretum collinum</u>	<i>jambakatan muso</i>	strong recognition; name means 'female <i>jambakatan</i> (<i>Combretum</i>)'	Berhaut 1974
<u>Combretum glutinosum</u>	<i>jambakatan kè</i>	very strong recognition; name means 'male <i>jambakatan</i> (<i>Combretum</i>)'	Malgras 1992; Shafer and Cooper 1980; Berhaut 1974
<u>Combretum micranthum</u>	<i>lake</i>	very strong recognition	

Table 9—Continued

Scientific Name	Maninka Name	Degree of Recognition by Informants	Similar Citations
<u>Combretum nigricans</u>	<i>sama labali jambakatan</i>	strong recognition; name means 'type of <i>jambakatan</i> (<i>Combretum</i>) which elephants can not pull up'	Aubréville 1950; Berhaut 1974; Berhaut 1967; Malgras 1992
<u>Combretum paniculatum</u>	<i>kònòding dolo</i>	good recognition; name means 'little bird's beer'	Berhaut 1974
<u>Combretum tomentosum</u>	<i>lake fìng</i>	poor recognition; name means 'black <i>lake</i> (<i>Combretum micranthum</i>)'	
<u>Combretum tomentosum</u>	<i>kari nòmbo</i>	poor recognition	
<u>Cordia myxa</u>	<i>daramu</i>	strong recognition	Aubréville 1950; Berhaut 1974; Malgras 1992
<u>Crateva adansonii</u>	<i>sinamu</i>	very strong recognition	Bailleul 1996; Berhaut 1974, 1967; Malgras 1992; Aubréville 1950
<u>Crotalaria pallida</u>	<i>nginyi nginyô</i>	very poor recognition	
<u>Cryptolepis sanguinolenta</u>	<i>bonje</i>	very poor recognition	
<u>Dichrostachys cinerea</u>	<i>tèrigo</i>	very strong recognition	Berhaut 1975a; Dalziel 1955; Aubréville 1950
<u>Diospyros abyssinica</u>	<i>koronkòye fìng</i>	very poor recognition; name means 'black <i>koronkòye</i> (<i>Hippocratea indica</i>)'	
<u>Diospyros mespiliformis</u>	<i>jonbo</i>	strong recognition	Berhaut 1975b
<u>Erythrina senegalensis</u>	<i>tènye</i>	strong recognition	

Table 9—*Continued*

Scientific Name	Maninka Name	Degree of Recognition by Informants	Similar Citations
<u>Erythrophleum guineense</u>	<i>talo</i>	poor recognition	Portrères 1965; Dalziel 1955; Aubréville 1950, 1959a; Fairhead and Leach 1996; Jaeger 1959
<u>Euphorbia sudanica</u>	<i>hamo</i>	very strong recognition	Berhaut 1975b
<u>Feretia apodanthera</u>	<i>tun su ma</i>	strong recognition; name means 'found at termite mound'	
<u>Ficus abutifolia</u>	<i>kobo</i>	good recognition	
<u>Ficus cordata</u>	(<i>kònò dumun</i>) <i>seko</i>	strong recognition; specific name means 'the type of <i>seko</i> (<i>Ficus</i>) which birds eat'	
<u>Ficus glumosa</u>	<i>toro (nganya)</i>	good recognition; specific name means 'rough-leaved <i>toro</i> (<i>Ficus</i>)'	
<u>Ficus sur</u>	(<i>dèn ba</i>) <i>toro</i>	good recognition; specific name means ' <i>toro</i> (<i>Ficus</i>) with big fruit'	
<u>Ficus sur</u>	(<i>siti</i>) <i>toro</i>	good recognition	Malgras 1992
<u>Ficus sycomorus</u>	<i>toro (nganya)</i>	strong recognition; specific name means 'rough-leaved <i>toro</i> (<i>Ficus</i>)'	
<u>Ficus thonningii</u>	<i>lèbe lèbe</i>	very poor recognition	
<u>Garcinia livingstonei</u>	<i>zere</i>	very poor recognition	
<u>Gardenia imperialis</u>	<i>kumbukambajuo</i>	poor recognition	
<u>Gardenia sokotensis</u>	<i>hatakulu te</i>	poor recognition	Aubréville 1950; Malgras 1992
<u>Gilletiodendron glandulosum</u>	<i>sènsão</i>	strong recognition; this name used in the Bafing, Bambugu, and Sulun traditional <i>kafolu</i>	

Table 9—*Continued*

Scientific Name	Maninka Name	Degree of Recognition by Informants	Similar Citations
<u>Gilletiodendron glandulosum</u>	<i>kololo</i>	good recognition; this name used in the area around Kita	Aubréville 1939, 1950; Jaeger 1956a
<u>Grewia bicolor</u>	<i>sambe fing</i>	strong recognition; name means 'black <i>sambe</i> (<i>Grewia</i>)'	Aubréville 1950
<u>Grewia lasiodiscus</u>	<i>sambe ge</i>	strong recognition; name means 'white <i>sambe</i> (<i>Grewia</i>)'	
<u>Gyrocarpus americanus</u>	<i>sabarō</i>	strong recognition	
<u>Hexalobus monopetalus</u>	<i>kunje</i>	very strong recognition	Berhaut 1971; Aubréville 1950
<u>Hibiscus sterculiifolius</u>	<i>bami</i>	very poor recognition	
<u>Hippocratea indica</u>	<i>koronkòye</i>	poor recognition	
<u>Indigofera arrecta</u>	<i>yirindin suma ko</i>	very poor recognition; name means 'bad-smelling shrub'	
<u>Ixora radiata</u>	<i>kò kuna</i>	poor recognition	
<u>Khaya senegalensis</u>	<i>jalo</i>	strong recognition	Berhaut 1979; Dalziel 1955; Shafer and Cooper 1980; Aubréville 1950
<u>Kigelia africana</u>	<i>magalintan</i>	very strong recognition	
<u>Lannea microcarpa</u>	<i>hego (munko)</i>	strong recognition; specific name means 'smooth-leaved <i>hego</i> '	
<u>Lannea velutina</u>	<i>hego (nganya)</i>	strong recognition; specific name means 'rough-leaved <i>hego</i> '	
<u>Lepisanthes senegalensis</u>	<i>bòombo</i>	poor recognition	
<u>Leptactina senegambica</u>	<i>jègè bòrò</i>	very poor recognition; name means 'fish sack'	

Table 9—Continued

Scientific Name	Maninka Name	Degree of Recognition by Informants	Similar Citations
<u>Leptadenia hastata</u>	<i>sarahate</i>	very strong recognition	Berhaut 1971
<u>Lophira lanceolata</u>	<i>mana se</i>	strong recognition; name means 'mana variety of sé (<u>Vitellaria paradoxa</u> Gaertn. f.)'	Jaeger 1959; Fairhead and Leach 1996; Aubréville 1950; Dalziel 1955
<u>Malacantha alnifolia</u>	<i>kababa</i>	poor recognition	
<u>Manilkara multinervis</u>	<i>hara to se</i>	good recognition; name means 'type of sé (<u>Vitellaria paradoxa</u>) which is found in rice fields'	
<u>Manilkara multinervis</u>	<i>dòliyo</i>	poor recognition	
<u>Maytenus senegalensis</u>	<i>tòre</i>	strong recognition	Berhaut 1974; Aubréville 1950
<u>Oxytenanthera abyssinica</u>	<i>bo</i>	very strong recognition	Dalziel 1955; Berhaut 1967
<u>Pachystela brevipes</u>	<i>kamba</i>	poor recognition	
<u>Paullinia pinnata</u>	<i>kalo wanjō</i>	good recognition	
<u>Piliostigma thonningii</u>	<i>haro</i>	very strong recognition	Berhaut 1975a; Aubréville 1950; Shafer and Cooper 1980; Dalziel 1955; Malgras 1992
<u>Prosopis africana</u> (Guill. & Perr.) Taub.	<i>gèlèyo</i>	very strong recognition	Malgras 1992; Dalziel 1955; Berhaut 1975a
<u>Pterocarpus lucens</u>	<i>baro</i>	very strong recognition	Aubréville 1950
<u>Pterocarpus erinaceus</u>	<i>genu</i>	very strong recognition	Aubréville 1950; Malgras 1992
<u>Pterocarpus santalinoides</u>	<i>jagungo</i>	good recognition	Berhaut 1976; Malgras 1992; Aubréville 1959a; Dalziel 1955

Table 9—Continued

Scientific Name	Maninka Name	Degree of Recognition by Informants	Similar Citations
<u>Raphia sudanica</u>	<i>ban</i>	very strong recognition	Dalziel 1955; Berhaut 1967; Adam 1965
<u>Saba senegalensis</u>	<i>saba</i>	very strong recognition	Malgars 1992; Berhaut 1971, 1967; Dalziel 1955; Imperato 1977
<u>Sarcocephalus latifolius</u>	<i>batio</i>	very strong recognition	Shafer and Cooper 1980
<u>Securinega virosa</u>	<i>gorongora</i>	very strong recognition	
<u>Spondias mombin</u>	<i>minkòn</i>	very strong recognition	Bailleul 1996; Berhaut 1971; Dalziel 1955
<u>Stereospermum kunthianum</u>	<i>mogo yiro</i>	very strong recognition; name translates as 'person tree'	Bailleul 1996; Malgras 1992; Aubréville 1950; Berhaut 1974
<u>Strophanthus sarmentosus</u>	<i>bonje</i>	poor recognition	
<u>Syzygium guineense</u>	<i>kubu kabo</i>	very poor recognition	
<u>Tamarindus indica</u>	<i>tombiyō</i>	very strong recognition	Malgras 1992, Berhaut 1975a, Dalziel 1955, Fairhead and Leach 1996, Aubréville 1950
<u>Tapinanthus dodoneaeifolius</u>	<i>yiri la dòn</i>	good recognition; name means 'forces trees open'	
<u>Tephrosia mossiensis</u>	<i>kalaliyon</i>	good recognition	
<u>Terminalia macroptera</u>	<i>wòlò</i>	very strong recognition	
<u>Trema orientalis</u>	<i>sukurão</i>	strong recognition	
<u>Trichilia emetica</u>	<i>wulu dun kun</i>	very poor recognition	
<u>Uvaria chamae</u>	<i>kara</i>	very poor recognition	

Table 9—*Continued*

Scientific Name	Maninka Name	Degree of Recognition by Informants	Similar Citations
<u>Vepris heterophylla</u>	<i>gèngèliba</i>	very strong recognition	Bailleul 1996; Imperato 1977; Malgras 1992
<u>Vernonia colorata</u>	<i>kò safuno</i>	good recognition; name translates as 'creek soap'	Berhaut 1974; Bailleul 1996; Malgras 1992; Dalziel 1955; Aubréville 1950, 1959c; Fairhead and Leach 1996
<u>Vitex doniana</u>	<i>kutuba</i>	good recognition	Bailleul 1996; Berhaut 1967; Imperato 1977; Malgras 1992
<u>Xeroderris stühlmannii</u>	<i>mansarin genu</i>	very strong recognition; name means 'genu (<i>Pterocarpus erinaceus</i>) of the descendants of the <i>mansa</i> (Sundiata)'	Aubréville 1950
<u>Xylopia elliotii</u>	<i>nkankalan je</i>	poor recognition	
<u>Ziziphus mucronata</u>	<i>surukun</i> <i>tòmbòròn</i>	very strong recognition; name means 'hyena <i>tòmbòròn</i> (<i>Ziziphus</i>)'	Aubréville 1950; Malgras 1992

Table 10. Maninka Uses of Plants in Gilletiodendron Forest

Plant	Reported Use	Use Observed?
<u>Adansonia digitata</u>	bark of young trees used to make rope	yes
<u>Adansonia digitata</u>	fruit eaten	yes
<u>Adansonia digitata</u>	leaves eaten and used to thicken sauces	yes
<u>Albizia zygia</u>	twigs used as gèsé (tooth brush)	no
<u>Allophyllus cobbe</u>	infusion of leaves mixed with milk used to treat constipation	no
<u>Anogeissus leiocarpus</u>	wood used in construction, particularly as <i>tarumalu</i> (posts) and <i>salalu</i> (cross beams)	yes
<u>Anogeissus leiocarpus</u>	boiled leaves yield dye	no
<u>Baissea multiflora</u>	shoots and bark used to make rope	no
<u>Baissea multiflora</u>	bathe in infusion of leaves to soothe back pain	yes
<u>Bombax costatum</u>	kapok used as tinder when striking fires with flint	yes
<u>Bombax costatum</u>	flowers used as forage or famine food	no
<u>Boscia angustifolia</u>	leaves mixed with oil taken to treat stomach pains	no
<u>Bridelia ferruginea</u>	wash wounds with infusion of leaves mixed with salt	no
<u>Burkea africana</u>	wood used in construction, particularly as <i>tarumalu</i> (posts) and <i>salalu</i> (cross beams)	yes
<u>Burkea africana</u>	twigs used as gèsé (tooth brush)	no
<u>Burkea africana</u>	bark used to tan leather	no
<u>Celtis integrifolia</u>	leaves used as forage for sheep or famine food	no
<u>Cissus populnea</u>	sap used to thicken and harden mud to seal floors and door jams	yes
<u>Cissus populnea</u>	stem produces liquid which may be drunk to relieve thirst in emergencies	no
<u>Cola laurifolia</u>	fruit eaten	yes
<u>Croton</u> sp.	infusion of leaves taken for coughs and fevers	no
<u>Combretum glutinosum</u>	firewood	yes
<u>Combretum micranthum</u>	infusion of leaves used against stomach aches	no

Table 10—*Continued*

Plant	Reported Use	Use Observed?
<u>Combretum micranthum</u>	cooked roots eaten with meat serve as male aphrodisiac	no
<u>Combretum nigricans</u>	bathe in infusion of leaves to soothe back pain	no
<u>Combretum nigricans</u>	infusion of leaves taken for constipation	no
<u>Combretum tomentosum</u>	stems used as <i>koto</i> , in roof construction	yes
<u>Cordia myxa</u>	fruit eaten	no
<u>Cordia myxa</u>	bark used to make rope	no
<u>Crateva adansonii</u>	leaves eaten as hungry season food	yes
<u>Diospyros mespiliformis</u>	fruit eaten	no
<u>Diospyros mespiliformis</u>	wood used to make wooden implements and iron implement handles	no
<u>Diospyros mespiliformis</u>	infusion of roots used to treat dysentery	no
<u>Euphorbia sudanica</u>	latex used as poison	no
<u>Feretia apodanthera</u>	leaves or infusion of leaves taken against diarrhea	no
<u>Feretia apodanthera</u>	bathe in infusion of leaves to treat body aches	no
<u>Ficus abutifolia</u>	planted to serve as shade tree	no
<u>Ficus abutifolia</u>	bathe in infusion of leaves or bark to treat fever	no
<u>Ficus glumosa</u>	leaves used as forage in times of scarcity	no
<u>Ficus glumosa</u>	figs eaten	no
<u>Ficus thonningii</u>	latex used to treat earaches	no
<u>Gardenia sokotensis</u>	bathe children with infusion of leaves to insure health	no
<u>Gilletiodendron glandulosum</u>	wood used in construction, particularly as <i>salalu</i> (cross beams) and <i>tarumalu</i> (posts)	yes
<u>Gyrocarpus americanus</u>	wood used to make drum bodies	no
<u>Gyrocarpus americanus</u>	seeds used to make beads	yes
<u>Hexalobus monopetalus</u>	fruit eaten	no
<u>Hibiscus sterculiifolius</u>	shoots and bark used to make rope	no
<u>Hippocratea indica</u>	wood used to make <i>tigo gosilan</i> (threshing rod for peanuts)	no
<u>Hippocratea indica</u>	drink infusion of leaves to treat upset stomach	no

Table 10—*Continued*

Plant	Reported Use	Use Observed?
<u>Lannea microcarpa</u>	fruit eaten	no
<u>Leptactina senegambica</u>	twigs and branches used as fish stringers	no
<u>Leptadenia hastata</u>	leaves eaten as hungry season food	no
<u>Leptadenia hastata</u>	sap used as dressing for wounds	no
<u>Lophira lanceolata</u>	twigs used as <i>gèsè</i> (tooth brush)	no
<u>Lophira lanceolata</u>	leaves used to bathe infants	yes
<u>Lophira lanceolata</u>	bathe in infusion of leaves to quell itching	no
<u>Malacantha alnifolia</u>	wood used for lumber	no
<u>Manilkara multinervis</u>	leaves eaten as famine food	no
<u>Oxytenanthera abyssinica</u>	multiple uses: construction, fencing, furniture	yes
<u>Pachystela brevipes</u>	bark used to make rope	no
<u>Paullinia pinnata</u>	twigs used as <i>gèsè</i> (tooth brush)	yes
<u>Piliostigma thonningii</u>	infusion of leaves used to flavor <i>moni</i> (breakfast gruel)	yes
<u>Pterocarpus erinaceus</u>	leaves used as livestock forage	yes
<u>Pterocarpus erinaceus</u>	wood used in construction, particularly as <i>tarumalu</i> (posts) and <i>salalu</i> (cross beams), and to make cooking utensils	yes
<u>Pterocarpus lucens</u>	wood used in construction, particularly as <i>salalu</i> (large cross beams) and <i>lalalu</i> (small cross beams)	yes
<u>Pterocarpus lucens</u>	wood used to make <i>kalalu</i> (implement handles)	yes
<u>Pterocarpus lucens</u>	infusion of leaves used as vermifuge	no
<u>Pterocarpus lucens</u>	leaves used as forage for sheep	no
<u>Pterocarpus santalinoides</u>	wood used in construction, particularly as <i>tarumalu</i> (posts) and <i>salalu</i> (cross beams)	no
<u>Pterocarpus santalinoides</u>	seeds eaten as hunger food	no
<u>Raphia sudanica</u>	petioles used to make furniture	yes
<u>Raphia sudanica</u>	sap fermented to make wine	no
<u>Saba senegalensis</u>	fruit eaten	yes
<u>Sarcocephalus latifolius</u>	fruit eaten	yes
<u>Securinega virosa</u>	branches and stems used as fencing	yes
<u>Spondias mombin</u>	fruit eaten	yes

Table 10—*Continued*

Plant	Reported Use	Use Observed?
<u>Stereospermum kunthianum</u>	infusion of bark used as an emetic	no
<u>Stereospermum kunthianum</u>	drink sap mixed with water to treat diarrhea	no
<u>Tamarindus indica</u>	leaves and fruit eaten and used as flavoring	yes
<u>Tephrosia mossiensis</u>	infusion of leaves and fruit used to flavor <i>moni</i> (breakfast gruel)	no
<u>Terminalia macroptera</u>	wood used in construction, particularly as <i>tarumalu</i> (posts) and <i>salalu</i> (cross beams)	yes
<u>Terminalia macroptera</u>	firewood	yes
<u>Trema orientalis</u>	leaves used as forage for sheep and goats	no
<u>Trema orientalis</u>	infusion of leaves used against abdominal pains in postpartum women	no
<u>Trema orientalis</u>	charcoal used to make gunpowder	no
<u>Trichilia emetica</u>	bathe with infusion of leaves to treat fevers	no
<u>Trichilia emetica</u>	juice extracted from pounded plant parts makes a poison	no
<u>Vepris heterophylla</u>	infusion of leaves used for stomach pain and other gastrointestinal ailments	yes
<u>Vernonia colorata</u>	twigs used as <i>gèsè</i> (tooth brush)	no
<u>Vernonia colorata</u>	bathe in infusion of leaves to treat fever	no
<u>Ziziphus mucronata</u>	fruit eaten to treat stomach pain	no

Table 11. Preference Ranking of Hardwoods Used for Construction. The number of instances a plant was given as the first, second, third, etc. response is shown. Not all informants gave the same number of responses. Total equals the number of first responses times five, second responses times four, third responses times three, etc.

Species	First	Second	Third	Fourth	Fifth	Total
<u>Prosopis africana</u>	11	8	2	0	0	93
<u>Anogeissus leiocarpus</u>	6	5	2	0	0	56
<u>Gilletiodendron glandulosum</u>	4	4	4	4	0	56
<u>Burkea africana</u>	4	2	5	1	0	45
<u>Pterocarpus erinaceus</u>	1	1	1	2	1	15
<u>Vitellaria paradoxa</u>	1	2	0	1	0	15
<u>Pterocarpus lucens</u>	1	0	1	1	0	10
<u>Pterocarpus santalinoides</u>	0	1	0	1	1	7
<u>kulikulio</u>	1	0	0	0	0	5
<u>galama</u>	1	0	0	0	0	5
<u>Terminalia macroptera</u>	0	1	0	0	0	4
<u>Diospyros mespiliformis</u>	0	0	1	0	0	3
<u>Cordyla pinnata</u> (Lepr. ex A. Rich)	0	0	0	1	0	2
Milne-Redhead <u>Borassus aethipicum</u>	0	0	0	0	1	1

Table 12. Actual Use of Gilletiodendron glandulosum in *Bire* Construction

Location	Total number of <i>tarumalu</i> (support posts)	Number of <u>Gilletiodendron</u> <i>tarumalu</i>	Percent of total
Manantali market	1,142	195	17.08%
Maréna	90	6	6.67%
Woundiamba	44	7	15.91%
Makadugu	86	4	4.65%
Sollo	67	2	3.00%
Total	1,429	214	14.98%
Total (excluding Manantali)	287	19	6.62%

Table 13. Chimpanzee Food Plants Occuring in Gilletiodendron Forest

Species	Location	Source
<u>Adansonia digitata</u>	Mali	Duvall, pers. obs.
<u>Bombax costatum</u>	Guinea	de Bournonville 1967
<u>Chaetacme aristata</u>	Uganda	Ghiglieri 1984
<u>Cissus populnea</u>	Mali	Duvall, pers. obs.
<u>Cola cordifolia</u>	Guinea	de Bournonville 1967
<u>Detarium microcarpum</u>	Côte d'Ivoire	McGrew et al. 1997
<u>Detarium senegalense</u>	Guinea	de Bournonville 1967
	Sierra Leone	Whitesides 1985
<u>Dialium guineense</u>	Guinea	de Bournonville 1967
<u>Erythrophleum guineense</u>	Guinea	de Bournonville 1967
<u>Ficus cordata</u>	Mali	Duvall, pers. obs.
<u>Ficus glumosa</u>	Mali	Duvall, pers. obs.
<u>Ficus sur</u>	Guinea	de Bournonville 1967
	Tanzania	Wrangham and Goodall 1989
	Uganda	Schaller 1965
	Uganda	Ghiglieri 1984
<u>Ficus sycomorus</u>	Tanzania	Wrangham and Goodall 1989
<u>Grewia bicolor</u>	Mali	Duvall, pers. obs.
<u>Lannea microcarpa</u>	Guinea	de Bournonville 1967
<u>Lepisanthes senegalensis</u>	Uganda	Ghiglieri 1984
<u>Lophira lanceolata</u>	Guinea	de Bournonville 1967
<u>Oxytenanthera abyssinica</u>	Mali	Duvall, pers. obs.
	Guinea	de Bournonville 1967
<u>Pterocarpus erinaceus</u>	Guinea	de Bournonville 1967
<u>Saba senegalensis</u>	Mali	Duvall, pers. obs.
	Guinea	de Bournonville 1967
<u>Sarcocephalus latifolius</u>	Guinea	de Bournonville 1967
<u>Spondias mombin</u>	Mali	Duvall, pers. obs.
	Guinea	de Bournonville 1967
<u>Syzygium guineense</u>	Guinea	de Bournonville 1967
<u>Uvaria chamae</u>	Guinea	de Bournonville 1967
<u>Zanha golungensis</u>	Uganda	Schaller 1965

SOURCES CITED

- Adam, J.G. 1956. Éléments pour la phytosociologie de l'Afrique occidentale. Bulletin de la société botanique de France, 103: 12-21.
- Adam, J.G. 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.
- Adam, J.G. 1962b. Une forêt de Copaliers au Sénégal (Guibourtia copallifera Benn.). Répartition en Afrique occidentale. Bulletin de la société botanique de France 109: 185-191.
- Adam, J.G. 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.
- Adam, J.G. 1965. Généralités sur la flore et la végétation du Sénégal. Études sénégalaises, 9(3): 155-214.
- Adam, J.G. 1966. Composition floristique des principaux types physiologiques de végétation du Sénégal. Journal of the West African Science Association 11(1-2): 81-97.
- Adam, J.G. 1968. La flore et la végétation du Parc National du Niokolo-Koba (Sénégal). Adansonia, série 2, 8(4): 439-459.
- Arnould, E.J. 1990. Changing the terms of rural development: Collaborative research in cultural ecology in the Sahel. Human Organization 49(4): 339-354.
- Assemblée Nationale et Présidence de la République du Mali. 1996. Loi no. 95-004/ Fixant les conditions de gestion des ressources forestières. Bamako, Mali: Présidence de la République.
- Aubréville, A. 1938. La forêt coloniale: Les forêts d'A.O.F. Annales de l'Académie des Sciences Coloniales 9: 1-261.
- Aubréville, A. 1939. Forêts reliques en Afrique Occidentale Française. Revue internationale de botanique appliquée et d'agriculture tropicale 19: 479-484.
- Aubréville, A. 1949. Contribution à la paléohistoire des Forêts de l'Afrique tropicale. Paris: Société d'Éditions Géographiques, Maritimes, et Coloniales.

- Aubréville, A. 1950. Flore forestière soudano-guinéenne: AOF - Cameroun - AEF. Paris: Société d'Éditions Géographiques, Maritimes, et Coloniales.
- Aubréville, A. 1959a. Flore forestière de la Côte d'Ivoire. Vol. 1. 2d ed. Nogent-sur-Maarne, France: Centre Technique Forestier Tropical.
- Aubréville, A. 1959b. Flore forestière de la Côte d'Ivoire. Vol. 2. 2d ed. Nogent-sur-Maarne, France: Centre Technique Forestier Tropical.
- Aubréville, A. 1959c. Flore forestière de la Côte d'Ivoire. Vol. 3. 2d ed. Nogent-sur-Maarne, France: Centre Technique Forestier Tropical.
- Aubréville, A. 1962. Savanisation tropicale et glaciations quaternaires. Adansonia 2(1): 16-84.
- Avenard, J.-M., J. Bonvallot, M. Latham, M. Renard-Dugerdil, and J. Richard. 1974. Aspects du contact forêt-savane dans le centre et l'ouest de la Côte d'Ivoire: Étude Descriptive. Paris: ORSTOM.
- Bailleul, C. 1981. Petit Dictionnaire Bambara-Français Français-Bambara. London: Avebury Publishing Company.
- Bailleul, C. 1996. Dictionnaire Bambara-Français. Baamako, Mali: Éditions Donniya.
- Baldwin P.J., W.C. McGrew, and C.E.G. Tutin. 1982. Wide-ranging chimpanzees at Mt. Assirik, Senegal. International Journal of Primatology 3(4): 367-385.
- Barbour, M.G., J.H. Burk, W.D. Pitts, F.S. Gilliam, and M.W. Schwartz. 1999. Terrestrial Plant Ecology. Menlo Park, CA: Addison Wesley Longman, Inc.
- Barrett, S.C.H. and J.R. Kohn. 1991. Genetic and evolutionary consequences of small population size in plants: Implications for conservation. In Genetics and Conservation of Rare Plants, ed. D.A. Falk and K.E. Holsinger: 3-30. New York: Oxford University Press.
- Baumer, M. 1995. Arbres, arbustes et arbrisseaux nourriciers en Afrique occidentale. Dakar, Senegal: Enda-Éditions.
- Bawa, K.S., and Ashton, P.S. 1991. Conservation of rare trees in tropical rain forests: A genetic perspective. In Genetics and Conservation of Rare Plants, ed. D.A. Falk and K.E. Holsinger: 62-71. New York: Oxford University Press.

- Berhaut, J. 1967. Flore du Sénégal. 2d ed. Dakar, Senegal: Clairafrique.
- Berhaut, J. 1971. Flore illustrée du Sénégal. Vol. 1. Dakar, Senegal: Direction des Eaux et Forêts, Ministère du Développement Rural et d'Hydraulique, Gouvernement du Sénégal.
- Berhaut. 1974. Flore illustrée du Sénégal. Vol. 2. Dakar, Senegal: Direction des Eaux et Forêts, Ministère du Développement Rural et d'Hydraulique, Gouvernement du Sénégal.
- Berhaut. 1975a. Flore illustrée du Sénégal. Vol. 3. Dakar, Senegal: Direction des Eaux et Forêts, Ministère du Développement Rural et d'Hydraulique, Gouvernement du Sénégal.
- Berhaut. 1975b. Flore illustrée du Sénégal. Vol. 4. Dakar, Senegal: Direction des Eaux et Forêts, Ministère du Développement Rural et d'Hydraulique, Gouvernement du Sénégal.
- Berhaut. 1976. Flore illustrée du Sénégal. Vol. 5. Dakar, Senegal: Direction des Eaux et Forêts, Ministère du Développement Rural et d'Hydraulique, Gouvernement du Sénégal.
- Berhaut. 1979. Flore illustrée du Sénégal. Vol. 6. Dakar, Senegal: Direction des Eaux et Forêts, Ministère du Développement Rural et d'Hydraulique, Gouvernement du Sénégal.
- Berlin, B. 1992. Ethnobiological Classification: Principles of Categorization of Plants and Animals in Traditional Societies. Princeton: Princeton University Press.
- Berlin, B., D.E. Breedlove, and P.H. Raven. 1974. Principles of Tzeltal Plant Classification: An Introduction to the Botanical Ethnography of a Mayan-Speaking People of Highland Chiapas. New York: Academic Press.
- Bird, C.S., ed. 1982. The Dialects of Mandekan. Bloomington, IN: African Studies Program, Indiana University.
- Boudet, G., J.P. Lebrun, and R. Demange. 1986. Catalogue des Plantes Vasculaires du Mali. Maisons Alfort, France: Institut d'Élevage et de Médecine Vétérinaire des Pays Tropicaux.
- Brown, J.H. and A. Gibson. 1983. Biogeography. St Louis: C.V. Mosby Co.

- 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, IN.
- Chardonnet, B., B. Bagayoko, H. Boulet, A. Daou, S. Diallo, B. Niagaté, N. Traoré. N.d. [1999]. Survol écologique de 3 zones du sud-ouest du Mali en vue de denombrement des élands de Derby et des autres grands mammifères: Rapport final. UICN-Mali/Direction Nationale de la Conservation de Nature, Bamako, Mali. Photocopied.
- Cissé, D. 1970. Structures des Malinké du Kita. Collection "Hier", Bamako, Mali: Éditions Populaires.
- Cissé, Y. 1964. Notes sur les sociétés de chasseurs Maninka. Journal de la Société des Africanistes 34(2): 175-226.
- Condit, R., S.P. Hubbell, J.V. Lafrankie, R. Sukumar, N. Manokaran, R.B. Foster, and 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.
- Conklin, H.C. 1954. The Relation of Hanunóo Culture to the Plant World. Unpublished Ph.D. Dissertation, Department of Anthropology, Yale University.
- Cotton, C.M. 1996. Ethnobotany: Principles and Applications. Chichester, UK: John Wiley and Sons.
- Cox, G.W. 1985. Laboratory Manual of General Ecology. 5th ed. Dubuque, IA: William C. Brown Publishers.
- Cutler, A. 1991. Nested faunas and extinction in fragmented habitats. Conservation Biology 5(4): 496-505.
- Dalby, D. 1971. Introduction: Distribution and nomenclature of the Manding people and their language. In Papers on the Manding, ed. Carleton T. Hodge: 1-14. Indiana University Publications, African Series, The Hague: Mouton & Co.
- Dalziel, J.M. 1955. The Useful Plants of West Tropical Africa. London: Crown Agents for Oversea Governments and Administrations, 1937: second reprint.
- Daubenmire, R. 1966. Vegetation: Identification of typl communities. Science 151: 291-298.

- Davis, S.D., S.J.M. Droop, P. Gregerson, L. Henson, C.J. Leon, J.L. Villa-Lobos, H. Synge, and J. Zantovska. 1986. Plants in Danger: What Do We Know? Gland, Switzerland: IUCN.
- 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.
- Decher, J. 1997. Conservation, small mammals, and the future of sacred groves in West Africa. Biodiversity and Conservation 6: 1007-1026.
- Detwyler, K., College Station, TX, to Chris Duvall, Fremont, CA, 15 March, 1999. E-mail letter, collection of the author.
- Dixon, R.K., J.A. Perry, E.L. Vanderklein, and F. Hiol Hiol. 1996. Vulnerability of forest resources to global climate change: Case study of Cameroon and Ghana. Climate Research 6: 127-133.
- Duong Huu Thoi. 1947. Introduction à l'étude de la végétation du Soudan français. In Conferencia International dos Africanistas Ocidentais, Bissau 2: 9-51.
- Dupont, L.M., and 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.
- Dupuy, A.R. 1970. Sur la présence du Chimpanzé dans les limites du Parc national du Niokolo-Koba (Sénégal). Bulletin de l'Institut Fondamental d'Afrique Noire, série A, 32: 1090-1099.
- Duvall, C. and 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 (DNRFFH), Bamako, Mali. Photocopied.
- Ehrlich, D., E.F. Lambin, and J.-P. Malingreau. 1997. Biomass burning and broad-scale land-cover changes in western Africa. Remote Sensing of the Environment 61: 201-209.
- Fairhead, J. and M. Leach. 1996. Misreading the African Landscape: Society and Ecology in a Forest-Savanna Mosaic. Cambridge: Cambridge University Press.

- Frederiksen, P. and J.E. Lawesson. 1992. Vegetation types and patterns in Senegal based on multivariate analysis of field and NOAA-AVHRR satellite data. Journal of Vegetation Science 3: 535-544.
- Garmin Corporation. 1999. GPS 12 Personal Navigator Owner's Manual and Reference. Olathe, KS: Garmin International, Inc.
- Geerling, C. 1987. Guide de terrain des ligneux sahéliens et soudano guinéens. 2d ed. Wageningen, The Netherlands: Agricultural University.
- Ghiglieri, M.B. 1984. The Chimpanzees of Kibale Forest: A Field Study of Ecology and Social Structure. New York: Columbia University Press.
- Goodstein, E.S. 1999. Economics and the Environment. Upper Saddle River, NJ: Prentice-Hall, Inc.
- Grigsby, W.J. 1990. Women's forest use, its social organization, and current and potential roles of credit in rural Mali. Unpublished M.S. Thesis, University of Idaho.
- Grigsby, W. 1996. Women, Descent, and Tenure Succession among the Bambara of West Africa: A Changing Landscape. Human Organization 55(1): 93-98.
- Grimm, C.D. 1991. The relationships between villagers in the context of relocation and on the interaction between relocatees and the officials involved in the implementation of the resettlement project in Manantali. Unpublished Ph.D. Dissertation, State University of New York at Binghamton.
- Grimm, C.D., Washington, D.C., to Chris Duvall, Fremont, CA, 16 March 1999. E-mail letter, collection of the author.
- 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. 1974. Distribution patterns of forest trees in Uganda and their historical significance. Vegetatio, 29: 21-35.
- Hamilton, A.C. 1992. History of forests and climate. In The Conservation Atlas of Tropical Forests: Africa ed. J.A. Sayer, C.S. Harcourt, N.M. Collins: 17-25. New York: IUCN/Simon and Schuster.
- Hartshorn, G.S. 1992. Possible effects of global warming on the biological diversity of tropical forests. In Global Warming and Biological Diversity, ed. R.L. Peters and T.E. Lovejoy: 137-146. New Haven, CT: Yale University Press.

- Hepper, F.N. 1965. Preliminary account of the phytogeographical affinities of the flora of west tropical Africa. Webbia 19(2): 593-617.
- Hielscher, S. and J. Sommerfeld. 1985. Concepts of illness and the utilization of health-care services in a rural Malian village. Social Science and Medicine 21(4): 469-481.
- Holsinger, K.E. and L.D. Gottlieb. 1991. Conservation of rare and endangered plants: Principles and prospects. In Genetics and Conservation of Rare Plants, ed. D.A. Falk and K.E. Holsinger: 195-208. New York: Oxford University Press.
- Hopkins, N.S. 1971. Maninka social organization. In Papers on the Manding, ed. Carleton T. Hodge: 99-129. Indiana University Publications, African Series, The Hague: Mouton & Co.
- Horowitz, M., D. Koenig, C. Grimm, and Y. Konaté. 1990. Resettlement at Manantali, Mali: Short-term success, long-term problems. Birmingham, NY: Institute of Development Anthropology.
- Hutchinson, J. and J.M. Dalziel. 1954. Flora of West Tropical Africa, Vol. 1, Part 1. Second Edition. Revised by R.W.J. Keay. London: Crown Agents for Oversea Governments and Administrations.
- Hutchinson, J. and J.M. Dalziel. 1958. Flora of West Tropical Africa, Vol. I, Part 2. Second Edition. Revised by R.W.J. Keay. London: Crown Agents for Oversea Governments and Administrations.
- Hutchinson, J. and J.M. Dalziel. 1963. Flora of West Tropical Africa, Vol. II. Second Edition. Edited by F.N. Hepper. London: Crown Agents for Oversea Governments and Administrations.
- Hutchinson, J. and J.M. Dalziel. 1968. Flora of West Tropical Africa, Vol. III, Part 1. Second Edition. Edited by F.N. Hepper. London: Crown Agents for Oversea Governments and Administrations.
- Hutchinson, J. and J.M. Dalziel. 1972. Flora of West Tropical Africa, Vol. III, Part 2. Second Edition. Edited by F.N. Hepper. London: Crown Agents for Oversea Governments and Administrations.
- Imperato, P.J. 1974. Traditional medical practitioners among the Bambara of Mali and their role in the modern health-care-delivery system. Rural Africana 26: 41-53.

- Imperato, P.J. 1977. African Folk Medicine: Practices and Beliefs of the Bambara and Other Peoples, Baltimore: York Press Inc.
- 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.
- Jaeger, P. 1956a. Contribution à l'étude des forêts reliques du Soudan occidental. Bulletin de l'Institut Français d'Afrique Noire, série A, 18(4): 993-1053.
- Jaeger, P. 1956b. Sur le comportement saisonnier du Kololo [Gilletiodendron glandulosum (Port.) J. Léonard-Césalpinaées]. Comptes rendus hebdomadaires des séances de l'Académie des Sciences 243: 1668-1670.
- Jaeger, P. 1959. Les plateaux gréseux du Soudan occidental. Leur importance phytogéographique. Bulletin de l'Institut Français d'Afrique Noire, série A, 21(4): 1147-1159.
- Jaeger, P. 1966. Sur l'endémisme dans les plateaux soudanais ouest-africains. Compte rendu sommaire des séances de la Société de Biogéographie 368: 38-48.
- Jaeger, P. 1968. Mali. Acta Phytogeographica Suecica 54: 51-53.
- Jaeger, P. and 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. and E. Lechner. 1957. Observations et réflexions au sujet du biotope du Kololo [Gilletiodendron glandulosum (Port.) J. Léonard, Césalpinaées]. Comptes rendus hebdomadaires des séances de l'Académie des Sciences 245: 944-946.
- Jaeger, P. and 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.
- Janzen, D.H. 1988. Tropical dry forests: The most endangered major tropical ecosystem. In Biodiversity, ed. E.O. Wilson: 130-137. Washington, DC: National Academy Press.
- Jones, W.I. 1970. The food economy of Ba Dugu Djoliba, Mali. In African Food Production Systems: Cases and Theory, ed. P.F.M. McLoughlin: 265-306. Baltimore: The Johns Hopkins University Press.

- Keay, R.W.J. 1959. Vegetation Map of Africa South of the Tropic of Cancer: Explanatory Notes. Oxford: Oxford University Press.
- Kéïta, R.N. 1972. Kayes et le haut Sénégal: Kayes et sa région. Éditions Populaires, Bamako.
- Killian, C. and 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.
- Kodric-Brown, A. and J.H. Brown. 1993. Highly structured fish communities in Australian desert springs. Ecology 74(6): 1847-1855.
- Koenig, D., T. Diarra, and M. Sow. 1998. Innovation and Individuality in African Development: Changing Production Strategies in Rural Mali. Ann Arbor: The University of Michigan Press.
- Kortland, A. 1983. Marginal habitats of chimpanzees. Journal of Human Evolution 12: 231-278.
- Küchler, A.W. 1988. The Classification of Vegetation. In Vegetation Science, ed. A.W. Küchler and I.S. Zonneveld: 67-80. Vol. 10, Handbook of Vegetation Science, H. Lieth, ed., Dordrecht, Germany: Kluwer Academic Publishers.
- Lambeck, R.J. 1997. Focal species: A multi-species umbrella for nature conservation. Conservation Biology 11(4): 849-856.
- Lawesson, J. E. 1995. Studies of woody flora and vegetation in Senegal. Opera Botanica 125: 1-172.
- Lekan, J. 1992. Seasonal coping strategies in central Mali. Disasters 16(1): 66-73.
- Léonard, J. 1951. Notulae systematicae XI. Les Cynometra et les genres voisins en Afrique tropicale. Bulletin du Jardin Botanique d'État, Bruxelles 20: 269-284.
- Letourneux, C. 1957. Le problème des feux au Soudan français. Bois et Forêts des Tropiques, 52: 21-28.
- Levtzion, N. 1975. North-west Africa: From the Maghrib to the fringes of the forest. In The Cambridge History of Africa, Vol. 4, ed. R. Gray: 142-222. Cambridge University Press, Cambridge, UK.

- Liesner, R., compiler. 1991. Techniques de terrain utilisées au Jardin Botanique du Missouri (MO). TMs (photocopy). St. Louis: Missouri Botanical Garden.
- Maley, J. 1987. Fragmentation de la forêt dense humide africaine et extensions des biotopes montagnards au Quaternaire récent: Nouvelles données polliniques et chronologiques. Implications paleoclimatiques et biogéographiques. Palaeoecology of Africa and the Surrounding Islands 18: 307-334.
- Maley, J. 1996. The African rain forest – main characteristics of changes in vegetation and climate from the Upper Cretaceous to the Quaternary. Proceedings of the Royal Society of Edinburgh Series B (Biological Sciences), 104: 31-73.
- Malgras, D. 1992. Arbres et arbustes guérisseurs des savanes maliennes. Paris: Éditions Karthala et ACCT.
- Maydell, H.-J. von. 1992. Arbres et arbustes du Sahel: leurs caractéristiques et leurs utilisations. Weikersheim, Germany: Verlag Josef Margraf Scientific Books.
- McCall, D.F. 1971. The cultural map and time-profile of the Mande speaking peoples. In Papers on the Manding, ed. Carleton T. Hodge: 27-98. Indiana University Publications, African Series, The Hague: Mouton & Co.
- McDonald, K.A. and Brown, J.H. 1992. Using montane mammals to model extinctions due to global change. Conservation Biology 6(3): 409-415.
- McGrew, W.C. 1989. Recent research on chimpanzees in West Africa. In Understanding Chimpanzees, ed. P.G. Heltne and L.A. Marquardt: 128-133. Cambridge: Harvard University Press.
- McGrew, W.C., R.M. Ham, L.J.T. White, C.E.G. Tutin, and M. Fernandez. 1997. Why don't chimpanzees in Gabon crack nuts? International Journal of Primatology 18(3): 353-374.
- McIntosh, S.K. and R.J. McIntosh. 1981. West African prehistory. American Scientist 69: 602-613.
- McKinney, M.L. 1997. Extinction vulnerability and selectivity: Combining ecological and paleontological views. Annual Review of Ecology and Systematics 28: 495-516.
- Meave, J. and M. Kellman. 1994. Maintenance of rain forest diversity in riparian forests of tropical savannas: Implications for species conservation during Pleistocene drought. Journal of Biogeography 21: 121-135.

- Michelin. 1994. Afrique Nord et Ouest: Carte Routière et Touristique [Map]. Paris: Pneu Michelin.
- Monnier, Y. 1990. La poussière et la cendre: Paysages, dynamique des formations végétales et stratégies des sociétés en Afrique de l'Ouest. Paris: Agence de Coopération Culturelle et Technique.
- Moore, J. 1985. Chimpanzee survey in Mali, West Africa. Primate Conservation 6:59-63.
- Paris, R. and M.S. Etchebarre. 1968. Présence de C-flavonosides chez une rutacée africaine: Le Teclea sudanica A. Chev. Annales pharmaceutiques françaises 26: 51-53.
- Park, M. 1896. The Life and Travels of Mungo Park. Edinburgh, UK: W.P. Nimmo.
- Parthasarathy, N., and R. Karthikeyan. 1997. Plant biodiversity inventory and conservation of two tropical dry evergreen forests on the Coromandel coast, south India. Biodiversity and Conservation 6: 1063-1083.
- Patterson, B.D. 1987. The principle of nested subsets and its implications for biological conservation. Conservation Biology 1(4): 323-334.
- Patterson, B.D.. 1991. The integral role of biogeographic theory in the conservation of tropical forest diversity. In Latin American Mammalogy: History, Biodiversity, and Conservation, ed. M.A. Mares, D.J. Schmidly: 124-149. Norman: University of Oklahoma Press.
- Pavy, J.-M. 1993. Mali: Bafing Faunal Reserve: Biodiversity and Human Resource: Survey and Recommendations. TMs (photocopy).
- Pimm, S., G. Russell, J. Gittleman, and T. Brooks. 1995. The future of biodiversity. Science 269: 347-354.
- Portrères, R. 1939. Quatre Légumineuses nouvelles de l'Afrique Occidentale. Revue internationale de botanique appliquée et l'agriculture tropicale 20: 785-789.
- Portrères, R. 1965. Les noms des riz en Guinée. Journal d'agriculture tropicale et de botanique appliquée 7(9-10): 370-402.
- Portrères, R. 1966. Les noms des riz en Guinée (suite). Journal d'agriculture tropicale et de botanique appliquée 13(1-3): 1-32.

- PREMA (Projet Développement rural régional Manantali). 1996. Analyse régionale réduite de la région de Manantali. Bamako, Mali: PREMA. Photocopied.
- Projet Inventaire par Télédétection des Ressources Ligneuses et de l'Occupation Agricole des Terres au Mali. 1990. Carte des Formations Végétales: Bafoulabé-Kita. [Map.] Bamako, Mali: Ministère de l'Environnement et de l'Élevage.
- Quinn, J.F. and S.P. Harrison. 1988. Effects of habitat fragmentation and isolation on species richness: Evidence from biogeographic patterns. Oecologia 75: 132-140.
- Rabinowitz, D. 1981. Seven forms of rarity. In Syngé, H., ed., The Biological Aspects of Rare Plant Conservation, pp. 205-218. New York: John Wiley and Sons.
- République du Mali. 1987. Loi 86-91/AN-RM/Code Domanial et Foncier, Bamako, Mali: Présidence de la République.
- Roberty, G. 1940. Contribution à l'étude phytogéographique de l'Afrique Occidentale Française. Candollea 8: 83-137.
- Rondeau, C. 1987. Paysannes du Sahel et stratégies alimentaires. Revue internationale d'action communautaire 17: 63-80.
- Rylands, A.B. 1990. Priority areas for conservation in the Amazon. Trends in Ecology and Evolution 5: 240-241.
- Ryti, R.T. 1992. Effect of the focal taxon on the selection of nature reserves. Ecological Applications 2(4): 404-410.
- Sanford, W.W. and A.O. Isichei. 1986. Savanna. In Plant Ecology in West Africa: Systems and Processes, ed. G.W. Lawson: 95-149. Chichester, UK: John Wiley and Sons.
- Sayer, J.A., C.S. Harcourt, and N.M. Collins, eds. 1992. The Conservation Atlas of Tropical Forests: Africa. New York: IUCN/Simon and Schuster.
- Schaller, G.B. 1965. Behavioral comparisons of the apes. In Primate Behavior: Field Studies of Monkeys and Apes, ed I. Devore: 474-483. New York: Holt, Rinehart, and Winston.
- Schemske, D.W., B.C. Husband, M.H. Ruckelshaus, C. Goodwillie, I.M. Parker, and J.G. Bishop. 1994. Evaluating approaches to the conservation of rare and endangered plants. Ecology 75(3): 584-606.

- Schnell, R. 1950. Noms vernaculaires et usages indigènes de plantes d'Afrique Occidentale. Études guinéennes 7(4): 56-87.
- 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.
- Schnell, R. 1976. Flore et végétation de l'Afrique tropicale. Vol. 1. Paris: Gauthier-Villars.
- Service Géographique d'Afrique Occidentale Française. 1958. Bafoulabé. [Map]. Dakar, Senegal: Service Géographique d'Afrique Occidentale Française.
- Shafer, M. and Cooper, C. 1980. Mandinko: The ethnography of a West African Holy Land. New York: Holt, Rinehart, and Winston.
- Smith, A.C. 1973. Angiosperm evolution and the relationship of the floras of Africa and America. In Tropical Forest Ecosystems in Africa and South America: A Comparative Review ed. B.J. Meggars, E.S. Ayensu, and W.D. Duckworth: 49-61. Washington, DC: Smithsonian Institution Press.
- Spradley, J.P. 1980. Participant Observation. New York: Holt, Rinehart, and Winston.
- Stebbins, G.L. 1980. Rarity of plant species: A synthetic viewpoint. Rhodora 82: 77-86.
- Stiling, P.D. 1996. Ecology: Theories and Applications. 2d ed. Upper Saddle River, NJ: Prentice Hall.
- Stockman, A. ed. 1993. Background Notes: Mali. Washington, DC: Office of Public Communication, Bureau of Public Affairs, U.S. Department of State.
- Suzuki, A. 1969. An ecological study of chimpanzees in savanna woodland. Primates 10: 103-148.
- Swaine, M.D. 1992. Characteristics of dry forest in West Africa and the influence of fire. Journal of Vegetation Science 3: 365-374.
- Tausch, R.J., P.E. Wigand, and J.W. Burkhardt. 1993. Viewpoint: Plant community thresholds, multiple steady states, and multiple successional pathways: Legacy of the Quarternary? Journal of Range Management 46: 439-477.
- Verdcourt, B. 1968. Why conserve natural vegetation? Acta Phytogeographica Suecica 54: 1-9.

- 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., Smith, J., and Manyong, M.V. 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. Buletin du Jardin Botanique National de Belgique 49: 11-55.
- White, F. 1983. The Vegetation of Africa: Maps and Memoir. Paris: UNESCO/AETFAT/UNSO.
- Whitesides, G.H. 1985. Nut cracking by wild chimpanzees in Sierra Leone, West Africa. Primates 26(1): 91-94.
- Wilson, E.O., ed. 1988. Biodiversity. Washington, DC: National Academy Press.
- World Conservation Monitoring Center. 1998. Tree Conservation Database. WCMC internet web site. URL: <http://www.wcmc.org.uk>
- Wrangham, R.W. and J. Goodall. 1989. Chimpanzee use of medicinal leaves. In Understanding Chimpanzees, ed. P.G. Heltne and L.A. Marquardt: 22-37. Cambridge: Harvard University Press.
- Wright, R.G., M.P. Murray, and T. Merrill. 1998. Ecoregions as a level of ecological analysis. Biological Conservation 86: 207-213.

APPENDICES

APPENDIX 1

Description of Research Sites

Site No.	Latitude and Longitude	Altitude	Description
1	13° 10.847' N 10° 26.260' W	280 m	Steep, rocky slope with seasonal drainage channel and large seepage area.
2	13° 10.851' N 10° 26.306' W	280 m	Very small grove in sheltered area amongst rock outcrops.
3	13° 11.340' N 10° 26.339' W	300 m	Steep, rocky, narrow ravine with semi-permanent stream and numerous seepage areas.
4/5	13° 11.425' N 10° 26.130' W	300 m	Steep, rocky ravine and long, narrow cliff edge with seasonal drainage channel and several seepage areas.
6	13° 11.518' N 10° 26.092' W	320 m	Sandstone cliff and several protected areas between 10-15 m high outcrops, with seepage area.
7	13° 11.411' N 10° 27.543' W	210 m	Sandstone outcrop with semi-permanent stream. Surrounded by savanna vegetation.
8	13° 10.911' N 10° 26.209' W	280 m	Steep, rocky slope with seasonal drainage channel and seepage area.
9	13° 11.971' N 10° 11.952' W	280 m	Steep, rocky, narrow ravine and rock outcrop surrounded by savanna vegetation. Semi-permanent stream and several drainage areas.
10	13° 11.989' N 10° 31.859' W	280 m	Steep, rocky slope and sandstone cliff. Seasonal drainage channel and large seepage area.
11	13° 14.207' N 10° 33.975' W	180 m	Steep, rocky slope and sandstone cliff with semi-permanent stream, several seasonal drainage channels, and several seepage areas.
12	12° 59.979' N 10° 36.317' W	360 m	Steep, rocky slope between 35 m outcrop and 45 m cliff.
13	12° 59.604' N 10° 36.654' W	360 m	Series of very narrow ravines and sandstone outcrops on top of small 60 m plateau. Numerous seepage areas.
14	12° 57.009' N 10° 36.613' W	340 m	Rocky slope along semi-permanent stream.
15	12° 57.680' N 10° 36.759' W	360 m	Sandstone cliff ledge and area between outcrops. Seasonal drainage channel.

Appendix 1—*Continued*

Site No.	Latitude and Longitude	Altitude	Description
16	12° 58.540' N 10° 26.798' W	380 m	Steep, rocky slope and sandstone cliff with semi-permanent stream and several seepage areas.
17	13° 02.211' N 10° 29.001' W	320 m	Sandstone outcrop and cliff with semi-permanent stream. Surrounded by savanna vegetation.

APPENDIX 2

Formulae Used in Calculations

Quadrat Sampling Formulae

$$\text{density} = \frac{\text{number of individuals}}{\text{area sampled}}$$

$$\text{relative density} = \frac{\text{density for a species}}{\text{total density for all species}} \times 100$$

$$\text{dominance} = \frac{\text{total of basal area values}}{\text{area sampled}}$$

$$\text{relative dominance} = \frac{\text{dominance for a species}}{\text{total dominance for all species}} \times 100$$

$$\text{frequency} = \frac{\text{number of plots in which species occurs}}{\text{total number of plots sampled}} \times 100$$

$$\text{relative frequency} = \frac{\text{frequency value for a species}}{\text{total of frequency values for all species}} \times 100$$

$$\text{importance value (sum)} = \text{relative density} + \text{relative dominance} + \text{relative frequency}$$

$$\text{importance value (average)} = \frac{\text{relative density} + \text{relative dominance} + \text{relative frequency}}{3}$$

Point-quarter Sampling Formulae

$$\text{total density of all species} = \frac{\text{unit area}}{(\text{mean point-to-plant distance})^2}$$

$$\text{relative density} = \frac{\text{individuals of a species}}{\text{total individuals of all species}} \times 100$$

$$\text{density} = \frac{\text{relative density of a species} \times \text{total density of all species}}{100}$$

dominance = $\frac{\text{density of species} \times \text{total basal area for a species}}{\text{number of individuals}}$

relative dominance = $\frac{\text{dominance for a species}}{\text{total dominance for all species}} \times 100$

frequency = $\frac{\text{number of points at which species occurs}}{\text{total number of points sampled}} \times 100$

relative frequency = $\frac{\text{frequency value for a species}}{\text{total of frequency values for all species}} \times 100$

importance value (sum) = relative density + relative dominance + relative frequency

importance value (average) = $\frac{\text{relative density} + \text{relative dominance} + \text{relative frequency}}{3}$

Line-intercept Formulae

M = maximum plant width perpendicular to transect line

$\sum 1/M$ = total of reciprocals of maximum plant width

density = $(\sum 1/M) \times \frac{\text{unit area}}{\text{total transect length}}$

relative density = $\frac{\text{density for a species}}{\text{total density for all species}} \times 100$

cover dominance = $\frac{\text{total of intercept lengths for a species}}{\text{total transect length}} \times 100$

relative dominance = $\frac{\text{total of intercept lengths for a species}}{\text{total of intercept lengths for all species}} \times 100$

frequency = $\frac{\text{intervals in which species occurs}}{\text{total number of transect intervals}} \times 100$

n = number of values of M

$$F = \frac{\sum 1/M}{n}$$

weighted frequency = (F) x (number of transect intervals in which species occurs)

relative frequency = $\frac{\text{weighted frequency for a species}}{\text{total of weighted frequencies for all species}} \times 100$

importance value (sum) = relative density + relative dominance + relative frequency

importance value (average) = $\frac{\text{relative density} + \text{relative dominance} + \text{relative frequency}}{3}$

total coverage = $\frac{\text{total transect length} - \text{total bare ground}}{\text{total transect length}} \times 100$

APPENDIX 3

Complete Results from Biodiversity Index Calculations.

Species	Number of Individuals	Simpson index		Shannon index	
		$n(n-1)$	$\frac{n(n-1)}{N(N-1)}$	p_i	$p_i(\ln p_i)$
Hi. in.	616	378840	0.0725	0.2695	0.3534
Gi. gl.	417	173472	0.0332	0.1824	0.3104
Gr. bi.	200	39800	0.0076	0.0875	0.2132
Di. ab.	107	11342	0.0022	0.0468	0.1433
Co. mi.	75	5550	0.0011	0.0328	0.1121
Di. me.	59	3422	0.00066	0.0258	0.0944
Ga. so.	50	2450	0.00047	0.0219	0.0834
Sp. mo.	50	2450	0.00047	0.0219	0.0837
Sa. la.	44	1892	0.00036	0.0192	0.0759
Gy. am.	37	1332	0.00026	0.0162	0.0668
Ox. ab.	37	1332	0.00026	0.0162	0.0668
Co. to.	36	1260	0.00024	0.0157	0.0652
Ma. al.	32	992	0.00019	0.0140	0.0598
Bo. co.	30	870	0.00017	0.0131	0.0568
Co. ni.	30	870	0.00017	0.0131	0.0568
Fe. ap.	29	812	0.00016	0.0127	0.0555
Ac. ch.	27	702	0.00013	0.0118	0.0524
Sa. se.	26	650	0.00012	0.0114	0.0510
Ve. co.	23	506	0.000097	0.0101	0.0464
St. ku.	22	462	0.000088	0.0096	0.0446
Co. af.	21	420	0.000080	0.0092	0.0431
Ci. po.	20	380	0.000073	0.0087	0.0413
Hi. af.	16	240	0.000046	0.0070	0.0347
Bo. sa.	15	210	0.000040	0.0066	0.0331
St. sa.	15	210	0.000040	0.0066	0.0331
Co. gr.	13	156	0.000030	0.0057	0.0295
Eu. su.	12	132	0.000025	0.0052	0.0273
Ma. mu.	12	132	0.000025	0.0052	0.0273
Al. co.	10	90	0.000017	0.0044	0.0239
Al. zy.	10	90	0.000017	0.0044	0.0239
Fi. co.	10	90	0.000017	0.0044	0.0239
Ix. ra.	10	90	0.000017	0.0044	0.0239

Appendix 3—Continued

Species	Number of Individuals	Simpson index		Shannon index	
		$n(n-1)$	$\frac{n(n-1)}{N(N-1)}$	p_i	$p_i(\ln p_i)$
Xe. st.	10	90	0.0000017	0.0044	0.0239
Ci. qu.	9	72	0.000014	0.0039	0.0216
Co. to.	9	72	0.000014	0.0039	0.0216
Ba. mu.	8	56	0.000011	0.0035	0.0198
Te. mo.	8	56	0.000011	0.0035	0.0198
Tr. or.	8	56	0.000011	0.0035	0.0198
Gr. la.	7	42	0.0000080	0.0031	0.0179
Bo. an.	6	30	0.0000057	0.0026	0.0155
Br. fe.	6	30	0.0000057	0.0026	0.0155
He. mo.	6	30	0.0000057	0.0026	0.0155
Pt. er.	6	30	0.0000057	0.0026	0.0155
Cr. mu.	5	20	0.0000038	0.0022	0.0135
Ps. ko.	5	20	0.0000038	0.0022	0.0135
Zi. mu.	5	20	0.0000038	0.0022	0.0135
Fi. sy.	4	12	0.0000023	0.0017	0.0108
Op. ce.	4	12	0.0000023	0.0017	0.0108
Uv. ch.	4	12	0.0000023	0.0017	0.0108
An. le	3	6	0.0000011	0.0013	0.0086
Co. la.	3	6	0.0000011	0.0013	0.0086
Co. my.	3	6	0.0000011	0.0013	0.0086
Col. co.	3	6	0.0000011	0.0013	0.0086
Com. co.	3	6	0.0000011	0.0013	0.0086
Cr. sa.	3	6	0.0000011	0.0013	0.0086
Di. ci.	3	6	0.0000011	0.0013	0.0086
Eu.	3	6	0.0000011	0.0013	0.0086
Fi. gl.	3	6	0.0000011	0.0013	0.0086
Fi. in.	3	6	0.0000011	0.0013	0.0086
La. mi.	3	6	0.0000011	0.0013	0.0086
Lept. se.	3	6	0.0000011	0.0013	0.0086
Lop. la.	3	6	0.0000011	0.0013	0.0086
Te. ma.	3	6	0.0000011	0.0013	0.0086
Ve. he.	3	6	0.0000011	0.0013	0.0086
As. pa.	2	2	0.00000038	0.0009	0.0061
Be. gr.	2	2	0.00000038	0.0009	0.0061
Ce. in.	2	2	0.00000038	0.0009	0.0061
Cr. ad.	2	2	0.00000038	0.0009	0.0061

Appendix 3—*Continued*

Species	Number of Individuals	Simpson index		p_i	Shannon index	
		$n(n-1)$	$\frac{n(n-1)}{N(N-1)}$		$p_i(\ln p_i)$	
Pa. br.	2	2	0.00000038	0.0009	0.0061	
Tr. em.	2	2	0.00000038	0.0009	0.0061	
Ac. at.	1	0	0	0.0004	0.0034	
Ad. di.	1	0	0	0.0004	0.0034	
An. no.	1	0	0	0.0004	0.0034	
Bu. af.	1	0	0	0.0004	0.0034	
Ch. ar.	1	0	0	0.0004	0.0034	
De. se.	1	0	0	0.0004	0.0034	
De. ve.	1	0	0	0.0004	0.0034	
Di. gu.	1	0	0	0.0004	0.0034	
Er. gu.	1	0	0	0.0004	0.0034	
Fi. su.	1	0	0	0.0004	0.0034	
Ga. li.	1	0	0	0.0004	0.0034	
Hi. st.	1	0	0	0.0004	0.0034	
Le. ha.	1	0	0	0.0004	0.0034	
Pt. sa.	1	0	0	0.0004	0.0034	
So. da.	1	0	0	0.0004	0.0034	
Sy. gu.	1	0	0	0.0004	0.0034	
Ta. in.	1	0	0	0.0004	0.0034	
Totals	2286		0.12100258			2.9596

The inverse of the Simpson index ($1 / 0.1210$) equals 8.26.

The Shannon index is 2.96.

APPENDIX 4

Complete Results from Point-quarter Survey

Species	No. Indivs.	Avg. Dom. (cm ²)	Density (#/ha)	Relative Density	Dom. (m ² /ha)	Relative Dom.	Freq.	Relative Freq.	Imp. Value (sum)	Imp. Value (avg.)
Gi. gl.	342	769.44	236.46	53.44	18.19	59.60	0.89	31.56	144.6	48.20
Gr. bi.	99	188.69	68.45	15.47	1.29	4.23	0.43	15.25	34.95	11.65
Fi. co.	6	390.57	4.15	0.94	0.16	0.52	0.38	13.48	14.94	4.98
Sp. mo.	22	706.86	15.21	3.44	1.08	3.54	0.13	4.61	11.59	3.86
Ad. di.	2	21851.54	1.38	0.31	3.02	9.90	0.01	0.35	10.56	3.52
Gy. am.	24	471.44	16.59	3.75	0.78	2.56	0.11	3.90	10.21	3.40
Co. mi.	18	98.52	12.45	2.81	0.12	0.39	0.09	3.19	6.39	2.13
Bo. co.	13	419.10	8.99	2.03	0.38	1.25	0.07	2.48	5.76	1.92
Di. me.	8	870.92	5.53	1.25	0.48	1.57	0.04	1.42	4.24	1.41
La. mi.	6	1372.28	4.15	0.94	0.57	1.87	0.04	1.42	4.23	1.41
De. se.	1	16060.61	0.69	0.16	1.11	3.64	0.01	0.35	4.15	1.38
Ma. mu.	7	697.46	4.84	1.09	0.34	1.11	0.04	1.42	3.62	1.21
Kh. se.	1	12948.51	0.69	0.16	0.89	2.92	0.01	0.35	3.43	1.14
Di. ab.	8	136.85	5.53	1.25	0.08	0.26	0.05	1.77	3.28	1.09
Bo. an.	6	359.68	4.15	0.94	0.15	0.49	0.04	1.42	2.85	0.95
Ma. al.	6	149.57	4.15	0.94	0.06	0.20	0.04	1.42	2.56	0.85
Col. co.	3	1712.87	2.07	0.47	0.35	1.15	0.02	0.71	2.33	0.78
Sa. la.	5	120.76	3.46	0.78	0.04	0.13	0.03	1.06	1.97	0.66
Xe. st.	5	128.68	3.46	0.78	0.04	0.13	0.03	1.06	1.97	0.66
Loph. la.	5	283.53	3.46	0.78	0.10	0.33	0.02	0.71	1.82	0.61

Appendix 4—Continued

Species	No. Indivs.	Avg. Dom. (cm ²)	Density (#/ha)	Relative Density	Dom. (m ² /ha)	Relative Dom.	Freq.	Relative Freq.	Imp. Value (sum)	Imp. Value (avg.)
Pt. er.	2	2099.28	1.38	0.31	0.29	0.95	0.01	0.52	1.78	0.59
Pa. br.	4	320.47	2.77	0.63	0.09	0.29	0.02	0.78	1.70	0.57
Fi. sy.	4	292.55	2.77	0.63	0.08	0.26	0.01	0.52	1.41	0.47
Fi. su.	3	120.76	2.07	0.47	0.02	0.07	0.02	0.78	1.32	0.44
Sa. se.	3	118.82	2.07	0.47	0.02	0.07	0.02	0.78	1.32	0.44
Co. la.	2	263.02	1.38	0.31	0.04	0.13	0.02	0.78	1.22	0.41
Ce. in.	2	794.23	1.38	0.31	0.11	0.36	0.01	0.52	1.19	0.40
Fi. gl.	2	789.24	1.38	0.31	0.11	0.36	0.01	0.52	1.19	0.40
Co. gl.	2	126.68	1.38	0.31	0.02	0.07	0.01	0.52	0.90	0.30
Ix. ra.	2	126.68	1.38	0.31	0.02	0.07	0.01	0.52	0.90	0.30
Ac. po.	1	383.60	0.69	0.16	0.03	0.10	0.01	0.52	0.78	0.26
Be. gr.	1	1231.63	0.69	0.16	0.08	0.26	0.01	0.26	0.68	0.23
Ga. li.	2	235.06	1.38	0.31	0.03	0.10	0.01	0.26	0.67	0.22
He. mo.	1	865.70	0.69	0.16	0.06	0.20	0.01	0.26	0.62	0.21
Fi. ab.	1	615.75	0.69	0.16	0.04	0.13	0.01	0.26	0.55	0.18
Sy. gu.	1	629.02	0.69	0.16	0.04	0.13	0.01	0.26	0.55	0.18
Bu. af.	1	307.91	0.69	0.16	0.02	0.07	0.01	0.26	0.49	0.16
Co. to.	1	248.85	0.69	0.16	0.02	0.07	0.01	0.26	0.49	0.16
Ps. ko.	1	394.08	0.69	0.16	0.03	0.10	0.01	0.26	0.49	0.16
Pt. sa.	1	232.35	0.69	0.16	0.02	0.07	0.01	0.26	0.49	0.16
Ra. su.	1	274.65	0.69	0.16	0.02	0.07	0.01	0.26	0.49	0.16
Vi. do.	1	251.65	0.69	0.16	0.02	0.07	0.01	0.26	0.49	0.16

Appendix 4—Continued

Species	No. Indivs.	Avg. Dom. (cm ²)	Density (#/ha)	Relative Density	Dom. (m ² /ha)	Relative Dom.	Freq.	Relative Freq.	Imp. Value (sum)	Imp. Value (avg.)
Al. co.	1	95.03	0.69	0.16	0.01	0.03	0.01	0.35	0.54	0.18
Co. af.	1	84.95	0.69	0.16	0.01	0.03	0.01	0.35	0.54	0.18
Co. ni.	1	109.36	0.69	0.16	0.01	0.03	0.01	0.35	0.54	0.18
Co. pa.	1	113.10	0.69	0.16	0.01	0.03	0.01	0.35	0.54	0.18
Eu. su.	1	86.59	0.69	0.16	0.01	0.03	0.01	0.35	0.54	0.18
Ps. ps.	1	100.29	0.69	0.16	0.01	0.03	0.01	0.35	0.54	0.18
Tr. or.	1	88.25	0.69	0.16	0.01	0.03	0.01	0.35	0.54	0.18
Xy. el.	1	78.54	0.69	0.16	0.01	0.03	0.01	0.35	0.54	0.18
Totals	634	1424.32	438.31		30.52		2.82			

APPENDIX 5

Complete Results from Line Intercept Survey

Sp.	No. of Indivs.	ΣI	No. of Inter- vals	Σ 1/M	D'sity. (#/ha)	Rel. D'sity.	Dom.	Rel. Dom.	Freq.	Wtd. Freq.	Rel. Freq.	Imp. Value (sum)	Imp. Value (avg.)
Gi. gl.	416	1235.5	178	27.34	131.44	8.22	59.40	33.76	85.58	99.32	14.30	56.28	18.74
Hi. in.	335	535.75	121	40.11	192.81	12.06	25.76	14.64	58.17	147.05	21.17	47.87	15.96
Gr. bi.	194	478.75	117	34.52	165.96	10.38	23.02	13.08	56.25	100.97	14.53	37.99	12.66
Co. mi.	91	219.50	63	25.66	123.36	7.71	10.55	6.00	30.29	57.73	8.31	22.02	7.34
Di. ab.	53	89.25	36	26.55	127.63	7.98	4.29	2.44	17.31	53.09	7.64	18.06	6.02
Ga. so.	15	11.25	15	16.92	81.36	5.09	0.54	0.31	7.21	36.26	5.22	10.62	3.54
Sp.mo.	38	106.5	24	14.12	67.88	4.24	5.12	2.91	11.54	18.82	2.71	9.86	3.29
Ac. ch.	11	9.75	11	10.24	49.21	3.08	0.47	0.27	5.29	18.77	2.70	6.05	2.02
Co. to.	23	43.75	18	10.02	48.17	3.01	2.10	1.20	11.06	7.84	1.13	5.34	1.78
Ci. po.	21	55.5	21	7.70	37.04	2.32	2.67	1.52	10.10	10.11	1.46	5.30	1.77
Fe. ap.	15	13.0	12	8.33	40.07	2.51	0.62	0.36	5.77	14.29	2.06	4.93	1.64
Sa. se.	26	53.75	18	6.37	30.63	1.92	2.58	1.47	8.65	7.17	1.03	4.42	1.47
Di. me.	17	53.0	12	5.33	25.63	1.60	2.55	1.45	5.77	5.82	0.84	3.89	1.30
Gy.am.	20	75.25	14	3.42	16.44	1.03	3.62	2.06	6.73	4.79	0.69	3.78	1.26
Hi. af.	11	8.0	8	6.21	29.87	1.87	0.38	0.22	3.85	8.28	1.19	3.28	1.09
Sa. la.	22	51.5	18	3.53	16.99	1.06	2.48	1.41	8.65	4.54	0.65	3.12	1.04
St. ku.	5	3.0	3	5.83	28.03	1.75	0.14	0.08	1.44	5.83	0.84	2.67	0.89
Bo. co.	21	34.0	13	3.64	17.51	1.10	1.63	0.93	10.10	4.31	0.62	2.65	0.88
Fi. co.	8	19.5	8	5.51	26.49	1.66	0.93	0.05	3.85	5.51	0.79	2.50	0.83
Bo. sa.	3	2	3	5.24	25.21	1.58	0.10	0.05	1.44	5.24	0.75	2.38	0.79

Appendix 5—Continued

Sp.	No. of Indivs.	Σ I	No. of Inter- vals	Σ 1/M	D'sity. (#/ha)	Rel. D'sity.	Dom.	Rel. Dom.	Freq.	Wtd. Freq.	Rel. Freq.	Imp. Value (sum)	Imp. Value (avg.)
Te.mo.	5	4.75	4	3.73	17.93	1.12	0.23	0.13	1.92	7.56	1.07	2.32	0.77
Ci. qu.	11	31.25	11	2.85	13.72	0.86	1.50	0.85	5.29	3.92	0.56	2.27	0.76
St. sa.	11	20.0	9	3.41	16.41	1.03	0.96	0.55	4.33	4.39	0.63	2.21	0.74
Co. gr.	9	17.25	8	3.64	17.49	1.09	0.83	0.47	3.85	4.16	0.60	2.16	0.72
Co. ni.	6	8.75	6	4.27	20.54	1.28	0.42	0.24	2.88	4.27	0.62	2.14	0.71
La. mi.	11	53.25	10	1.27	6.11	0.38	2.56	1.46	4.81	1.59	0.23	2.07	0.69
Ve. co.	2	3.5	2	4.29	20.60	1.29	0.17	0.10	0.96	4.29	0.62	2.01	0.67
Cr. sa.	2	0.75	1	4.0	19.23	1.20	0.04	0.02	0.48	4.0	0.58	1.80	0.60
Di. ci.	1	0.25	1	4.0	19.23	1.20	0.01	0.01	0.48	4.0	0.58	1.79	0.60
Ox. ab.	16	31.5	11	1.78	8.58	0.54	1.51	0.86	5.29	2.45	0.35	1.75	0.58
Ma. al.	8	23.75	8	1.81	8.69	0.54	1.14	0.65	3.85	2.07	0.30	1.49	0.50
Br. fe.	6	8.75	5	2.23	10.70	0.67	0.42	0.24	2.88	2.78	0.40	1.31	0.44
Ma. mu.	6	34.75	6	0.76	3.66	0.22	1.67	0.95	2.88	0.76	0.11	1.28	0.43
Gr. la.	7	15.25	7	1.80	8.65	0.54	0.73	0.42	3.37	2.10	0.30	1.26	0.42
Pa. br.	7	29.0	6	0.94	4.54	0.28	1.39	0.79	2.88	1.13	0.16	1.23	0.41
Le. ha.	2	2.0	2	0.40	1.92	0.12	0.10	0.05	0.96	0.8	0.12	1.20	0.40
Ba.mu.	2	3.25	2	2.22	10.68	0.67	0.16	0.09	0.96	2.22	0.32	1.08	0.36
Ce. in.	2	2.75	2	2.20	10.58	0.66	0.13	0.08	0.96	2.20	0.32	1.06	0.35
Al. co.	6	6.75	4	1.66	7.98	0.50	0.32	0.18	1.92	2.21	0.32	1.00	0.33
Bo. an.	5	12.5	5	1.47	7.08	0.44	0.60	0.34	2.40	1.47	0.21	0.99	0.33

Appendix 5—Continued

Sp.	No. of Indivs.	ΣI	No. of Inter- vals	Σ 1/M	D'sity. (#/ha)	Rel. D'sity.	Dom.	Rel. Dom.	Freq. Value	Wtd. Freq.	Rel. Freq.	Imp. Value (sum)	Imp. Value (avg.)
Ps. ko.	1	3.0	1	0.24	1.13	0.07	0.14	0.82	0.48	0.24	0.03	0.92	0.31
Eu.	1	0.75	1	2.0	9.62	0.60	0.04	0.02	0.48	2.0	0.29	0.91	0.30
Tr. or.	5	11.75	4	1.19	5.72	0.36	0.56	0.32	1.92	1.59	0.23	0.91	0.30
Co. gl.	3	4.0	2	1.66	8.00	0.50	0.19	0.10	0.96	1.66	0.24	0.84	0.28
Co. la.	5	14.25	5	0.89	4.30	0.27	0.69	0.39	2.40	0.89	0.13	0.79	0.26
Eu. su.	1	0.25	1	2.0	9.62	0.60	0.01	0.01	0.48	2.0	0.29	0.78	0.26
Co. af.	5	13.75	3	0.87	4.19	0.26	0.66	0.38	1.44	0.87	0.13	0.77	0.26
Fi. gl.	4	18.5	4	0.44	2.12	0.13	0.89	0.51	1.92	0.59	0.08	0.72	0.24
Col.co.	5	20.5	4	0.33	1.64	0.10	0.99	0.56	1.92	0.33	0.05	0.71	0.24
Ps. ps.	10	18.75	2	0.21	1.00	0.06	0.90	0.51	0.96	0.20	0.03	0.60	0.20
So. da.	1	0.5	1	1.33	6.39	0.40	0.02	0.01	0.48	1.33	0.19	0.60	0.20
He.mo.	3	3.0	3	1.05	5.03	0.31	0.14	0.08	1.44	1.05	0.15	0.54	0.18
As. pa.	2	2.5	2	0.90	4.33	0.27	0.12	0.07	0.96	0.90	0.13	0.47	0.16
Kh. se.	2	14.5	2	0.12	0.57	0.04	0.70	0.40	0.96	0.24	0.03	0.47	0.16
Ve. he.	2	4.25	2	0.79	3.78	0.24	0.20	0.12	0.96	0.79	0.11	0.47	0.16
Fi. sy.	3	5.75	3	0.60	2.88	0.18	0.28	0.16	1.44	0.60	0.09	0.43	0.14
Di. gu.	2	4.0	2	0.65	3.13	0.20	0.19	0.11	0.96	0.65	0.09	0.4	0.13
Bu. af.	2	8.75	2	0.33	1.59	0.10	0.42	0.24	0.96	0.33	0.05	0.39	0.13
Op. ce.	2	5.25	2	0.57	2.77	0.17	0.25	0.14	0.96	0.57	0.08	0.39	0.13
Ix. ra.	3	6.0	2	0.43	2.06	0.13	0.29	0.16	0.96	0.43	0.06	0.35	0.12
Be. gr.	2	9.5	2	0.14	0.68	0.04	0.46	0.26	0.96	0.14	0.02	0.32	0.11
Zi. mu.	1	0.75	1	0.67	3.21	0.20	0.04	0.02	0.48	0.67	0.10	0.32	0.11

Appendix 5--Continued

Sp.	No. of Indivs.	Σ I	No. of Inter- vals	Σ 1/M	D'sity. (#/ha)	Rel. D'sity.	Dom.	Rel. Dom.	Freq.	Wtd. Freq.	Rel. Freq.	Imp. Value (sum)	Imp. Value (avg.)
Xe. st.	2	4.5	2	0.38	1.81	0.11	0.21	0.12	0.96	0.38	0.05	0.28	0.09
Lepi.	1	1.75	1	0.50	2.40	0.15	0.08	0.05	0.48	0.5	0.07	0.27	0.09
se.													
Pa. pi.	2	7.5	1	0.17	0.80	0.05	0.36	0.20	0.48	0.17	0.02	0.27	0.09
Pt. er.	1	7.5	1	0.11	0.53	0.03	0.36	0.20	0.48	0.11	0.02	0.25	0.08
Ki. af.	2	6.25	2	0.16	0.76	0.05	0.30	0.17	0.96	0.16	0.02	0.24	0.08
Ra. su.	5	5.0	1	0.22	1.07	0.07	0.24	0.14	0.48	0.22	0.03	0.24	0.08
Te. ma.	1	2.0	1	0.44	2.14	0.13	0.10	0.05	0.48	0.44	0.06	0.24	0.08
Ga. li.	2	2.5	1	0.33	1.60	0.10	0.12	0.07	0.48	0.33	0.05	0.22	0.07
Lept.	1	1.25	1	0.40	1.92	0.12	0.06	0.03	0.48	0.40	0.06	0.21	0.07
se.													
Lon. la.	1	5.25	1	0.15	0.74	0.05	0.25	0.14	0.48	0.15	0.02	0.21	0.07
Lop. la.	2	5.5	1	0.14	0.69	0.04	0.26	0.15	0.48	0.14	0.02	0.21	0.07
Vi. do.	1	5.5	1	0.14	0.66	0.04	0.26	0.15	0.48	0.14	0.02	0.21	0.07
Pt. sa.	1	4.0	1	0.17	0.84	0.05	0.19	0.11	0.48	0.17	0.03	0.19	0.06
De. se.	2	4.0	2	0.11	0.53	0.03	0.19	0.11	0.96	0.22	0.03	0.17	0.06
Fi. su.	2	2.5	1	0.22	1.07	0.07	0.12	0.07	0.48	0.22	0.03	0.17	0.06
An. le.	1	4.0	1	0.11	0.52	0.03	0.19	0.11	0.48	0.11	0.02	0.16	0.05
Fi. ab.	1	2.0	1	0.17	0.84	0.05	0.10	0.05	0.48	0.17	0.03	0.13	0.04
Ga. im.	1	1.5	1	0.15	0.74	0.05	0.07	0.04	0.48	0.15	0.02	0.11	0.04
Totals	1564	3651.3	208	332.6	1599.1		175.5						
Open	59	171.0	58										

APPENDIX 6

Results from Quadrat Sampling Survey

Species	No. of Plots	No. of Indivs.	Avg. Ht., All Indivs.	Avg. Ht., Indivs. ≥ 10 cm DBH	D'sity. (#/ha)	Rel. D'sity.	Dom. (m ² /ha)	Rel. Dom.	Freq.	Rel. Freq.	Imp. Value (sum)	Imp. Value (avg.)
Hi. in.	75	852	2.85 ± 3.50	20	886.33	26.75	1.00	2.91	0.77	10.64	40.30	13.43
Gr. bi.	68	277	4.22 ± 2.42	6.62 ± 1.54	287.77	8.69	1.14	3.31	0.70	9.65	21.65	7.22
Di. ab.	36	149	2.70 ± 1.96	6.85 ± 1.15	153.96	4.65	0.10	0.28	0.37	5.11	10.04	3.35
Co. mi.	43	105	3.19 ± 1.70	7	107.91	3.26	0.06	0.19	0.44	6.10	9.55	3.18
Ox. ab.	8	52	5.63 ± 3.41		53.24	1.61	2.16	6.28	0.08	1.14	9.03	3.01
Sp. mo.	21	69	9.74 ± 8.93	18.18 ± 4.64	71.94	2.17	0.55	1.60	0.22	2.98	6.75	2.25
Ac. ch.	20	37	2.00 ± 1.65		38.85	1.17	0	0	0.21	2.84	4.01	1.34
Sa. la.	13	61	2.5 ± 1.42	5.00 ± 1.41	63.31	1.91	0.02	0.05	0.13	1.84	3.80	1.27
Co. to.	16	49	4.33 ± 4.50	12.00 ± 5.66	50.52	1.54	1.17	0.01	0.16	2.20	3.75	1.25

Appendix 6—Continued

Species	No. of Plots	No. of Indivs.	Avg. Ht., All Indivs.	Avg. Ht., Indivs. ≥10 cm DBH	D'sity. (#/ha)	Rel. D'sity.	Dom. (m ² / ha)	Rel. Dom.	Freq.	Rel. Freq.	Imp. Value (sum)	Imp. Value (avg.)
Ma. al.	14	44	5.80 ±4.07	8.33 ±2.60	46.04	1.39	0.12	0.35	0.14	1.99	3.73	1.24
Fe. ap.	16	40	1.71 ±1.00		41.73	1.26	0.0037	0.01	0.16	2.27	3.54	1.18
Ci. po.	16	28	3.7 ±2.63	8	28.78	0.87	0.0027	0.01	0.16	2.27	3.15	1.05
Bo. co.	10	41	6.09 ±4.89	9.5 ±4.09	43.17	1.30	0.14	0.41	0.10	1.42	3.13	1.04
Co. gr.	8	18	6.33 ±2.89		18.71	0.56	0	0	0.08	1.14	1.7	0.57
Ci. qu.	7	12	3.00 ±0.82		12.95	0.39	0	0	0.07	0.99	1.38	0.46
Ba. mu.	7	11	7.40 ±6.15		11.51	0.35	0	0	0.07	0.99	1.34	0.45
Fi. co.	6	14	2.40 ±2.19	6	14.39	0.43	0.0029	0.01	0.06	0.85	1.29	0.43
Hi. af.	4	22	1.38 ±0.89		23.02	0.69	0	0	0.04	0.57	1.26	0.42
Co. af.	2	29	5.26 ±2.28		30.22	0.91	0.0039	0.01	0.02	0.28	1.20	0.40
Bo. an.	6	8	6.00 ±1.41		8.63	0.26	0.0093	0.03	0.06	0.85	1.14	0.38

Appendix 6—Continued

Species	No. of Plots	No. of Indivs.	Avg. Ht., All Indivs.	Avg. Ht., Indivs. ≥10 cm DBH	D'sity. (#/ha)	Rel. D'sity.	Dom. (m ² / ha)	Rel. Dom.	Freq.	Rel. Freq.	Imp. Value (sum)	Imp. Value (avg.)
Ve. co.	1	32	1.18 ±0.50	2	33.09	1.00	0	0	0.01	0.14	1.14	0.38
Gr. la.	5	10	2.14 ±1.86	6	10.07	0.30	0	0	0.05	0.71	1.01	0.34
Al. co.	4	14	2.38 ±1.85		14.39	0.43	0	0	0.04	0.57	1.00	0.33
Br. fe.	5	8	2.20 ±1.30		8.63	0.26	0	0	0.05	0.71	0.97	0.32
Eu. su.	3	17	1.40 ±0.54		17.27	0.52	0.0018	0.01	0.03	0.43	0.96	0.32
Tr. or.	4	11	3.57 ±1.27	3.25 ±0.96	11.51	0.35	0.0035	0.01	0.04	0.57	0.93	0.31
Zi. mu.	5	7	3.25 ±3.30	8	7.19	0.22	0	0	0.05	0.71	0.93	0.31
Te. mo.	4	11	1.00±0		11.51	0.35	0	0	0.04	0.57	0.92	0.31
He. mo.	4	8	2.60 ±3.05	8	8.63	0.26	0	0	0.04	0.57	0.83	0.28
Pt. er.	4	8	3.60 ±3.78	10	8.63	0.26	0	0	0.04	0.57	0.83	0.28

Appendix 6—Continued

Species	No. of Plots	No. of Indivs.	Avg. Ht., All Indivs.	Avg. Ht., Indivs. ≥ 10 cm DBH	D'sity. (#/ha)	Rel. D'sity.	Dom. (m ² /ha)	Rel. Dom.	Freq.	Rel. Freq.	Imp. Value (sum)	Imp. Value (avg.)
Ps. ko.	4	7	3.40 ± 4.83	12	7.19	0.22	0	0	0.04	0.57	0.79	0.26
Xe. st.	2	14	6.80 ± 3.16	9.40 ± 1.95	14.39	0.43	0.0098	0.03	0.02	0.28	0.74	0.25
Al. zy.	2	14	3.10 ± 3.00	10	14.39	0.43	0	0	0.02	0.28	0.71	0.24
Fi. sy.	3	6	9.75 ± 2.22	9.75 ± 2.22	5.76	0.17	0.0066	0.02	0.03	0.43	0.62	0.21
Op. ce.	3	6	4.00 ± 4.24	4.00 ± 4.24	5.76	0.17	0	0	0.03	0.43	0.60	0.20
Fi. gl.	3	4	12.67 ± 4.16	12.67 ± 4.16	4.32	0.13	0.0092	0.03	0.03	0.43	0.59	0.20
Ix. ra.	1	14	3.00 ± 0	3.00 ± 0	14.39	0.43	0	0	0.01	0.14	0.57	0.19
La. mi.	3	4	9.67 ± 9.61	14.00 ± 8.49	4.32	0.13	0.0037	0.01	0.03	0.43	0.57	0.19
Col. co.	2	4	20.00 ± 4.58	20.00 ± 4.58	4.32	0.13	0.016	0.05	0.02	0.28	0.46	0.15
Uv. ch.	2	6	1.25 ± 0.50	1.25 ± 0.50	5.76	0.17	0	0	0.02	0.28	0.45	0.15
Co. my.	2	4	1.33 ± 0.58	1.33 ± 0.58	4.32	0.13	0	0	0.02	0.28	0.41	0.14

Appendix 6—Continued

Species	No. of Plots	No. of Indivs.	Avg. Ht., All Indivs.	Avg. Ht., Indivs. ≥10 cm DBH	D'sity. (#/ha)	Rel. D'sity.	Dom. (m ² / ha)	Rel. Dom.	Freq.	Rel. Freq.	Imp. Value (sum)	Imp. Value (avg.)
Di. ci.	2	4	1.00 ±0		4.32	0.13	0	0	0.02	0.28	0.41	0.14
Fi. in.	2	4	4.67 ±2.52		4.32	0.13	0	0	0.02	0.28	0.41	0.14
Ve. he.	2	4	2.33 ±0.58		4.32	0.13	0	0	0.02	0.28	0.41	0.14
As. pa.	2	3	2.00 ±0		2.88	0.09	0	0	0.02	0.28	0.37	0.12
Ce. in.	2	3	1.50 ±0.71		2.88	0.09	0	0	0.02	0.28	0.37	0.12
Pa. br.	2	3	6.00 ±2.83		2.88	0.09	0	0	0.02	0.28	0.37	0.12
Cr. pa.	1	7	1.20 ±0.45		7.19	0.22	0	0	0.01	0.14	0.36	0.12
Ad. di.	1	1			1.44	0.04	0.047	0.14	0.01	0.14	0.32	0.11
An. le	1	4			4.32	0.13	0	0	0.01	0.14	0.27	0.09
Co. la.	1	4	5.33 ±4.04	9	4.32	0.13	0	0	0.01	0.14	0.27	0.09
Com. co.	1	4	5.33 ±3.74	8	4.32	0.13	0	0	0.01	0.14	0.27	0.09
Cr. sa.	1	4			4.32	0.13	0	0	0.01	0.14	0.27	0.09
Eu.	1	4	2.33 ±2.31		4.32	0.13	0	0	0.01	0.14	0.27	0.09

Appendix 6—Continued

Species	No. of Plots	No. of Indivs.	Avg. Ht., All Indivs.	Avg. Ht., Indivs. ≥10 cm DBH	D'sity. (#/ha)	Rel. D'sity.	Dom. (m ² / ha)	Rel. Dom.	Freq.	Rel. Freq.	Imp. Value (sum)	Imp. Value (avg.)
Lept. se.	1	4	1.67 ±1.15		4.32	0.13	0	0	0.01	0.14	0.27	0.09
Lop. la.	1	4	10.67 ±8.50	15.50 ±2.12	4.32	0.13	0	0	0.01	0.14	0.27	0.09
Te. ma.	1	4	5.00 ±1.73	6	4.32	0.13	0	0	0.01	0.14	0.27	0.09
Ac. at.	1	1	1		1.44	0.09	0	0	0.01	0.14	0.23	0.08
Bu. af.	1	1		10	1.44	0.09	0	0	0.01	0.14	0.23	0.08
An. no.	1	1	1		1.44	0.09	0	0	0.01	0.14	0.23	0.08
Be. gr.	1	3	11.50 ±14.85	22	2.88	0.09	0	0	0.01	0.14	0.23	0.08
Ch. ar.	1	1	5		1.44	0.09	0	0	0.01	0.14	0.23	0.08
Cr. ad.	1	3	1.50 ±0.71		2.88	0.09	0	0	0.01	0.14	0.23	0.08
De. se.	1	1		20	1.44	0.09	0	0	0.01	0.14	0.23	0.08
De. ve.	1	1	1		1.44	0.09	0	0	0.01	0.14	0.23	0.08
Di. gu.	1	1	6		1.44	0.04	0.017	0.05	0.01	0.14	0.23	0.08
Er. gu.	1	1	1		1.44	0.09	0	0	0.01	0.14	0.23	0.08
Fi. su.	1	1	1		1.44	0.09	0	0	0.01	0.14	0.23	0.08
Ga. li.	1	1		4	1.44	0.09	0	0	0.01	0.14	0.23	0.08

Appendix 6—Continued

Species	No. of Plots	No. of Indivs.	Avg. Ht., All Indivs.	Avg. Ht., Indivs. ≥10 cm DBH	D'sity. (#/ha)	Rel. D'sity.	Dom. (m ² / ha)	Rel. Dom.	Freq.	Rel. Freq.	Imp. Value (sum)	Imp. Value (avg.)
Hi. st.	1	1	2		1.44	0.09	0	0	0.01	0.14	0.23	0.08
Le. ha.	1	1	7		1.44	0.09	0	0	0.01	0.14	0.23	0.08
Pt. sa.	1	1		6	1.44	0.09	0	0	0.01	0.14	0.23	0.08
So. da.	1	1	1.5		1.44	0.09	0	0	0.01	0.14	0.23	0.08
Sy. gu.	1	1	1		1.44	0.09	0	0	0.01	0.14	0.23	0.08
Ta. in.	1	1	1		1.44	0.09	0	0	0.01	0.14	0.23	0.08
Tr. em.	1	3	2.00 ±0		2.88	0.09	0	0	0.01	0.14	0.23	0.08
Di. me.	18	82	2.61 ±2.84	11.67 ±0.58	84.89	2.56	0.03	0.07	0.19	2.55	5.18	1.73
Ga. so.	21	69	1.29 ±0.52		71.94	2.17	0.0026	0.01	0.22	2.98	5.16	1.72
Gy. am.	18	51	8.34 ±5.01	11.50 ±8.34	53.24	1.61	0.25	0.73	0.19	2.55	4.89	1.63
Gi. gl.	86	577	7.69 ±7.45	13.60 ±6.78	600.00	18.11	28.62	83.15	0.89	12.20	113.46	37.82
Sa. se.	12	36	4.95 ±3.68	8.29 ±2.75	37.41	1.13	0.02	0.05	0.12	1.70	2.88	0.96
Bo. sa.	12	21	1.31 ±0.63		21.58	0.65	0	0	0.12	1.70	2.35	0.78

Appendix 6—Continued

Species	No. of Plots	No. of Indivs.	Avg. Ht., All Indivs.	Avg. Ht., Indivs. ≥10 cm DBH	D'sity. (#/ha)	Rel. D'sity.	Dom. (m ² / ha)	Rel. Dom.	Freq.	Rel. Freq.	Imp. Value (sum)	Imp. Value (avg.)
Co. ni.	7	41	2.17 ±2.86		43.17	1.30	0	0	0.07	0.99	2.29	0.76
St. sa.	11	21	3.54 ±3.62		21.58	0.65	0	0	0.11	1.56	2.21	0.74
St. ku.	8	30	1.75 ±1.52		31.65	0.96	0	0	0.08	1.14	2.10	0.70
Ma. mu.	9	17	11.58 ±7.86	16.00 ±6.93	17.27	0.52	0.04	0.12	0.09	1.28	1.92	0.64
Totals	97	3158	4.72 ±5.33	11.48 ±6.33	3289.3		34.42		7.27			

APPENDIX 7

Complete Results for Upper Canopy Cover Dominance

Species	Number of Individuals	ΣI	Number of Intervals	Dominance	Relative Dominance
Gi. gl.	333	989.0	142	47.55	59.60
Hi. in.	117	187.5	43	9.01	11.30
Sp. mo.	31	85.25	20	4.10	5.14
Gy. am.	15	71.5	14	3.44	4.31
La. mi.	8	45.25	8	2.18	2.73
Ma. mu.	5	31.25	5	1.50	1.88
Bo. co.	16	27.0	10	1.30	1.63
Di. me.	8	24.0	7	1.15	1.45
Ci. po.	7	19.5	7	0.94	1.18
Sa. se.	8	18.75	8	0.90	1.13
Pa. br.	3	17.5	2	0.84	1.05
Kh. se.	2	14.5	2	0.70	0.87
Co. la.	4	13.0	3	0.63	0.78
Co. to.	4	11.25	4	0.54	0.68
Be. gr.	2	9.5	2	0.46	0.57
Bu. af.	2	8.75	2	0.42	0.53
Fi. gl.	1	7.5	1	0.36	0.45
Pt. er.	1	7.5	1	0.36	0.45
Fi. co.	2	6.75	2	0.32	0.41
Sa. la.	8	6.5	7	0.31	0.39
Ki. af.	2	6.25	2	0.30	0.38
Vi. do.	1	5.5	1	0.26	0.33
Co. gr.	3	5.25	3	0.25	0.32
Lon. la.	1	5.25	1	0.25	0.32
Lop. la.	1	5.0	1	0.24	0.30
Ci. qu.	2	4.75	2	0.23	0.29
St. sa.	2	4.75	2	0.23	0.29
De. se.	2	4.0	2	0.19	0.24
Fi. sy.	1	3.5	1	0.17	0.21
Ps. ko.	1	3.0	1	0.14	0.18
Ba. mu.	1	2.5	1	0.12	0.15
Ma. al.	1	2.5	1	0.12	0.15
Co. af.	1	2.0	1	0.10	0.12

Appendix 7—*Continued*

Species	Number of Individuals	ΣI	Number of Intervals	Dominance	Relative Dominance
Te. ma.	1	2.0	1	0.10	0.12
Ga. im.	1	1.5	1	0.07	0.09
Totals	598	1659.5		79.78	

APPENDIX 8

Complete Results for Lower Canopy Cover Dominance

Species	Number of Individuals	ΣI	Number of Intervals	Dominance	Relative Dominance
Gr. bi.	194	478.75	117	23.02	24.04
Hi. in.	218	348.25	111	16.74	17.48
Gi. gl.	83	246.5	79	11.85	12.38
Co. mi.	91	219.50	63	10.55	11.02
Di. ab.	53	89.25	36	4.29	4.48
Sa. la.	14	45.00	12	2.16	2.26
Ci. po.	14	36.0	14	1.73	1.81
Sa. se.	18	35.00	12	1.68	1.76
Co. to.	19	32.50	16	1.56	1.63
Ox. ab.	16	31.5	11	1.51	1.58
Di. me.	9	29.00	8	1.39	1.46
Ci. qu.	9	26.50	9	1.27	1.33
Ma. al.	7	21.25	7	1.02	1.07
Sp. mo.	7	21.25	7	1.02	1.07
Col. co.	5	20.5	4	0.99	1.03
Ps. ps.	10	18.75	2	0.90	0.94
St. sa.	9	15.25	8	0.73	0.77
Gr. la.	7	15.25	7	0.73	0.77
Fe. ap.	15	13.0	12	0.63	0.65
Fi. co.	6	12.75	6	0.61	0.64
Bo. an.	5	12.5	5	0.60	0.63
Co. gr.	6	12.00	6	0.58	0.60
Co. af.	4	11.75	2	0.56	0.59
Tr. or.	5	11.75	4	0.56	0.59
Pa. br.	4	11.50	4	0.55	0.58
Ga. so.	15	11.25	15	0.54	0.56
Fi. gl.	3	11.00	3	0.53	0.55
Ac. ch.	11	9.75	11	0.47	0.49
Br. fe.	6	8.75	5	0.42	0.44
Co. ni.	6	8.75	6	0.42	0.44
La. mi.	3	8.00	3	0.38	0.40
Hi. af.	11	8.0	8	0.38	0.40

Appendix 8—*Continued*

Species	Number of Individuals	ΣI	Number of Intervals	Dominance	Relative Dominance
Pa. pi.	2	7.5	1	0.36	0.38
Bo. co.	5	7.0	5	0.34	0.35
Al. co.	6	6.75	4	0.32	0.34
Ix. ra.	3	6.0	2	0.29	0.30
Op. ce.	2	5.25	2	0.25	0.26
Ra. su.	5	5.0	1	0.24	0.25
Te. mo.	5	4.75	4	0.23	0.24
Xe. st.	2	4.5	2	0.22	0.23
Ve. he.	2	4.25	2	0.20	0.21
An. le.	1	4.0	1	0.19	0.20
Co. gl.	3	4.0	2	0.19	0.20
Di. gu.	2	4.0	2	0.19	0.20
Pt. sa.	1	4.0	1	0.19	0.20
Gy. am.	5	3.75	5	0.18	0.19
Ma. mu.	1	3.50	1	0.17	0.18
Ve. co.	2	3.5	2	0.17	0.18
He. mo.	3	3.0	3	0.14	0.15
St. ku.	5	3.0	3	0.14	0.15
Ce. in.	2	2.75	2	0.13	0.14
As. pa.	2	2.5	2	0.12	0.13
Fi. su.	2	2.5	1	0.12	0.13
Ga. li.	2	2.5	1	0.12	0.13
Fi. sy.	2	2.25	2	0.11	0.11
Bo. sa.	3	2	3	0.10	0.10
Fi. ab.	1	2.0	1	0.10	0.10
Le. ha.	2	2.0	2	0.10	0.10
Lepi. se.	1	1.75	1	0.08	0.09
Co. la.	1	1.25	1	0.06	0.06
Lept. se.	1	1.25	1	0.06	0.06
Ba. mu.	1	0.75	1	0.04	0.04
Cr. sa.	2	0.75	1	0.04	0.04
Eu.	1	0.75	1	0.04	0.04
Zi. mu.	1	0.75	1	0.04	0.04
Lop. la.	1	0.50	1	0.02	0.03
So. da.	1	0.5	1	0.02	0.03

Appendix 8—*Continued*

Species	Number of Individuals	ΣI	Number of Intervals	Dominance	Relative Dominance
Di. ci.	1	0.25	1	0.01	0.01
Eu. su.	1	0.25	1	0.01	0.01
Totals	966	1991.75		95.70	

APPENDIX 9

Research Permits

**MINISTRE DES ENSEIGNEMENTS
SECONDAIRE SUPERIEUR ET DE
LA RECHERCHE SCIENTIFIQUE**

**CENTRE NATIONAL DE LA RECHERCHE
SCIENTIFIQUE ET TECHNOLOGIQUE**

REPUBLIQUE DU MALI
Un Peuple - Un But - Une Foi

M C
Centre National de
Recherche Scientifique
et Technologique

AUTORISATION DE RECHERCHE N°69/CNRST/99

Le Directeur Général du Centre National de la Recherche Scientifique et Technologique (CNRST) Autorise : Monsieur,

Nom : DUVALL

Prénoms : Christopher Shane

Nationalité : Américaine

Adresse au Mali : B.P.19, Manantali

Adresse à l'étranger : 334 A 32nd Ave. San Francisco, CA 94121, USA

A effectuer des recherches dans (la) les régions de : Kayes

Cercle (s) de : Bafoulabé, Kéniéba et Kita

En compagnie de : seul

Du : 1^{er} /09/99 Au : 17/12/99

**Adresse de l'organisme dont relève le chercheur : San José State University,
USA**

Prénoms et Nom du chercheur principal :

Correspondant Scientifique au Mali : Bourama NIAGATE, DNAER

Domaine de Recherche : Flore Forestière de la Forêt sèche soudanaise

**Thème et titre du projet : Etat de conservation de l'arbre Gilletiodendron
Glandulosum.**

Objectif du projet : L'état de la conservation de cet arbre

Source (s) de Financement : San José State University

NB : Pour la délivrance de l'autorisation de recherche , l'intéressé(e) doit déposer au CNRST un dossier comprenant :

- un avant - projet ou un projet de recherche
- une demande d'autorisation de recherche timbrée à 100 f
- une attestation d'institution malienne d'attache
- 3 photos d'identité.

Bamako, le 6 Septembre 1999
Le Directeur Général

Dr. M. DIALLO IAM

ENGAGEMENT

La délivrance de l'autorisation de recherche implique impérativement pour le chercheur :

1. Avant de sortir du territoire national malien, le dépôt d'un RAPPORT PRELIMINAIRE d'au moins trois (3) pages au CNRST.

Ce rapport doit contenir les matériaux de recherche, la méthodologie utilisée, les problèmes rencontrés, les perspectives et les suggestions. Tout rapport insuffisant sera cause de non renouvellement de l'autorisation de recherche.

2. La remise au CNRST dans les meilleurs délais de :

- Deux exemplaires du rapport définitif détaillé ;
- Deux exemplaires de tout document publié sur la recherche effectuée.

3. Dans le cas des recherches Archéologiques et Minières, le chercheur s'engage à ne sortir du territoire malien aucun matériel archéologique et minier sans autorisation expresse de l'autorité compétente sous peine de s'exposer à des poursuites.

Tout chercheur qui ne respecterait pas le présent engagement ne sera plus autorisé à effectuer des recherches au Mali.

AMPLIATIONS :

- CNRST _____	2
- Dtion Nat. de la Sûreté _____	1
- Dtion Nat. Adm. Territoriale _____	1
- Inst. Malienne d'attache _____	1
- Intéressé (e) _____	1

LU ET APPROUVE

BAMAKO, LE 30/08/99

LE CHERCHEUR

U. Delle...

MINISTERE DE L'ENVIRONNEMENT

DIRECTION NATIONALE DE LA
CONSERVATION DE LA NATURE

REPUBLIQUE DU MALI
UN PEUPLE - UN BUT - UNE FOI

1159

ATTESTATION DE RECHERCHE

Je soussigné le Directeur National de la Conservation de la Nature, atteste que Monsieur Chris DUVALL de « San José State University aux Etats Unis » est autorisé à faire des recherches sur l'espèce végétale le *Gilletiodendron glandulosum* dans la Région de Kayes (Kita, Bafoulabé, Kénieba).

L'intéressé est tenu de signaler sa présence aux Services et Antennes de la Conservation de la Nature de la zone de recherche qui l'assisteront au besoin dans ses déplacements et contacts avec les communautés.

Il remettra également en fin de recherche un résumé des résultats obtenus.

En foi de quoi, la présente attestation lui est délivrée pour servir et valoir ce que de droit.

Ampliations :

Intéressé.....1
DRCN/ Kayes.....1
SCN- Bafoulabé - Kita - Kénieba.....1
DAFPR - DNCN.....1
Arch/Chrono.....1/5

Bamako, le 31 Août 1999

P/ Le Directeur National / PO
L'Adjoint

Hamid AG Mohamed LAMINE
Ingénieur des Eaux et Forêts

San José State
UNIVERSITY

**Office of the Academic
Vice President**

**Associate Vice President
Graduate Studies and Research**

One Washington Square
San Jose, CA 95192-1025
Voice: (408) 924-2480
Fax: (408) 924-2477
E-mail: gstudres@ward.sjsu.edu
http://www.sjsu.edu

TO: Chris Duvall
334 A 32nd Ave.
San Francisco, CA 94121

FROM: Nabil Ibrahim,
AVP, Graduate Studies & Research

DATE: May 22, 2000

The Human Subjects-Institutional Review Board has approved
your request to use human subjects in the study entitled:

**"Conservation of the Tree Gilletiodendron
Glandulosum in Mali, West Africa"**

This approval is contingent upon the subjects participating in your research project being appropriately protected from risk. This includes the protection of the anonymity of the subjects' identity when they participate in your research project, and with regard to any and all data that may be collected from the subjects. The Board's approval includes continued monitoring of your research by the Board to assure that the subjects are being adequately and properly protected from such risks. If at any time a subject becomes injured or complains of injury, you must notify Nabil Ibrahim, Ph.D., immediately. Injury includes but is not limited to bodily harm, psychological trauma and release of potentially damaging personal information.

Please also be advised that all subjects need to be fully informed and aware that their participation in your research project is voluntary, and that he or she may withdraw from the project at any time. Further, a subject's participation, refusal to participate, or withdrawal will not affect any services the subject is receiving or will receive at the institution in which the research is being conducted.

If you have any questions, please contact me at
(408) 924-2480.

The California State University:
Chancellor's Office
Bakersfield Chico Dominguez Hills
Fresno Fullerton Hayward Humboldt
Long Beach Los Angeles Maritime Academy
Monterey Bay Northridge Pomona
Sacramento San Bernardino San Diego
San Francisco San Jose San Luis Obispo
San Marcos Sonoma Stanislaus