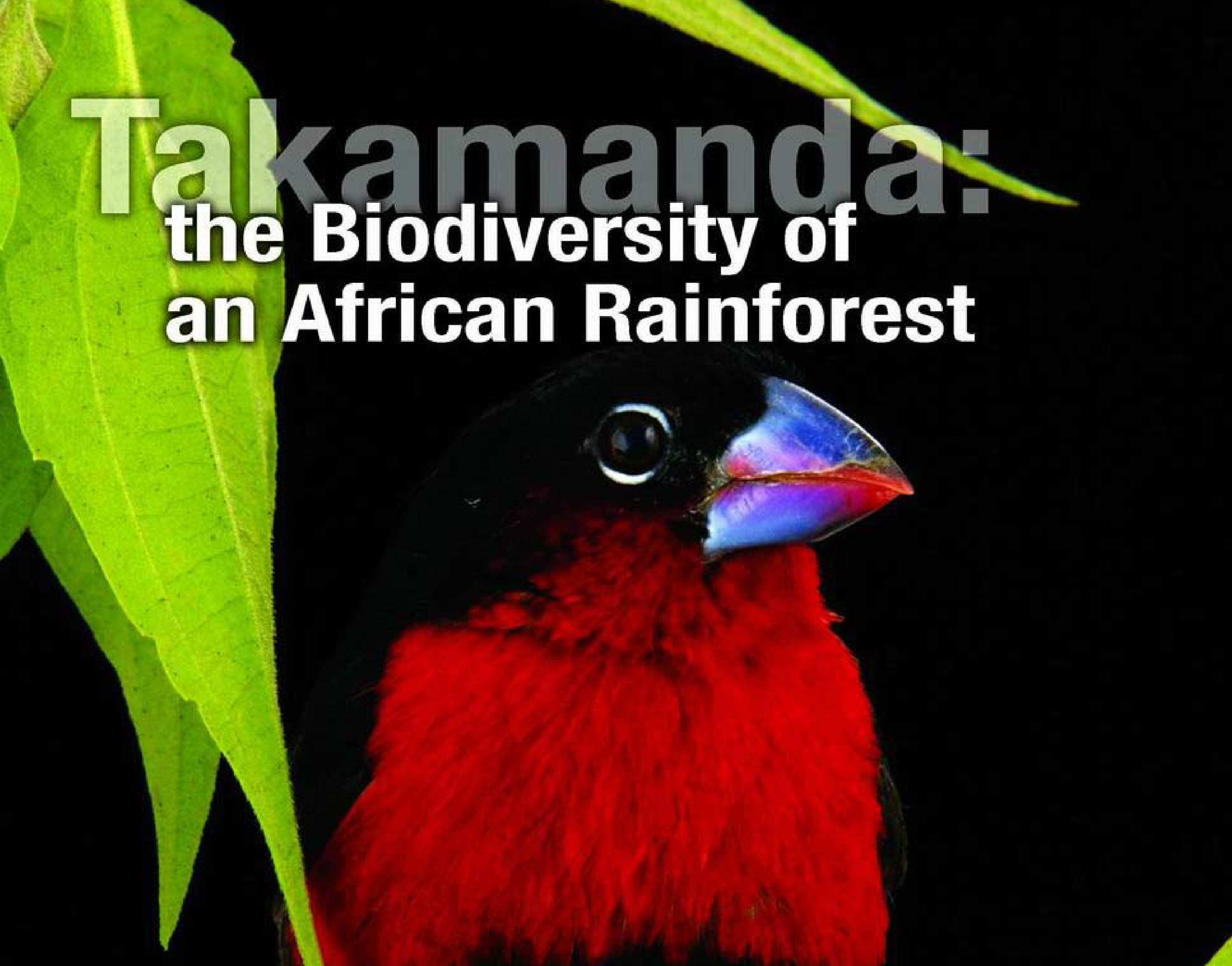
Takamanda: the Biodiversity of an African Rainforest



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Preface

The Smithsonian Institution has long been aware of the importance of southwestern Cameroon to global biodiversity and as a storehouse of resources with potentially significant value to humankind. In the 1990s, scientists from the Division of Experimental Therapeutics at Walter Reed Army Institute of Research and the Bioresources Development and Conservation Programme approached the Smithsonian with an offer to join research in Nigeria and Cameroon aimed at using development of pharmaceutical drugs to catalyze conservation of biodiversity. Out of those initial discussions, the International Cooperative Biodiversity Groups for West Africa was formed, based on the belief that the discovery and development of pharmaceuticals and other useful products from natural resources can, under appropriate circumstances, promote sustained economic growth in developing countries and conserve the biological resources from which the products are derived. Priority objectives were to establish and maintain an inventory of species used in traditional medicine; collect, chemically analyze, and test plant samples for potential medicinal development; identify key compounds for the treatment of diseases such as malaria, HIV-AIDS, cancer, cystic fibrosis, and leischmaniasis; establish and maintain research plots for long-term assessment of ecological dynamics in rainforests; conduct economic value assessments of major species in host countries; and train Nigerian and Cameroonian scientists and technicians in the various aspects of plant research and ecology.

For nearly ten years, the Smithonsian and Bioresources Development and Conservation Programme have coordinated biodiversity conservation and training for the International Cooperative Biodiversity Group. The Smithsonian has focused on establishing an extensive network of biodiversity monitoring plots in Nigeria and Cameroon and an intensively researched forest dynamics plot in Korup National Park, Cameroon. The goal is increased understanding of the processes that maintain biodiversity in Central and West African forests.

Smithsonian has conducted detailed forest biodiversity assessments in collaboration with numerous partner organizations to provide baseline information needed to develop regional conservation strategies. We have also provided professional training in plant taxonomy, collection techniques, biodiversity monitoring, data analysis, and environmental leadership for in-country students and natural resource technicians. Our other efforts in the region include support of herbariums, computer facilities, and other components of local infrastructure and capacity. Partners who have joined in the drug screening and resource development aspect of the program include Walter Reed Army Institute of Research, University of Buea (Cameroon), University of Dschang (Cameroon), University of Jos (Nigeria), Pace University (New York), Southern Research Institute (Alabama), the University of Utah, the University of Miami, and Florida State University.

Funding for the overall program stems from the International Cooperative Biodiversity Groups Program, a consortium of the National Institutes of Health, the Biological Sciences Directorate of the National Science Foundation, and the Foreign Agriculture Service of the U.S. Department of Agriculture. Cooperating National Institutes of Health agencies include Fogarty International Center, National Cancer Institute, National Institute of Allergy and Infectious Diseases, National Institute of Mental Health, National Institute on Drug Abuse, and National Heart, Lung, and Blood Institute.

The Takamanda Project was a collaborative, multi-institutional effort to provide an initial series of assessments for selected taxa in this region of southwestern Cameroon and elicit the data needed to form a baseline for future research and conservation. Takamanda Forest Reserve was relatively unexplored until this project. Increasing threats to the long-term survival of both flora and fauna in the Reserve prompted the authors and their respective affiliations to conduct the biodiversity assessments that we report on in this book..

An additional outcome of the Takamanda Project was formal training through courses conducted by the Smithsonian Institution in collaboration with the Bioresources Development and Conservation Program, the International Cooperative Biodiversity Groups, WWF Cameroon, the Wildlife Conservation Society and the US Agency for International Development's Central African Regional Program for the Environment. Continued capacity building was conducted throughout the different field activities.

As an outgrowth of the International Cooperative Biodiversity Groups Program, the Takamanda Project is based on the premise that the discovery and development of products (including pharmaceuticals) from natural resources may well promote sustainable use of those resources and contribute to the economic and social well-being of local communities.

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The editors of this publication extend their gratitude to the many people who assisted in the preparation of this book, particularly those who worked in the field and whose valuable contributions are reflected in the chapters contained within.

Dan Slayback of NASA (formerly of the Peace Corps in Cameroon) was key to the production of maps, far beyond the call of duty.

We thank the many technicians who worked on this project, especially "tree spotters" Anacletus Koufani of the National Herbarium and Bioresources Development Conservation Programme-Cameroon, Maurice Elad of Tropenbos, and Aron Bibout and Paul Owono Nguille of ONADEF. With their expertise, much of this work and that which preceded it was of great value.

Marina Mdaihli and Julius Ayeni of the GTZ-funded project PROFA were instrumental in developing the multi-taxa approach employed throughout the study and were the source of much logistical, financial, and moral support. Thanks also to Raphael Ebot, former Division Chief of Forestry for Manyu Division, for his unstinting support of the study and to the MINEF staff in Mamfe.

The Ministry of Scientific and Technical Research, most notably Mr. John Che, deserves our gratitude for facilitating the procurement of relevant research and export permits.

We are most pleased to recognize Dr. Nouhou Ndam and the staff of Limbe Botanical and Zoological Gardens and its marvelous herbarium for giving us an institutional home. We hope that our work has succeeded in promoting the excellent research facilities of this center.

We appreciate the staff of the Smithsonian MAB Program, most assuredly Tatiana Pacheco for her administrative skills. Thanks also to Patricia Ojeda for her thorough work in verifying species taxonomic nomenclatures, Deanne Kloepfer for reviewing and editing the chapters, and Bryan Hayum for his assistance in formatting the final publication, while Patrick Campbell, Alfonso Alonso, Francisco Dallmeier, Roger Soles, Adam Wilcox, Sandra Rubini, and Geri Philpott provided additional reviews. Carlton Ward Jr. and authors of the chapters are responsible for photographs, while Velvette De Laney expertly executed the insert and cover designs.

Funding for the vegetation assessments, training courses, and current publication was provided by the International Cooperative Biodiversity Group for West and Central Africa. We thank the Bioresources Development and Conservation Programme, and especially Professor Maurice Iwu, for continued support for the Smithsonian Institution's work in Cameroon and Nigeria. Additional funds for training were provided by USAID’s Central African Regional Program for the Environment.

Last but not least, we extend our heartfelt appreciation to all Chiefs, Traditional Council Members, Youth Leaders, and community representatives of the Takamanda Forest Reserve and its environs for their help, hospitality, and significant contributions to this publication. Martin Ashu, Zach Abang, Martin Tiko, Yisa Emmanuel, Jasper Obi, Denis Agbor, Esalo Godwin, and Jackson Aveh deserve special mention, although many others showed dedication in making this publication possible. As the saying goes, "It takes two hands to tie a bundle!"

Takamanda Forest Reserve, Cameroon

Jacqueline L. Sunderland-Groves, Terry C. H. Sunderland,
James A. Comiskey, Julius S. O. Ayeni, and Marina Mdaihli

1 The region

The Republic of Cameroon extends from 2° N to 13° N latitude and between 8° 25' E and 16° 20' W longitude. The country has a total area of 475,440 km² and is bordered by Chad, Nigeria, Congo, Gabon, Equatorial Guinea and a 350-km stretch of the Atlantic Ocean coastline. Takamanda Forest Reserve (TFR) is located in the Southwest Province of Cameroon. The Reserve is part of the Guineo-Congolean forest, which encompasses approximately 2.8 million km² mostly below 600 m, except where Precambrian highlands such as the Jos Plateau of Nigeria and the Cameroon Highlands rise above 1000m (Lawson 1996). The highest point is Mount Cameroon at 4,079 m.

Rainfall in this vast forest varies from 1500 to more than 10,000 mm per year, giving rise to a variety of vegetation floristic regions (White 1983). The region contains 84% of known African primates, 68% of known African passerine birds, and 66% of known African butterflies (Groombridge and Jenkins 2000). For this reason, the Guineo-Congolian rainforest is an important focal point for conservation efforts in Africa.

The Southwest Province and adjacent portions of southeastern Nigeria are rich in biodiversity. Floristically, this area is part of the Hygrophylous Coastal Evergreen Rainforest, which occurs along the Gulf of Biafra. This vegetation sub-unit is associated with high rainfall levels (White 1983) and is part of the Cross-Sanaga-Bioko Coastal Forest ecoregion, an area of 52,000 km² (Olson *et al.* 2001, World Wildlife Fund 2001). The ecoregion is considered an important center of plant diversity because of its probable isolation during the Pleistocene (Davis *et al.* 1994).

Protected areas in the region include Cross River National Park in Nigeria and Korup National Park in Cameroon, as well as an extensive network of forest reserves such as Ejagham and Takamanda (Figure 1).

2 Takamanda Forest Reserve

Takamanda Forest Reserve (05º59’-06º21’N: 09º11-09º30’E), covering 67,599 ha, is situated in the northernmost corner of the Southwest Province, northeast of the extensive Cross River Valley. The Reserve stretches along the eastern border of Nigeria (Figure 2), which forms the north and northwest boundaries of TFR (Gartlan 1989).

Created by decree in 1934, the area was first gazetted as part of a network of forest reserves (production forests) by the British colonial administration in what was then the British Cameroons. Akin with forest policy throughout the British Empire, TFR was initially established to protect watersheds and restrict the expansion of agricultural, but more importantly to conserve areas for future logging. As with all gazetted areas in Cameroon, the Reserve is managed on the national level by the Cameroon Government Forestry Department’s Ministry of Environment and Forests (MINEF) through the Ministry’s Manyu Division Office in Mamfe. The Manyu office is responsible to the Provincial Delegate in Buea.

3 Geomorphology and drainage

Much of the lowland forest area in the southern and central part of the Reserve lies between 100 and 400 m. The terrain is rolling in the lowland areas, but rises sharply to an altitude of 1,500 m in the northern part of the Reserve, where slopes are extremely steep. Small

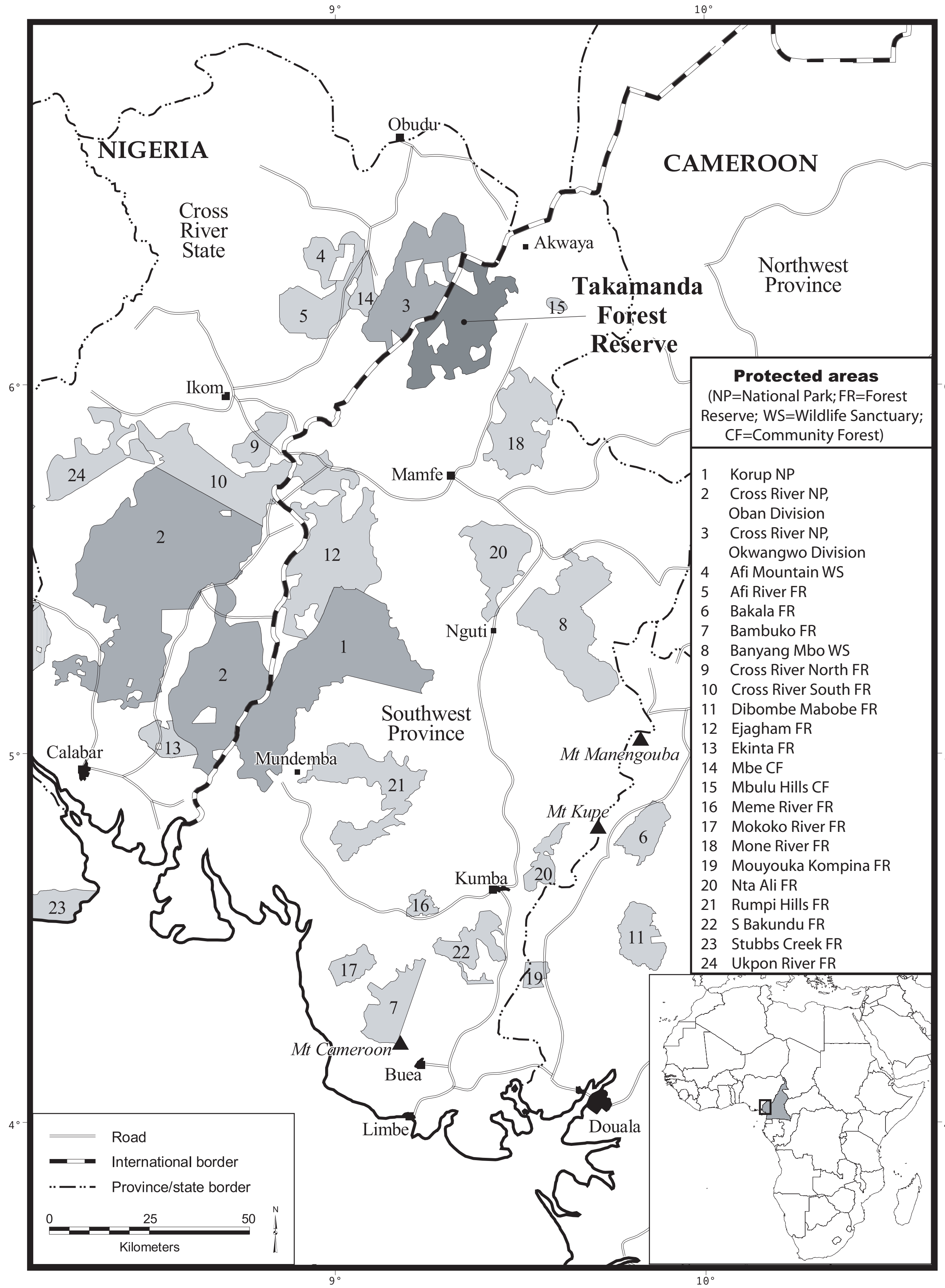

Figure 1. Southwest Province of Cameroon and the associated protected areas.

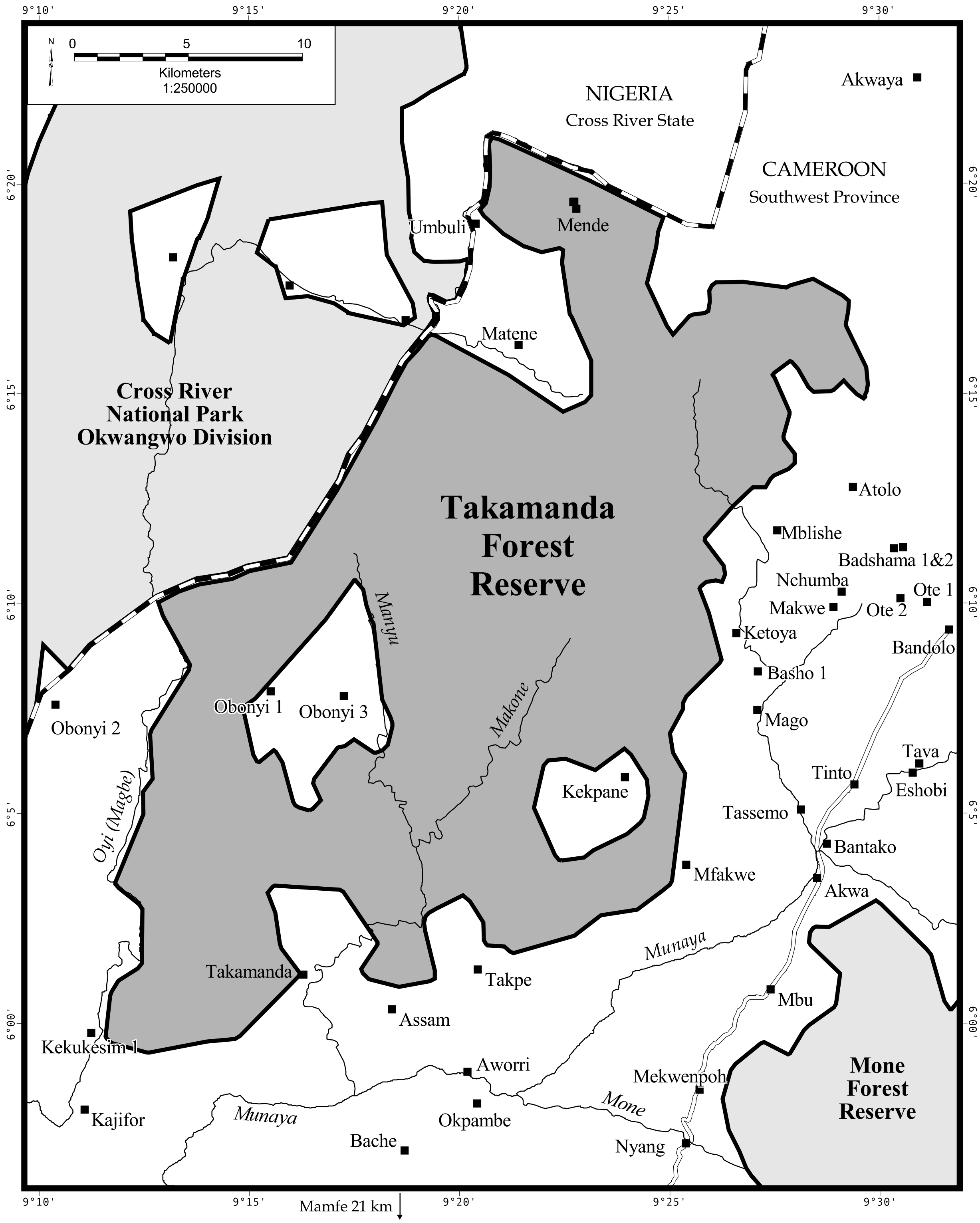

Figure 2. Takamanda Forest Reserve and nearby villages.

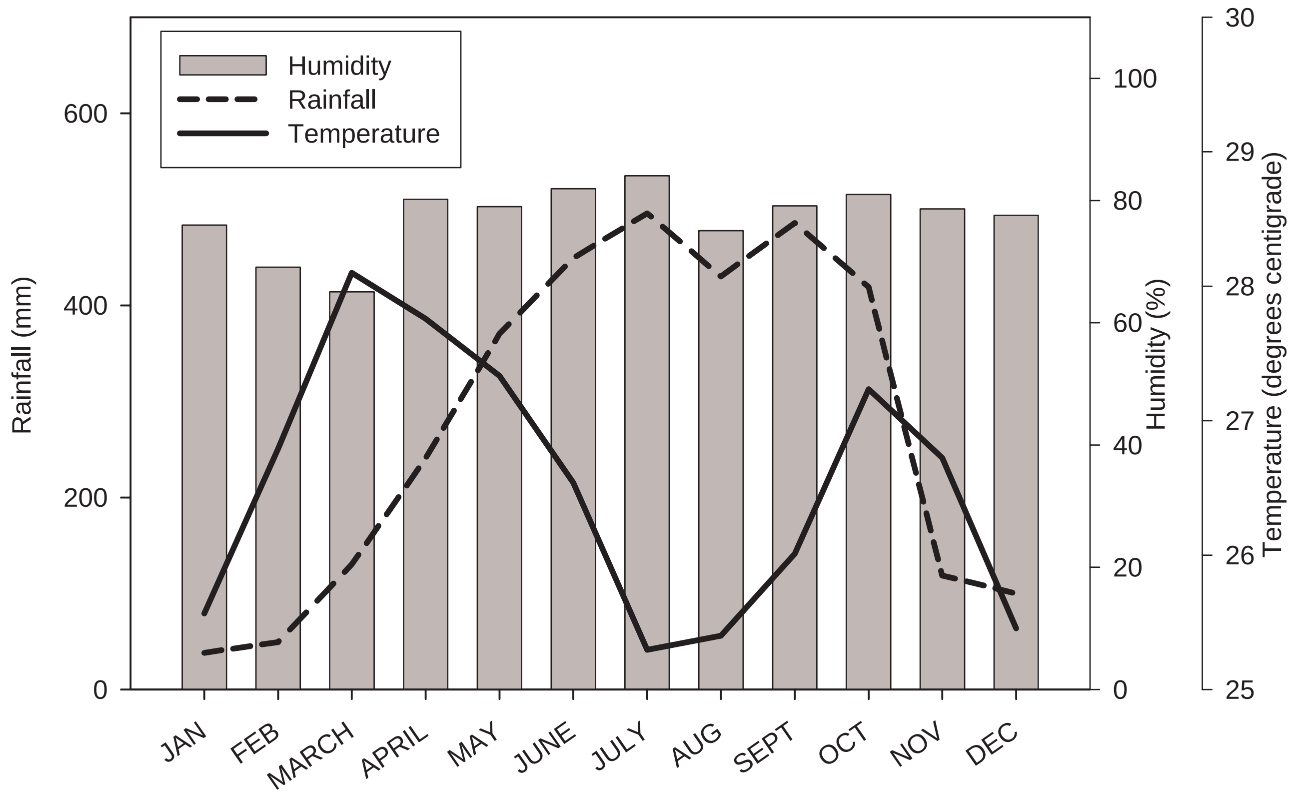

Figure 3. Climatic data for Besong-Abang to the south of Takamanda Forest Reserve, Cameroon

hills, up to 725 m in elevation, lie to the north of the Obonyi villages along the border with Nigeria. The hills separating the villages of Kekpane and Basho are similar in elevation, rising to between 600 and 700 m.

A basement complex of granite, gneisses, schist, and quartzites underlies the region, giving to shallow sedimentary soils (ENPLAN 1974). Marine sediment deposition occurred during the Precambrian, resulting in ferrite derived from crystalline rock and large areas of alluvial soil toward the southern end of the reserve.

The Cross River and its numerous headwater tributaries form the main water system in the region. The general direction of the drainage pattern is from north to south, with two major rivers, the Makone and Magbe, flowing through the Reserve. (The Magbe is called the Oyi on the Nigerian side of the border.) The Makone drains the Matene Highlands and runs southwest through the Reserve to meet the Munaya River. The Magbe flows from Matene through Nigeria and curves back into Takamanda; it represents a portion of the Reserve's western boundary and eventually drains into the Mamfe River.

4 Climate and temperature

The Takamanda area lacks accurate climatological data, which undoubtedly vary due to the elevational gradient that occurs within the reserve. In general, the region has two distinct seasons with most rainfall occurring from April to November, peaking in July and August with a second peak in September (Figure 3). The total annual rainfall is probably similar to that of the Nigerian side of the border in the Okwangwo region—up to 4,500 mm per year (World Wildlife Fund 1990). From November to April, the climate is mainly dry; some months, usually January and February, may receive no rain at all. The mean annual temperature is about 27º C. Normally, it is cooler in the rainy season than in the dry season.

5 Settlement and culture

Three enclaved villages, Kekpane, Obonyi I, and Obonyi III, lie in the Reserve. Five more villages are located along the Reserve's boundary, and there are additional outlying villages. Letouzey (1985) estimated the human population of Takamanda to be between 6 and 12 individuals per km². A more recent survey calculated that the 43 villages within and around TFR, including 12 villages on the Nigerian side of the border, contain 15,707 people (Schmidt-Soltau et al. 2001).

The dominant tribe within the area is Anyang, and the main spoken language is Denya. The majority of villagers, especially those located close to the Nigerian border, also speak or understand the closely-related Boki language, which is spoken on the Nigerian side of the border. Because of ethnic ties, people in Takamanda communities appear to have long-standing affinity with nearby Nigerian villagers.

During gazettement of the Reserve, local poplulations were granted traditional rights to use the forest for their subsistence-based livelihoods. They also have legal right of passage through TFR, and themain travel route is the basis of a strong cross-border trading pattern. Agriculture, hunting, fishing, and the gathering of non-timber forest products are widespread throughout the Reserve (Mdahli *et al.* this volume, Sunderland *et al.* this volume). The main agricultural activities are subsistence farming for maize, plantain, banana, yams, and cassava. Cultivation of these annual crops often extends for some distance from the villages and has resulted in the removal of virtually all the trees in the immediate vicinity of settlements. Further from the villages, less extensive cultivation occurs, notably for oil palm, which is a major export from the Takamanda area. In anticipation of improved road access, cash crops—primarily cocoa and coffee—have recently been introduced to the area.

6 Flora and fauna

Despite identification of the area as a priority for conservation (Gartlan 1989), biodiversity in the Takamanda region was not well known until relatively recently. Early expeditions concentrated on large mammals, particularly gorillas (Sanderson 1940, March 1957, Critchley 1968 Struhsaker, 1967, Thomas 1988, Sunderland-Groves *et al.* this volume). A more comprehensive study of TFR provides significantly more information on the unique fauna of the area (Groves and Maisels 1999, Groves 2002). It is now known that the Reserve and the neighboring Okwangwo region in Nigeria are important areas for many large mammals, including an isolated population of the Cross River gorilla (*Gorilla gorilla diehli*) and the Nigerian chimpanzee (*Pan troglodytes vellerosus*), drill (*Mandrillus leucophaeus*), and Preuss's Guenon (*Cercopithecus preussi*). As well, the forest elephant (*Loxodonta africana cyclotis*) and buffalo (*Syncerus caffer nanus*) are local denizens.

The wider biodiversity of the area, including the vegetation, remained unstudied, although it was speculated that because of the transition from lowland forest to montane savanna, the area would be particularly diverse for all biological taxa (Gartlan 1989). Letouzey (1985) and ONADEF (n.d.) mapped vegetation in the Reserve and the surrounding area as part of a national vegetation survey, providing two broad classification categories. Those studies were based on aerial photographs, however, ground-truthing was not conducted. Subsequent work by Thomas (1988) and Etuge (1998) elicited more details within the wide categories of Letouzey and ONADEF. Still, until the present work (see Sunderland *et al.* this volume), knowledge of TFR vegetation was inadequate.

The present study provides for the first time a comprehensive overview of biodiversity in the Takamanda area using analytical techniques developed by the Smithsonian Institution's Monitoring and Assessment of Biodiversity Program (SI/MAB) within the context of an adaptive management approach for conducting assessments and monitoring of biodiversity. The work was modeled in part on SI/MAB projects in other regions of the world, including Peru and Gabon (Comiskey *et al.* 2000, Dallmeier *et al.* 2002).

7 Conservation issues at Takamanda Forest Reserve

In the past, Takamanda and the surrounding area had largely been protected, more by default than by design, because of its inaccessibility. However, recent human activities such as a logging concession granted in 1995 outside the Reserve and the development of a road from Mamfe to Akwaya (ongoing) have enabled easier access to the area. Subsequently, the export of non-timber forest products, including bushmeat, has increased. With enhanced access, future logging and agricultural expansion, either by the local population or through government concessions, have become major concerns. Without official elevation of the protected status of the Reserve, the forest is open to such activities.

The major threat facing fauna in the Reserve is hunting. Local people have had hunting rights, using traditional methods, since the area was gazetted in 1934, but they were prohibited from using firearms. Thus, most hunting in bygone years was for subsistence. Today, smaller mammals such as duikers are killed through wire traps or snares, while larger mammals, including apes, primates, elephants, and buffalos, are killed with rifles or locally made shotguns ("dane" guns). Almost all hunters in the area own a gun, and with few other options for alternative employment, hunting to provide bushmeat for trade (income) is now common. Meat is consumed locally and exported to Mamfe and Bamenda in Cameroon and across the border to Nigeria in large quantities. As a result, many mammal populations are being depleted at an alarming rate.

One of the most important conservation species in Takamanda is the gorilla. Recently, scientists concluded that the gorillas from this region are geographically and morphologically distinct from other gorillas (Sarmiento and Oates 2000), and they are now recognized as the fourth gorilla sub–species—the Cross River gorilla—and classified as critically endangered (IUCN 2000). Groves *et al.* (this volume) estimated in 2002 that there were approximately 180 Cross River gorillas remaining in TFR and the adjacent forest areas of Mone Forest Reserve and Mbulu, with a total overall population in Cameroon and Nigeria of only about 270 weaned individuals. This total density is considerably less than that of the better known mountain gorilla (*Gorilla gorilla beringei*). In the past, the main threat to survival of the gorilla was hunting. But since 1998, when biological studies began in Takamanda, hunting of apes all but ceased through local community hunting bans. Now by far the greatest threat facing the Cross River gorilla is continued habitat fragmentation. Presently, the Cross River gorillas are restricted to highland areas where the terrain is difficult to access and hunting pressure is thus lower. The gorillas appear to be unwilling or unable to cross large tracts of lowland forest to interact with other groups. The road from Mamfe to Akwaya, under construction, will almost certainly have an effect on any current gorilla movements between Takamanda Forest Reserve and adjacent Mbulu forest, thereby increasing the isolation of Cross River gorilla groups. If lowland forest corridors cannot be secured and if gorillas are deterred from using lowland corridors to reach gorilla groups in other highland sites, inbreeding and loss of genetic variation may imperil these isolated groups.

The forests of Takamanda are also important for a great diversity of birds as recognized by Birdlife International when it designated the Reserve an Important Bird Area. Surveys by Languy and Motombe (this volume) registered 309 species, bringing the total count for TFR to 313 species. Of these, nine species are classified threatened, one endangered, and two vulnerable within IUCN categories. Sixteen additional bird species have restricted ranges—their total world range is less than 50,000 km^2. Two species are new records for Cameroon, while an additional 20 species extend their range within the country (Languy and Motombe this volume).

Reptile diversity is equally impressive. The present study described 81 species in TFR, or about 30% of Cameroon's total (LeBreton *et al.* this volume). An additional three undescribed species were collected during recent visits, and several endemics and regional endemics as well as endangered species have been registered.

Butterflies (111 species, O'Kah this volume) and dragonflies (67 species, Vick this volume) have high levels of diversity. Both groups are important indicators of forest change. Likewise, 54 species of fish were registered, many of which provide an important protein source to local communities (Mdaihli *et al.* this volume).

Flora also proves to be extremely rich with more than 950 species of plants registered over the course of the present surveys. Of these, 351 species were trees with diameters greater than 10 cm (Sunderland *et al.* this volume). All species were registered in the biodiversity plots in the Reserve that will be the basis of long-term monitoring of Takamanda's forest at different elevations.

8 About the Takamanda Project

The Takamanda Project arose from a general interest in the area expressed by numerous government agencies and non-governmental organizations that have been conducting biodiversity assessments in Cameroon and neighboring Nigeria. Large mammal studies focusing on the Cross River gorilla in the Akwaya area, supported by World Wildlife Fund (WWF) and the Wildlife Conservation Society (WCS), were initiated in late 1997 and are continuing. In early 2000, the Smithsonian Institution conducted a training course ("Biodiversity Assessment and Monitoring for Adaptive Management") in Mundemba, Cameroon, where participants expressed their desire to conduct biodiversity assessments in Takamanda Forest Reserve. Follow-up activities led to the current project. The authors of the various chapters coordinated field teams in the Reserve. Primary objectives follow.

- Identify key habitats using cartographic information and remote sensing.
- Describe forest structure, composition, and diversity.
- Determine the current conditions (species composition, frequency of encounters, population densities) of key taxonomic groups, including large mammals, birds, reptiles, and selected arthropods.
- Gather and understand indigenous knowledge on the species and their uses.
- Evaluate fisheries activities.
- Develop land-use change maps.

This volume presents the findings of the surveys, which were conducted by numerous researchers and agencies. It provides an important first step in documenting the impressive biodiversity of an area that has high conservation priority in Cameroon. Our goal is to provide a solid foundation for future conservation and management of Takamanda Forest Reserve and the species that call it their home.

Acknowledgments

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Adaptive Management: A Framework for Biodiversity Conservation in Takamanda Forest Reserve, Cameroon

James A. Comiskey and Francisco Dallmeier

1 Introduction

As the world's human population increases, the threat to biodiversity becomes greater (WRI 2000). The situation is much more pronounced in tropical regions, with sub-Saharan Africa expecting a rise in the current population of 133 million to an estimated 189 million by 2020 and 307 million by 2050. For Cameroon, a country with 18 protected areas covering just over 2 million has, or 4.4% of the country (WRI 2001), the current population of about 15 million is estimated to increase to 20 million by 2020 and 31 million by 2050. The associated increased demand for natural resources is likely to be expressed through land clearance for agriculture and bushmeat hunting at levels far beyond those now experienced in the region. The demand for bushmeat has had the greatest impact on regional biodiversity, resulting in localized species extinctions (Eves *et al.* 2002). Under these circumstances, there is an urgent need to protect and study what biodiversity remains and develop strategies for its conservation.

Southwestern Cameroon and adjacent southeastern Nigeria are known as an important area for biodiversity (Obot and Ogar 1997, Sunderland-Groves *et al.* this volume). The Guineo-Congolian rainforest in the area is unique because of high rainfall levels (White 1983) and the presence of highlands that provide a variety of habitats for flora and fauna. The forests of Takamanda Forest Reserve (TFR), located in the northernmost tip of Cameroon's Southwest Province and ranging from 100 to 1,500 m in elevation, are of particular value (Sunderland-Groves *et al.* this volume) and are regarded as having significant conservation importance (Gartlan 1989). Surveys in the greater region have been conducted in Korup National Park to the south (for example, Rodewald *et al.* 1994, Larsen 1997, Cheek and Stuart 1997), Ejagham Forest Reserve (Sunderland *et al.* 1997), and the Rumpi Hills (Usongo 1995). But until recently, most surveys conducted in the Takamanda area focused primarily on large mammals and apes (Groves and Maisel 1999), and there is little information to develop comprehensive conservation and monitoring strategies for overall biodiversity.

The series of biodiversity assessments in the current volume are an important step in providing baseline information for management of TFR. The Smithsonian Monitoring and Assessment of Biodiversity Program (SI/MAB), in collaboration with the Wildlife Conservation Society, devised the framework for the assessments, and the results confirm that TFR harbors a rich diversity of species, including 15 large mammal species—eight of them primates (Sunderland-Groves and Maisels this volume), more than 950 species of plants (Sunderland *et al.* this volume), 313 bird species (Languy this volume), and 71 species of reptiles (LeBreton and Motombe this volume).

In this paper, we take into consideration the findings and recommendations from the assessments to present an overview of an adaptive management framework, which we propose as a means of implementing conservation and monitoring strategies for Takamanda Forest Reserve. Adaptive management has been employed extensively in the United States (for example, Walters 1986) and recently for conservation projects in Latin America (Dallmeier *et al.* 2002) and Africa (SI/MAB 2002). A more detailed description of adaptive management principles and implementation has been published by Comiskey *et al.* (2000).

2 Challenges Facing Takamanda Forest Reserve

Until recently, the biotic resources of TFR have remained isolated because of the Reserve's remote location. The 1990s, however, saw an increase in the number and activities of logging concessions in the vicinity of TFR. The human population has grown in the region as access has improved to extract timber, with a subsequent increase in the clearance of forest for agriculture (Slayback this volume) and a dramatic rise in the trade of bushmeat (Sunderland-Groves and Maisel this volume). Illegal hunting is of particular concern because of the presence of the endemic and highly threatened Cross River Gorilla in the Reserve and the adjoining highlands of Nigeria (Sunderland-Groves *et al.* this volume). An additional threat is posed by current construction of a road from Mamfe to Akwaya that will further increase access to the area, resulting in additional immigration and hunting. Fragmentation of the landscape as more families build houses and grow their crops is likely to have a negative impact on large mammal species in the area, especially the Cross River Gorilla population that is already isolated in highland areas. Likewise, fragmentation is likely to affect other taxonomic groups including the birds (Languy and Motombe this volume), reptiles (LeBreton *et al.* this volume) as well as the arthropod populations (O'Kah this volume, Vick this volume). Population growth will likely put further strain on the limited resources, resulting in a rise in bushmeat hunting, fisheries (Mdaihli *et al.* this volume), and non-timber forest product use (Sunderland *et al.* this volume).

3 The Adaptive Management Framework

Adaptive management provides a means by which conservation and management practices can be improved through lessons learned. The process assumes that there are uncertainties in management and that different practices can be tested and measured (Elzinga *et al.* 1998, Comiskey *et al.* 2000). Within the adaptive management framework, monitoring of biodiversity provides the information to determine whether practices must be changed to achieve desired outcomes—in the case of TFR, maintaining biodiversity in an optimally functioning state. Human activities can have drastic impacts that may require long and costly investment for recovery of landscapes or species or that may cause irreversible changes such as the loss of species. For these reasons, management to conserve biodiversity can help avoid or mitigate such impacts (Naveh 1994, Freitag *et al.* 1998, van Jaarsveld *et al.* 1998, Poiani *et al.* 2000). This model has proven successful in combination with development projects in the tropical forests of Peru (Dallmeier *et al.* 2002) and Gabon (SI/MAB 2002), helping to minimize the negative impacts of natural resource extraction on biodiversity.

Adaptive management is a cyclical process that involves four major steps, each of which allows for the calibration of goals and objectives through feedback from monitoring (Figure 1). The steps are: (1) determine the monitoring objectives and plan, (2) implement management practices, (3) assess and monitor management practices, and (4) evaluate the results and make appropriate decisions, altering management practices, if necessary. Each step is periodically reviewed to assure that the appropriate information feeds the next level. The cyclical nature of the process is essential to validate the results of each step (Holling 1978, Walters 1986, Comiskey *et al.* 2000).

4 Initial Steps in Takamanda Forest Reserve

Recommendations for conservation and management of Takamanda Forest Reserve require a basic understanding of conservation priorities and, where possible, ecosystem functions. The Takamanda Project, undertaken to provide this information, represented a multidisciplinary, coordinated approach for gathering, analyzing, and disseminating information about TFR and the surrounding area that has been influenced by different land-use activities. The World Wildlife Fund and Wildlife Conservation Society initiated work in the Reserve through a series of surveys to determine the status of the Cross River Gorilla, sub-species with high conservation priority (Sarmiento and Oates 2000). The two organizations sought assistance from the Smithsonian

Institution's Monitoring and Assessment of Biodiversity Program (SI/MAB) to help establish a biodiversity monitoring program and build in-country capacity.

4.1 Consultation and Training

SI/MAB and the Wildlife Conservation Society, in collaboration with the Bioresources Development Conservation Program, consulted stakeholders with an interest in TFR. These included local, national, and international experts and institutions with knowledge about the region (WWF, Birdlife International, Cameroon Ornithology Club, CamHerp, Limbe Botanic Gardens, GTZ) as well as government agencies (MINEF), representatives from the different communities in the area, and national universities. From the outset, most stakeholders expressed a desire to share expertise, costs, and logistical arrangements in conducting assessments and monitoring in the remote TFR.

As part of the International Cooperative Biodiversity Groups funded by the U.S. National Institutes of Health, the Smithsonian Institution and WWF with additiona support from the Central African Regional Program for the Environment conducted a training course on biodiversity assessment and monitoring in Mundemba, Cameroon, in 2000. The participants, all of whom were stakeholders with an interest in conservation in Cameroon, learned about use of the adaptive management framework as a tool for conservation management in their respective projects. Initial plans and consultation for the Takamanda Project were discussed, and several organizations agreed to participate in the project. Training of the field personnel was conducted at the time of the training course and continued during field assessments at TFR.

4.2 Biodiversity Assessments

Multi-stakeholder biodiversity assessments were completed in TFR during 2001 and 2002 in different seasons. A series of protocols and sampling methodologies were developed and used by teams of researchers at different locations. The research sites represented a range of vegetation types and elevations. The protocols helped ensure credible scientific research and analysis, the results of which can be used in making conservation and management recommendations for the area.

The project emphasized the following site-specific objectives:

- Identify key habitats, using cartographic information and remote sensing.
- Describe forest structure, composition, and diversity.
- Determine the current conditions (species composition, frequency of encounters, population densities) of key taxonomic groups, including large mammals, birds, reptiles, and selected arthropod groups.
- Gather and understand indigenous knowledge on the species and their uses.
- Evaluate fisheries activities.
- Develop land use change maps.

Conducting the assessments over dry and rainy seasons allowed the scientists to generate a robust baseline of information about biodiversity in TFR for the long-term monitoring program.

4.3 Information Dissemination

The current publication forms an important first step in determining future activities for TFR. Each institution involved in the Takamanda Project produced a variety of reports for their agencies and funders, as well as the papers published in this book. The consensus among all participants was that TFR is extremely important to biodiversity and that we are only just beginning to gain an understanding of the different ecological components of the area. Nevertheless, TFR remains threatened by many land uses, including road construction that will open the region to increased immigration.

The remainder of this paper proposes adaptive management as a framework to achieve conservation and management goals in TFR and suggests potential next steps to implement such a program.

5 Adaptive Management in Takamanda

Much more baseline information needs to be collected from TFR, but as knowledge of the different taxonomic groups increases, conservation and management recommendations will be developed and adjusted. Design and implementation of conservation efforts that sustain biodiversity at an optimal level are a key goal for stakeholders in the region. Thus, the effectiveness of conservation and management decisions must be closely monitored in the future. There is no land-use or management plan for TFR. Such a plan will comprise the first step to protect and manage the reserve. The plan should describe the resources that are of importance to the area and strategies for their conservation, leading to a monitoring program to ensure the most effective management.

5.1 Monitoring Objectives and Planning

Monitoring within the adaptive management framework involves the collection and analysis of repeated measurements to evaluate progress toward meeting conservation management objectives (Comiskey *et al.* 2000). The initial steps in defining and establishing the monitoring program involve the collection of baseline information that helps to establish conservation priorities, a process that has been initiated in TFR.

Changes in biodiversity have many causes, including (among others) variations in natural population cycles, climatic effects, and direct impacts from human activities, and these are not fully known for the Reserve. Some monitoring activities are already in place at TFR; ten one-hectare biodiversity plots have been established along an altitudinal gradient to evaluate long-term changes in floristic communities (Sunderland *et al.* this volume); monitoring of large mammals and apes—key indicators of general ecosystem health and human activities—is in place (Sunderland-Groves *et al.* this volume); and changes in land use have been monitored using remote sensing over a ten-year interval (Slayback this volume). The other assessments described in this volume will provide the baseline upon which priority taxa can be defined for monitoring and against which future change can be evaluated.

5.1.1 Stakeholder consultation

Further stakeholder participation will help to identify the next steps and priorities based on current knowledge of TFR. Through continued stakeholder workshops and consultations, critical biodiversity issues can be identified, including priority areas for further assessments, indicator species or taxa for monitoring based on current knowledge, potential conservation and management strategies, and resources needed for the next steps. For example, it is known that the population of apes in the region is unique and threatened (Sunderland-Groves *et al.* this volume) and may be flagship species for conservation. Likewise, several important bird species may serve as indicators for monitoring and conservation purposes (Languy and Motombe this volume).

5.1.2 Identify resource needs

An understanding of resource needs is essential to ensure success of the project. Critical resources include time commitment and funding allocated to the project, as well as a sufficient number of trained people to conduct biodiversity assessments, devise monitoring strategies, and improve sampling protocols. These elements must be balanced with professional expertise, adequate technology to manage information and voucher collections, and an appropriate budget for field equipment, data management, and publications. For TFR, resources are a particular challenge because of the remoteness of the region and the difficulty in accessing sites where assessment and monitoring must be conducted.

5.1.3 Capacity building

Continued support for local capacity is definitely needed for the long-term success of monitoring projects. Support and training should focus on developing the capacity of ecologists who are already familiar with the ecosystem types in the Reserve, taxa-specific specialists, skilled

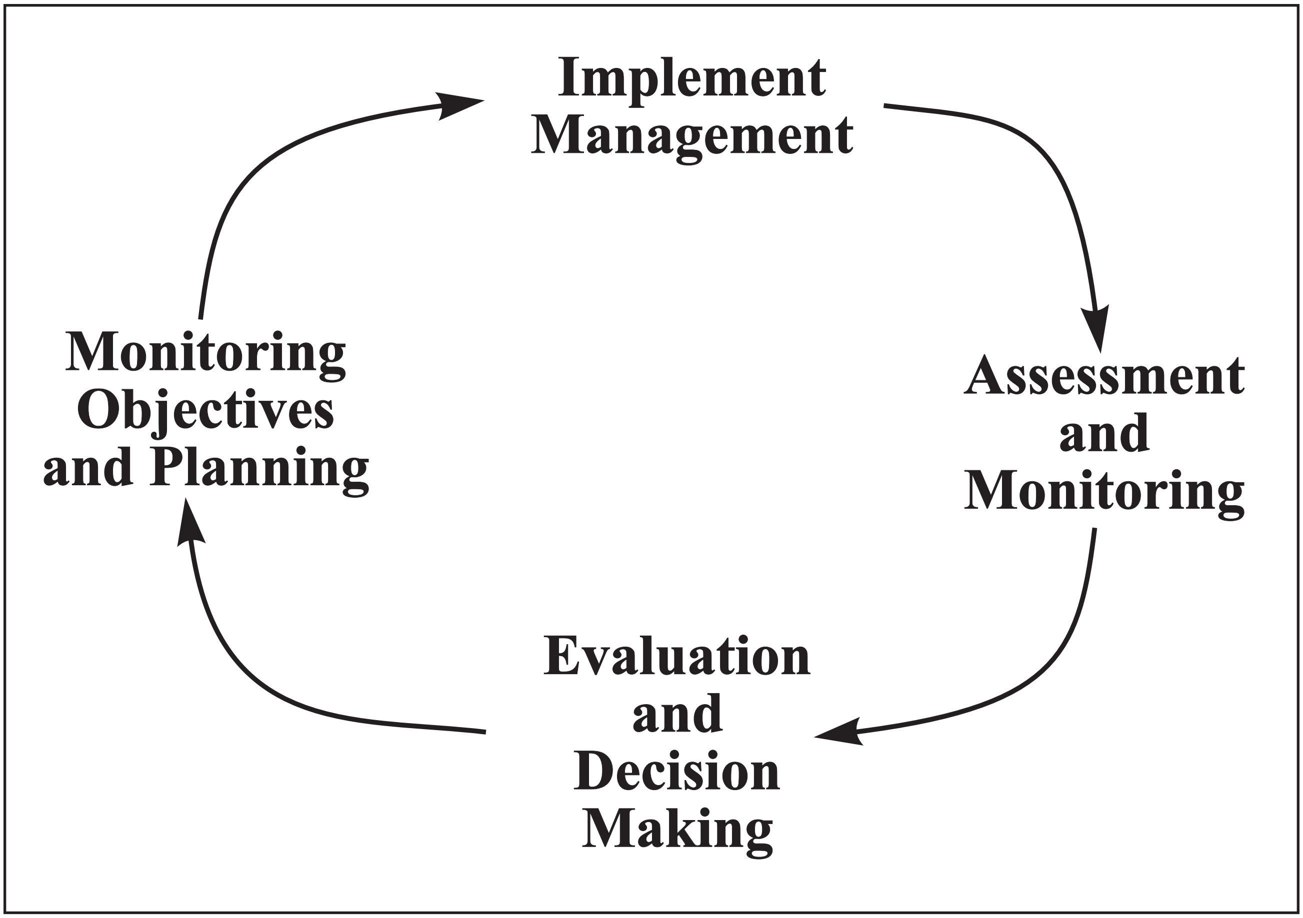

Figure 1. Phases in the adaptive management cycle as a model for Takamanda Forest Reserve, Cameroon.

field technicians who can gather and identify field samples, data managers, and geographic information system (GIS) specialists to compile the information. SI/MAB has found it useful to conduct courses in which participants with an interest in continued training are identified and supported through on-the-ground training during biodiversity assessments. Such candidates can reach a high level of expertise through hands-on experience, and, in some cases, this has facilitated their continued academic and professional careers. Through SI/MAB's vegetation assessments at TFR, three Cameroonian collaborators have furthered their education by completing Masters-level studies at local institutions.

5.1.4 Defining specific management objectives and responses

Once conservation priorities and the potential indicators or species of conservation interest are identified through consultations, the next step is to design a management strategy. For the TFR, the ideal management plan should include clear and specific objectives related to biodiversity—for example, maintaining the population of Cross River Gorillas at current levels. Such objectives provide the base for launching the monitoring program, which should be targeted at meeting the objectives.

A "threshold" level should also be determined, beyond which some form of intervention would be required to ensure the long-term survival of the population(s) being monitored. In the case of the Cross River Gorilla, a threshold population density must be identified at the outset, with the goal of defining the point at which inaction will imperil the population. Where sufficient knowledge of the biology of populations is lacking, it is particularly challenging to determine the proper threshold and identify the appropriate management response. That is why initial assessments and more in-depth studies are so important.

5.2 Implement Management

Implementation of management and subsequent monitoring enables researchers to decide whether they are achieving the desired conservation goals. At TFR, implementing the management plan may prove difficult because of the tenuous legal status of the Reserve and because sufficient personnel and financing are not yet available. Therefore, monitoring should be aimed at providing baseline information that can be used to establish both a legal mandate and a conservation strategy. As an example, current construction of the road between Mamfe and Akwaya is likely to increase immigration into the area with a subsequent increase in land clearance and bushmeat extraction. Monitoring, using remote sensing, can help evaluate the extent and type of land-use changes in the region caused by the road (Slayback this volume), and the amount of habitat fragmentation can be correlated to impacts on species such as large mammals (Sunderland-Groves and Maisel this volume). The information can identify areas of the Reserve that are most at risk and provide the basis for implementing conservation strategies. Market surveys can provide an evaluation of local bushmeat consumption and can be correlated to mammal survey data from the field.

5.3 Assessment and Monitoring

The next stage of the adaptive management process addresses monitoring options to establish potential alternatives for gathering additional knowledge over a shorter period of time. The two most typical kinds of monitoring for this purpose are baseline monitoring and management-based monitoring. Baseline monitoring elicits information to increase understanding of how natural processes operate on biotic components in the study area. In TFR, baseline monitoring has been employed for vegetation along the altitudinal gradient (Sunderland *et al.* this volume). Information obtained over time from the plots add to our knowledge of the dynamics of these habitat types and constitute the baseline for making management recommendations related to forest resources in the Reserve and other forests of the region.

In the adaptive management process, monitoring is also linked to the implementation of some form of management, providing information on whether management practices are achieving the desired outcome and, if not, pointing to needed changes in the management approach. At TFR, information from monitoring through remote sensing of the road construction could well be used to evaluate land-use changes. Monitoring of large mammal populations, as well as market surveys, will indicate the degree to which increased access for bushmeat hunting caused by the road is impacting those populations.

5.3.1 Monitoring design

Initial assessments provide a baseline to study long-term changes. Subsequent assessments help researchers evaluate changes that can be related to ecosystem health. Nevertheless, it is important to bear in mind that ecosystems are extremely complex entities, primarily because of numerous ecological interactions among different biotic and edaphic variables in space and across time (for example, Diamond and Case 1986). A challenge for any monitoring program is to distinguish the changes that are inherent in the natural population—the noise—from those that are influenced by external factors—the signal. In monitoring, we compare the results over time to those gleaned from baseline monitoring to detect whether change is an actual "signal" or merely "noise."

Monitoring protocols should take into consideration sampling design, data management and analysis, interpretation of results, and reporting mechanisms. Objectives must specify the limits of change permitted before management action must be taken, and each objective must be realistic, specific, and measurable. For example, qualitative monitoring (habitat condition) is quicker and less expensive to conduct than quantitative monitoring (estimates of the frequency and abundance of a species). However, qualitative monitoring is often more variable because of the differences among observers. This has important implications—not only in distinguishing real changes from those caused by sampling variability but also for management actions.

5.3.2 Spatial and temporal scales

Biodiversity assessment and monitoring plans should be carried out at both local and regional scales to provide decision-makers with high-quality data and cost-effective choices. At the spatial scale in TFR, sampling should take into consideration proximity to local communities and variability in habitats along the Reserve's altitudinal gradient. For example, the current vegetation monitoring strategy is focused on natural forest habitats at different elevations (Sunderland *et al.* this volume); future strategies might seek to gather baseline information in areas that are under management by local communities, thus increasing our understanding of human impacts on biodiversity. At the temporal scale, sampling in TFR must take into account the variability in biotic communities during the wet and dry seasons because seasons affect our ability to detect noticeable changes in biodiversity over time.

5.3.3 Sampling design

Sampling strategies can be systematic, random, or stratified, depending on the taxa and sampling objectives. Random sampling, where points have an equal probability of being sampled, was used to conduct general collections of plants in TFR (Sunderland *et al.* this volume). Systematic sampling (employing a grid or transect) was conducted for the mammal and ape surveys (Sunderland-Groves *et al.* this volume). Stratified sampling, which involves the definition of different habitats within the reserve, was used to monitor vegetation (Sunderlant *et al.* this volume) and bird populations (Languy and Motombe this volume). Ultimately, the most appropriate method will stem from the specific objectives defined for the monitoring program.

The number and size of the samples will be determined by the precision required for monitoring. If the monitoring program is attempting to detect a small change, then a large number of samples are needed. It is also necessary to decide whether the samples should be permanent or temporary. Permanent points allow for repeated sampling, although they cost more in time and money to establish. In TFR, the large ape populations are known to have a low density, but accurate estimates are difficult because even during intense survey, only a few sightings have been registered (Sunderland-Groves *et al.* this volume). It will be very difficult to record precise estimates of changes in ape density because current personnel and financial resources are not sufficient to enact the large-scale sampling strategy that is needed. For vegetation, the investment in sampling will be significantly less because the same populations, which are stationary, can be monitored over time (Sunderland *et al.* this volume).

5.3.4 Data collection and management

Data collection entails the measurement and assimilation of information in the field under consistent standards. During assessments conducted to date in TFR, assistants and local guides have been trained specifically for this task. Standard protocols were used to facilitate cross-site comparisons and evaluation in multi-taxa monitoring.

Accurate transfer of data from field data sheets and secure storage of information are required to ensure the availability of credible data for analysis. Managing the datasets includes data entry, verification, validation, archiving, and documentation. To assist in the detection of errors at TFR, the vegetation team used the Biodiveristy Monitoring Database (BioMon), which incorporates validity checks into the process of transferring data from the field forms to the computer (Comiskey and Mosher 1999). In planning the monitoring program, the costs of data management should be included in long-term budgets.

5.4 Evaluation and Decision-making

Evaluation elicits answers to the questions that underly a project's objectives and thus facilitates the process of making recommendations and the calibration of the overall program. Future activities in the Takamanda Project should include an evaluation process whereby the results of biodiversity assessments and monitoring are used to help achieve the project's objectives. The evaluation should consist of a determination of whether the collected data are subject to appropriate techniques for data management and analysis and if the data gathered can be coupled with new technologies for analysis and management.

Such an evaluation will enable team members to identify those mechanisms that work best in the timely transfer of data and information for conservation decisions. Alternatives should be devised if it is determined that the monitoring is not providing the necessary information to evaluate management actions. Likewise, if management is not having the desired outcome, other options must be explored. Ultimately, we must remember that the adaptive management process can help ensure the overall objective to maintain biodiversity at Takamanda Forest Reserve in an optimal state.

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Vegetation Assessment of Takamanda Forest Reserve, Cameroon

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1 Introduction

Aside from South Africa, Cameroon is the most biologically rich country known to date on the African continent (IUCN 1986). It encompasses an intricate mosaic of diverse habitats, with moist, tropical forest dominating in the south and southeast and covering 54% of the country (WCMC 1994), montane forest and alpine savannah in the highlands, and sub-sahelian savannah and near desert in the far north (Letouzey 1968 and 1985, White 1983). These diverse habitats harbor more than 9,000 species of plants, 160 of which are endemic (WCMC 1994). The majority of the endemic taxa are concentrated around Mount Cameroon and other highland areas.

The forests of the cross-border region between Cameroon and Nigeria are also extraordinarily diverse, with a high degree of endemism (Davis *et al.* 1994). This area, where forest types are heavily influenced by drainage patterns and topographical features, is the last refuge in Cameroon for the Cross River gorilla (*Gorilla gorilla deihli*; Sunderland-Groves *et al.* this volume). Compared to other forests in the Guineo-Congolian region, Cross River border forests are floristically diverse, with forest formations in Takamanda Forest Reserve (TFR) representing much of this diversity.

This paper presents the findings of a vegetation study conducted in TFR between September 2000 and July 2001. For a more complete description of the Reserve, see Sunderland-Groves *et al.* (this volume).

1.1 Vegetation Surveys

Botanical expeditions have been conducted in the larger study area since the 1920s when numerous collections were made in the Obudu Plateau of Nigeria, which forms the western extension of the Bamenda Highlands of Cameroon (Hall and Medler 1975). Keay (1979) provides descriptions of habitats identified during a botanical expedition conducted in 1948. On the Cameroon side, attention has focused on the mountainous region, especially Mount Cameroon (for example, Cable and Cheek 1998, Hall 1973, Richards 1963a and b). To the west and bordering on Nigeria's Cross River National Park, Korup National Park has been the setting for extensive botanical and ecological work, including quantitative assessments (Newbery and Gartlan 1996), phenology (Newbery *et al.* 1996), and studies of nutrients and mycorrhizae (Gartlan *et al.* 1986, Newbery *et al.* 1988, Newbery *et al.* 1997). A preliminary botanical expedition to Takamanda was conducted by Etuge (1998). Two 1-ha biodiversity plots were established in 1997, the first in Cross River National Park and the second in the Okwangwo Division (Comiskey *et al.* unpublished data).

Recently, the Smithsonian Institution established a forest dynamics plot where all trees with a diameter greater than 1 cm were measured in a 50-ha area in Korup National Park (Schuster *et al.* 1999, Thomas *et al.* 2003, Songwe *et al.* in press). To the north of Korup in the Ejagham Forest Reserve, two 1-hectare biodiversity plots were established in 1997 (Sunderland *et al.* 1997). These plots were remeasured in 2002 and provide the first quantitative information on dynamics of forests in the region (Comiskey and Sunderland unpublished data).

1.2 Takamanda Vegetation Assessment

Until recently, there was a considerable lack of detailed knowledge about vegetative composition in the Takamanda area. As part of the present assessment, a preliminary landuse change and vegetation map was prepared by Slayback and Sunderland (see photo gallery, this volume). This chapter provides comprehensive descriptions of the forest types found in TFR.

The objectives of the vegetation survey were to:

- Elicit baseline information on the structure and composition of the different forested habitat types in TFR.
- Initiate long-term monitoring of vegetation in the area to help better understand the natural dynamics of the different habitat types.
- Build a framework for the assessment of other taxonomic groups.
- Complete a biological baseline to inform elaboration of a management plan for the area.

The current study presents the first comprehensive vegetation survey for Takamanda Forest Reserve. The vegetation assessment we conducted is part of the network of long-term vegetation monitoring sites established in Cameroon and Nigeria through the International Cooperative Biodiversity Groups, a project examining the link between biodiversity and human health and drug discovery. Two long-term biodiversity monitoring plots have been established in the Ejagham Forest Reserve, located south of TFR, and three at the Campo Faunal Reserve in South Province, Cameroon.

3 Methods

3.1 Introduction

The methodology employed for these surveys concentrated on both quantitative and qualitative assessments of vegetative composition. In the former, both permanent 1-ha biodiversity plots (BDPs) were established in conjunction with Modified Whitaker plots (MWPs). Ten 1-ha BDPs and 38 MWPs were established throughout the Reserve (Table 1). In addition to the quantitative vegetation assessment, qualitative surveys were undertaken through textensive collection of voucher specimens.

3.2 Quantitative sampling

The assessment sites were determined from an initial reconnaissance survey of TFR, accompanied by examination of available aerial photographs and the main vegetative components identified (Sunderland 2000). At each site, it was intended that:

- the area should contain species representative of the habitat type;
- the common and/or dominant species should be represented, and
- the plots should be located in each habitat type to provide a "true" representation of the area's diversity.

At each site, one BDP and four MWPs were established, using standard protocols (Figure 1). The protocol for establishing a BDP (100 x 100 m), reported in detail by Dallmeier *et al.* (1992) and Dallmeier and Comiskey (1996), is in use at more than 300 plots in 23 countries (Dallmeier and Comiskey 1998a, 1998b) and provides a unique comparative data set from forested regions throughout the tropics. All trees with a diameter at breast height (dbh; 1.3 m) ≥ 10 cm were measured, tagged, and marked. Where possible, measurements

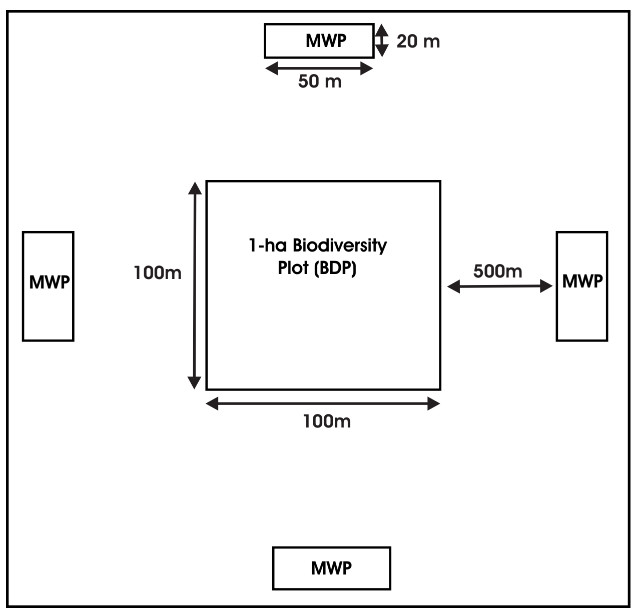


Figure 1. Field arrangement of 1-ha biodiversity plots (BDPs) and modified Whitaker plots (MWPs)

Table 1. Location of plots in Takamanda Forest Reserve, Cameroon. The ten BDPs are numbered from P6 through P15. Plots 1-3 are sited in the Campo Faunal Reserve and plots 4 and 5 in the Ejagham Forest Reserve, Cameroon. MWPs are numbered M1 to M36.

Plot #	Location	Gazeteer	Elevation	Terrain and site description
P6 M1, M2, M3, M4	Basho hills	06°07'818''N; 09°24'776''E	320m	Steep sloping ridges
P7 M5, M6, M7, M8	Basho hills	06°07'871''N; 09°24'589''E	400m	On hillside plateau
P8 M9, M10	Matene to Mendi hills	06°18'349''N; 09°22'396''E	780m	Steep sloping hillside
P9 M11, M12	Mendi hills to Obudu	06°19'400''N; 09°23'474''E	1,200m	Montane gallery forest in grassland
P10, M13, M14, M15, M16	Mboh-Matene	06°11'340''N; 09°20'339''E	210m	Flat plateau in lowland forest
P11 M17, M18, M19, M20	Mboh-Matene	06°11'815''N; 09°20'302''E	210m	Flat plateau in lowland forest
P12 M21, M22, M23, M24	Magbe	06°07'488''N; 09°12'888''E	150m	Riverine forest; flat plateau
P13 M25, M26, M27, M28	Magbe	06°07'885''N; 09°13'109''E	150m	Riverine forest; flat plateau
P14 M29, M30, M31, M32	Takamanda camp	06°03'160''N; 09°16'794''E	120m	Flat plateau in lowland forest
P15 M33, M34, M35, M36	Takamanda camp	06°03'264''N; 09°16'507''E	120m	Flat plateau in lowland forest

avoided protrusions occurring at dbh on the trunk. The height of all individuals was also measured.

Through the inclusion of herbs and other life forms, MWPs provide a more comprehensive overview of forest diversity, composition, and structure than do BDPs, where the focus is trees ≥10cm dbh. To represent as wide a vegetation sample as possible, MWPs were established in a standard formation in close proximity to BDPs. Along each of the four 100-m long sides of each BDP, a MWP was sited perpendicular at a linear distance of 500 m (Figure 1). Hence, each BDP had four "satellite" MWPs sited around it except plots P8 and P9 that were sited in narrow strips of montane gallery forest and where only two MWPs were established.

MWPs, each 0.1-ha (20 x 50 m) in size, are composed of 13 multi-scale, rectangular, nested subplots of proportional dimensions, corrected for slope (Stohlgren 1995). All trees ≥ 10 cm dbh were measured, marked, and identified throughout MWPs. In the center 20 x 5-m 'C' subplot, all trees ≥ 5 cm dbh were measured, marked, and identified. In a similar fashion, all trees ≥ 1 cm dbh were measured in the two 5 x 2-m 'B1' and 'B2' subplots. All individual stems of herbaceous plants were identified and counted, but not marked, in the ten 2 x 0.5-m 'A' subplots.

3.3 Qualitative sampling

Random collections of fertile material were undertaken throughout the Reserve for the duration of the field work, both by professional botanists and villagers trained as parataxonomists to ensure intense local involvement in the data collection process and to help allay suspicions regarding the removal of botanical samples. The local collectors were responsible for the sampling of the majority of the voucher specimens outside the plots (more than 50% of the total specimens), and they contributed significantly to knowledge of the Reserve's flora. The presence of the collectors on a year-round basis also helped in the recording of phenological differences between seasons.

3.4 Identification of plant material

Through the use of professional tree spotters, many of the species encountered on the plots were identified in the field. Voucher specimens were not collected where a consensus was achieved as to identification of a sampled individual (that is, three individuals agree on each field identification). Voucher specimens were collected for specimens that could not be identified in the field. To avoid unnecessary duplication of effort, morphospecies were identified and a single representative voucher collected for each. These vouchers, along with the fertile vouchers collected during the qualitative surveys, were identified at the Limbe Botanic Garden Herbarium. Duplicates have been sent for confirmation to family specialists in herbaria around the world, and it is likely the checklist will continue to be revised as the duplicates are examined. Name changes, authorities, and synonymy were checked using the Missouri Botanical Garden's Tropicos nomenclature database.

3.5 Data analysis

Each assessment site was described based on the species "importance value index" (IVI). Hence, species with the highest IVI are referred to as the most "important" at that site (Comiskey *et al.* 2001). The IVI is calculated as follows:

$$\text{Rel. Density} = \frac{\text{\# of individuals of species}}{\text{\# of individuals of all species}} \text{ x } 100$$

Basal Area (BA) = pi (½ dbh)^2

$$\text{Relative Basal Area} = \frac{\text{BA of species}}{\text{BA all species}} \text{ x } 100$$

Frequency = Number of quadrats in which a species is found

$$\text{Rel. Frequency} = \frac{\text{Frequency of a species}}{\text{Frequency of all species}} \text{ x } 100$$

Cover value index (CVI) = Relative density + Relative dominance.

Importance value index (IVI) = CVI + Relative frequency

The most appropriate measures of diversity to use for 1-ha plots are the Shannon-Weiner index (H') and Fischer's index (α), which have been shown to be more representative of diversity in larger areas. Shannon's index is a measure of uncertainty, providing the probability of picking a dominant species at random:

$$H' = -\sum p_i \ \ln \ p_i$$

where p_i is the proportion of individuals of a species (Relative density of species/100), and ln is the natural logarithm. The maximum value of H' is the natural logarithm of the number of species (ln S). Evenness (E) describes the distribution among species, reaching a value of 1 when all species have equal numbers of individuals. Pielou's evenness is described by the following equation:

$$E = \frac{H'}{\ln S}$$

Fisher's Index (α) is defined by the following equation:

$$S = \alpha \ ln\left(1 + \frac{N}{\alpha}\right)$$

where α was calculated using Biodiversity Professional. Alpha is particularly useful as it enables accurate extrapolation to larger population sizes.

4 Results

4.1 General floristics

The results and discussion in this section are based on analysis of the data gathered during the present study. These data consist of 14,374 individual plant records from TFR that were gathered during the field surveys. In summary, these plant records:

- total 4,628 individual trees ≥ 10cm dbh measured in ten BDPs and representing 351 species, 210 genera, and 58 families. Cumulatively, the trees have a mean dbh of 29 cm and a mean basal area (BA) of 30.8 m^2/ha.

- total 8,885 individuals, representing 442 species, 243 genera, and 75 families recorded from MWPs;

- total 861 voucher specimens representing 612 species, 277 genera, and 91 families.

In all, the 14,374 individual records represent 953 species, 504 genera, and 113 families (Appendix 1).

4.2 Vegetation classification

The plots were locaed in five main habit types. For purposes of this study, these are defined as lowland forest (with a number of sub-types), lowland ridge forest, mid-elevation forest, montane forest, and high-altitude grassland. Table 2 shows general characteristics of each plot.

4.2.1 Lowland forest

Lowland forest covers much of the southern half of TFR and despite some variation, is somewhat homogenous in its structure and composition. A common component of the lowland forests is the family Huaceae, represented by the extremely gregarious *Afrostyrax kamerunensis* that occurs in great abundance (Figure 2). This species is present throughout the forest formations of the entire TFR. The Irvingiaceae is well represented in the lowland forest and exhibits particularly high levels of diversity. Along with *Klainedoxa gabonensis* and *Desbordesia glaucescens*, the genus *Irvingia* is represented by *I. gabonensis*, *I. wombolu*, *I. robur*, *I. Smithii*, and *I. grandifolia*. Other large canopy trees include *Alstonia congensis*, *Blighia welwitchii*, *Canarium schweinfurthii*, *Carapa procera*, *Duboscia macrocarpa*, *Entandrophragma angolense*, *Lophira alata*, *Lovoa trichilioides*, *Ongokea gore*, *Panda oleosa*, *Parkia bicolor*, *Parinari exselsa*, *Pentaclethra macrophylla*, *Pentadesma butyracea*, *Piptandeniastrum africanum*, *Plagiostylea africanum, Pterocarpus soyauxii, Symphonia globulifera,* and *Terminalia invorensis*. To a lesser extent, the Caesalpiniaceae is also represented in the forest canopy,

Table 2. Summary of floristic data for plots in Takamanda Forest Reserve, Cameroon

Site	Plot #	# of trees	# of species	Shannon's Index (H')	Evenness (E)	Fisher's Index	Mean dbh (cm)	Total BA
Lowland ridge forest	6	491	103	3.95	0.85	39.7	30.0	34.7
Lowland ridge forest	7	498	98	3.82	0.83	36.0	32.8	42.1
Lowland rainforest	10	414	90	3.86	0.86	34.8	29.7	28.7
Lowland rainforest	11	428	113	4.01	0.85	50.1	25.4	21.7
Lowland (riverine) rainforest	12	426	93	3.81	0.84	36.1	30.9	32.0
Lowland (riverine) rainforest	13	477	118	4.03	0.84	50.2	29.3	32.1
Lowland rainforest	14	406	83	3.62	0.82	31.0	35.6	40.5
Lowland rainforest	15	438	91	3.89	0.87	33.7	31.1	33.2
Mid-altitude	8	527	64	3.29	0.79	19.1	24.4	24.6
Montane/savanna	9	523	74	3.59	0.84	23.5	21.3	18.6

with species including *Berlinia bracteosa, B. craibiana, Afzelia pachyloba, A. bipindensis, Microberlinia bisulcata, Erythrophloem ivorense, Gilbertiodendron brachystegioides, G. deweveri, Monopetalanthus letestui, M. microphyllus,* and *Brachystegia kennedyi.*

Along with *Afrostyrax kamerunensis*, the family Olacaceae dominates the middle-story of lowland forest with *Strombosia grandiflora, S. pustulata, S. scheffleri,* and *Strombosiopsis tetandra* being particularly abundant. The Ebenaceae are also a common component of the middle-story, particularly the genus Diospyros represented by *D. crassiflora, D. preussii, D. sanzaminika, D. simulans, D. suaveolens,* and *D. zenkeri*. The Celastraceae are also abundant with many species of *Salacia* present. Other abundant species are *Angylocalyx zenkeri, Annickia chlorantha, Anonidium mannii, Polyalthia suaveolens, Calpocalyx dinklagei, Corynanthe pachyceras, Cyrtogonone argentea, Dacryodes igaganga, Dactyladenia mannii, Dialium bipindensis, Discoglypremna caloneura, Garcinia mannii, Grewia coriacea, Homalium dolichophyllum, Hypnodaphnis zenkeri, Isolona hexaloba, Monodora tenuifolia, Pausinystalia macroceras, Plagiostyles africana, Polayalthia suaveolens, Protomegabaria stapfiana, Scottelia mimfiensis, Sorindeia grandifolia, Tabernaemontana crassa, Tapura africana, Treculia obovoidea, Usteria guineensis, Xylopia staudtii,* and the stilt-rooted *Santiria trimera* and *Uapaca guineensis*.

Common small trees in the understory include *Antidesma laciniatum var. laciniatum, Baphia leptobotrys, B. nitida, Dorstenia tubinata, Lasianthera africana, Maesobotrya dusenii, Mareya micrantha, Mareyopsis longifolia, Massularia acuminata, Rinorea dentate,* and *Rothmannia lujae*.

Common herbs in the closed-canopy lowland forest are *Costus englerianus*, *Dracaena camerooniana*, *D. phrynoides*, *Dorstenia mannii*, *D. barteri* var. *multiradiata*, *Mapania amplivaginata*, *Renealmia polypus,* and *Scadoxus cinnabarinus*. The Commelinaceae is also well represented in the herbaceous layer, notably *Aneilmia beninense*, *Palisota ambigua*, *P. barteri*, *P mannii*, *P. capitata,* and *Pollia condensata*. Groups of the crimson rosettes of the parasitic *Thonningia sanguinea* are often seen on the forest floor.

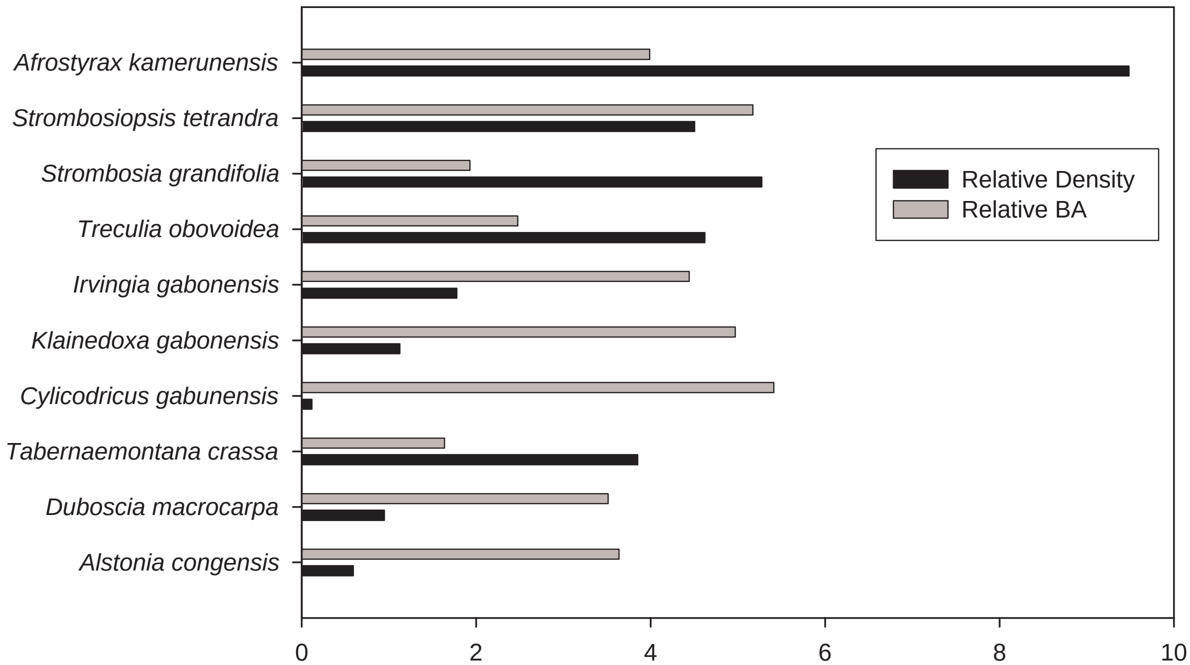
In the lowland forest, additional vegetation sub-types are distinguishable; that is, riverine forest and extensive areas of secondary forest. Two plots were established in the riverine forest, but only qualitative collections were conducted in the secondary forests.

4.2.1.1 Riverine forest

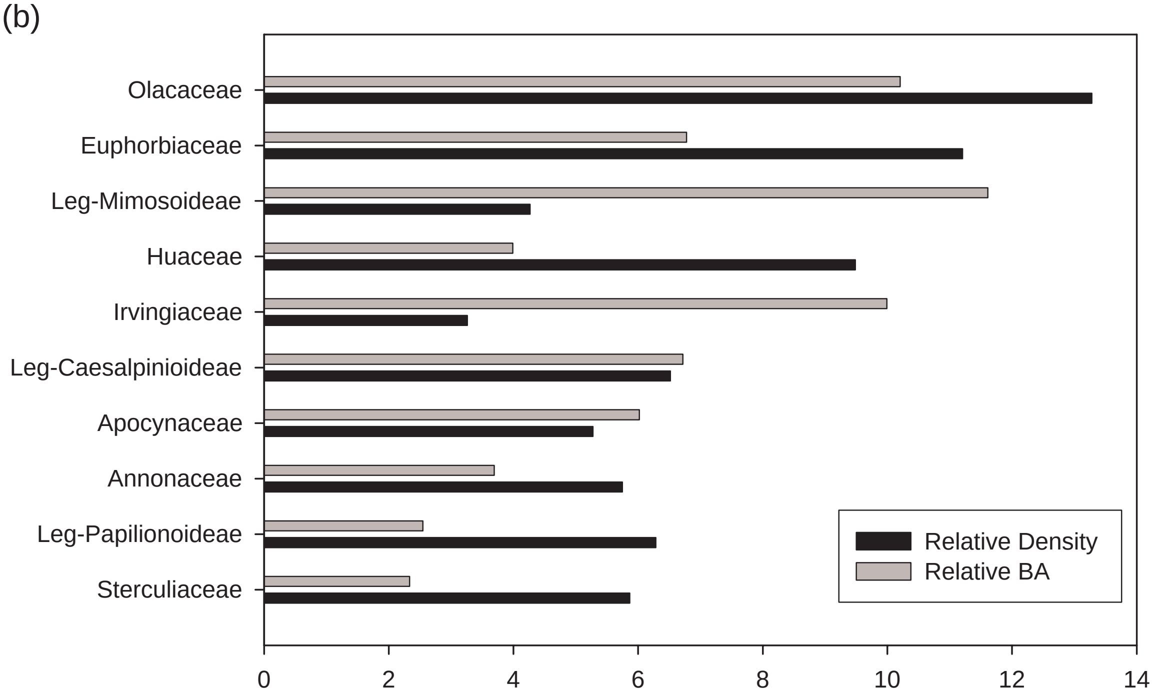
The extensive drainage pattern of the Takamanda region has given rise to large areas of lowland forest heavily influenced by seasonal inundation and periodic flooding. This forest formation is relatively extensive within the

Figure 2. Structure and composition of lowland forest habitat in Takamanda Forest Reserve, Cameroon, from biodiversity plots, showing relative density and relative basal area by (a) species, and (b) family.

(a)



(b)



lowland forest, somewhat distinct in composition from the *terra firma* forest described above, and particularly characteristic of the forests along the Magbe and Oyi rivers. The vegetation is dominated by *Protomegabaria stapfiana* and *Uapaca staudtii* with *Oubangia alata, Aningeria* sp. *Aubrevillea kerstingii*, *Cynomentra sanagaensis, Diogoa zenkeri,* and *Belonophora talbotii* less abundant. Large populations of *Pandanus* and the utilitarian palm *Raphia hookeri* are common where there is seasonal flooding, creating swamp forest. Other monocotyledons such as rattan palms as well as members of the Marantaceae (especially *Aetnidia conferta* and *Sarcophrynium priogonium* var. *priogonium*) and Zingiberaceae (*Aframomum* spp.) are also a common component of this formation.

At the edges of wider rivers such as the Makone, *Kanahia laniflora* (Asclepiadaceae) is commonly seen growing in gravel. Along smaller rocky streams, the forest is often characterized by a rich herbaceous flora, in particular a number of species of *Impatiens* (*I. irvingii,* and *I. namniamensis*) and *Begonia* (*B. ciliobracteata* and *B. quadrialata* subsp. *quadrialata*). The highly seasonal nature of the Takamanda area also means that variations in water levels in many rivers and streams expose extensive rocky areas. Common and persistent colonizers of these oft-flooded rocks in open areas are *Biophytum umbraculum* and in forest streams *Anubias barteri*. Both are found throughout the lowland forest areas of the TFR.

4.2.1.2 Secondary forest

Because agriculture is an important component of survival throughout the TFR area, cultivated areas of annual crops surround villages in and outside the Reserve boundary. Trees are generally removed from cultivated land, although the oil palm (*Elaeis guineensis*) and characteristic *Ceiba pentandra* are regularly found on intensively cropped farmland. Further from villages, other cultivated areas are more commonly cleared on a rotational basis in extensive formations of farm fallow and later secondary forest. Farm fallow contains extensive groves of oil palm, many of which are planted as annual crops along with early colonizers such as *Alchornea floribunda, Musanga cecropioides*, and *Anthocleista vogellii* and dense thickets of Marantaceae (particularly *Marantochloa* spp. and *Thaumatococcus danielii*) and Zingiberaceae (*Aframomum* sp.). Climbers and scandent shrubs such as *Adenia cissampeloides, Clerodendrum splendens, C. umbellatum, Heinsia crinita, Gloriosa superba, Jateorhiza macrantha, Momordica cissoides, Mussaenda tenuifolia, Paullinia pinnata,* and *Smilax anceps* are also common in secondary forest.

Land in the area that is not cultivated for up to 20 years regenerates well and forms dense secondary forest formations that grade easily into closed-canopy forest. This late-secondary forest is characterized by large trees such as *Piptadeniastrum africanum, Ricinodendron heudelotii* subsp. *africanum, Vitex grandifolia, Pycnanthus angolensis* and smaller trees: *Leea guineensis, Milletia barteri, Myrianthus arboreus, Harungana madagascariensis, Barteria fistulosa,Rauvolfia vomitoria, Tabernaemontana crassa,*and *Voacanga bracteata.*

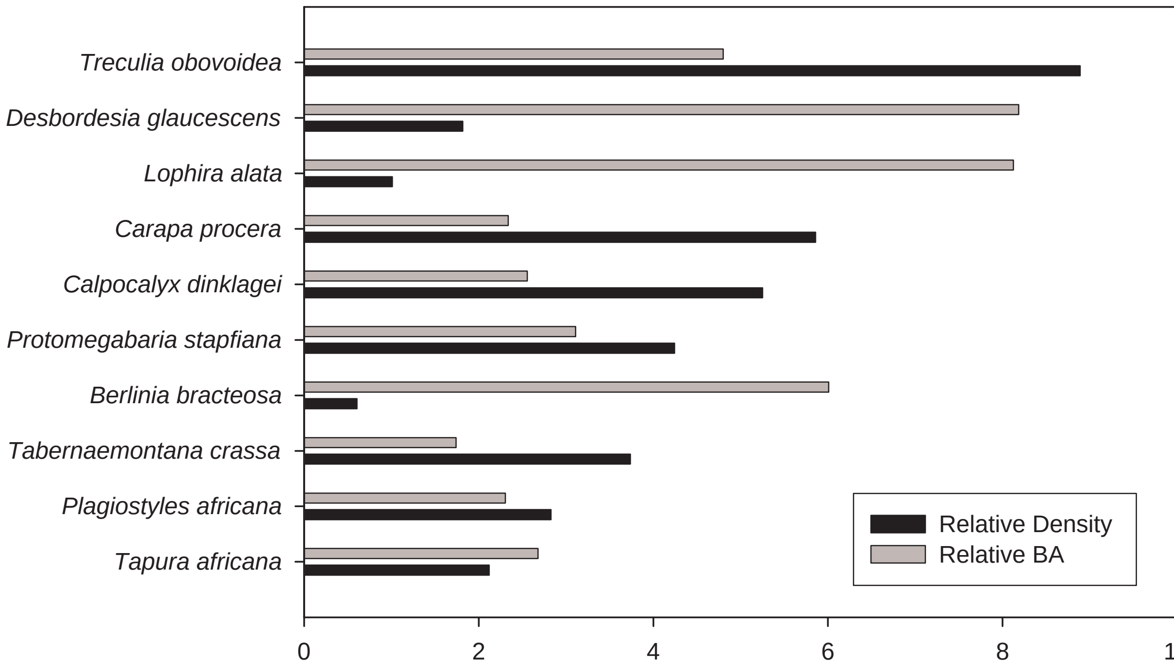
4.2.2 Lowland ridge forest (300-500 m)

As the altitude increases sharply in the north of TFR, long finger-like ridges protrude into the lowland forest. Although they contain many elements of lowland forest flora, these ridges provide gradation from true lowland forest to mid-elevation and montane forest and in some areas are quite distinct in their vegetative composition. The ridge forest formation is particularly prevalent in the Kekpani/Basho hills and to a lesser extent in the higher areas to the north of Obonyi I and to the south of Matene as the lowland expanse gives way to higher land.

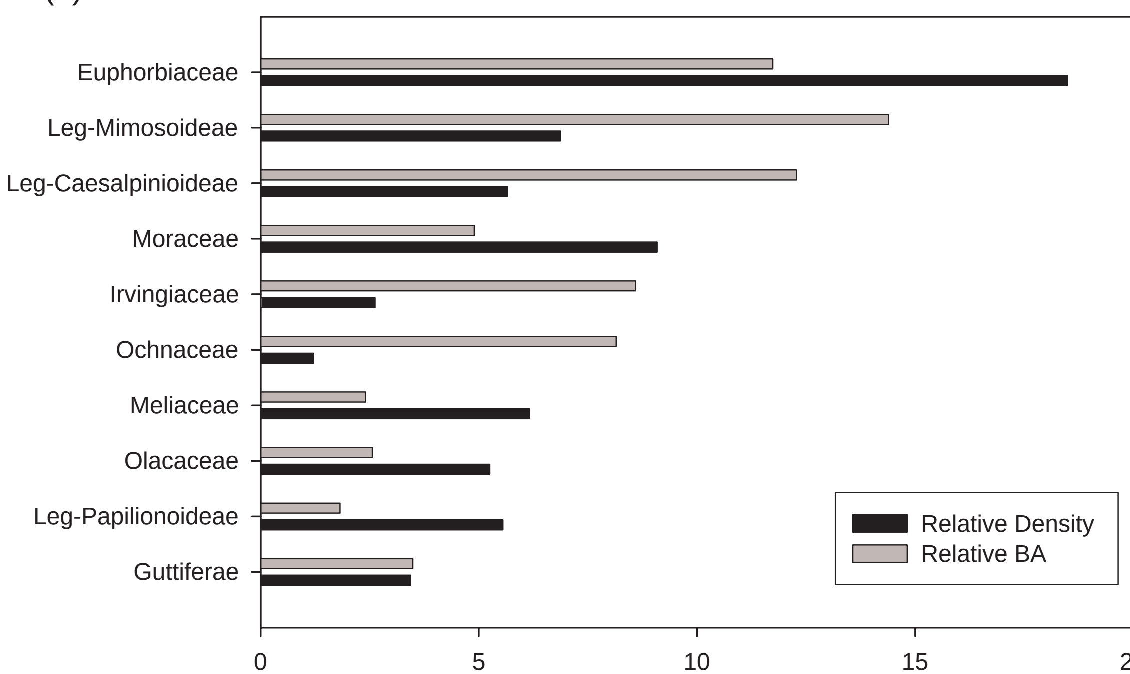
These long ridges are often characterized by stands of even-aged canopy trees (Figure 3), usually *Lophira alata*, *Canarium schweinfurthii*, *Terminalia superba, Nauclea diderichii,* and *Poga oleosa*. The Caesalpiniaceae is better represented in the ridge forest through *Berlinia bracteosa, Afzelia bipindensis, Microberlinia bisulcata,* and *Erythrophloem ivorense*. All of these species are valued as timber, and these ridges probably contain the greatest abundance of merchantable timber in TFR. The abundance of such large individuals, with a correspondingly clear understory, often creates an

Figure 3. Structure and composition of lowland ridge forest habitat in Takamanda Forest Reserve, Cameroon, from biodiversity plots, showing relative density and relative basal area by (a) species, and (b) family.

(a)



(b)



impressive cathedral-like effect. The Myristicaceae is represented by large numbers of *Scyphocephalium mannii* and *Coelocaryon preussii*. Other trees present include *Allanblackia floribunda, Tapura africana, Bielschmiedia obscura, Canthium arnoldianum, Chrysophyllum beguei, C. boukokoensis, Zanthoxylum heitzii*, *Aubrevillea kerstingii, Pseudospondias microcarpa, Camptostylus mannii, Maranthes glabra, Newtonia grandifolia,* and *Dacryodes klaineana.*

The ridge forests are not only species diverse. Their flora is also unique in TFR. In the Kekpani/Basho hills, the following species were not recorded elsewhere during our surveys: *Allophyllus bullatus*, *Anisophyllea polyneura*, *Anopyxis klaineana, Antrocaryon klaineanum, Aulacocalyx talbotii, Camptostylus mannii, Chytranthus mortenhanii, Cola anomala, C. verticillata, C. semecarpophylla,Dialium pachyphyllum, Diospyros cococarpa, D. physocalycina, Drypetes preussii, Lecaniodiscus cupanioides, Leonardoxa africana, Manniophyton fulvum, Maprounea membranacea, Microdesmis zenkeri, Petersianthus africanus, Pterygota macrocarpa, Rhabdophyllum affine, Soyauxia gabonensis, Strychnos asterantha, Trichilia gilgiana, Trilipisium madagascariensis, Uapaca acuminata, Uapaca staudtii,* and *Uvariodendron connivens*

The understory of the ridge forests is relatively open with a notable absence of herbs and smaller shrubs. The genera *Cola* and *Diospyros* dominate this layer, and in many areas *Cola semecarpophylla* form sparse, monospecific stands.

4.2.3 Mid-elevation forest (500-800 m)

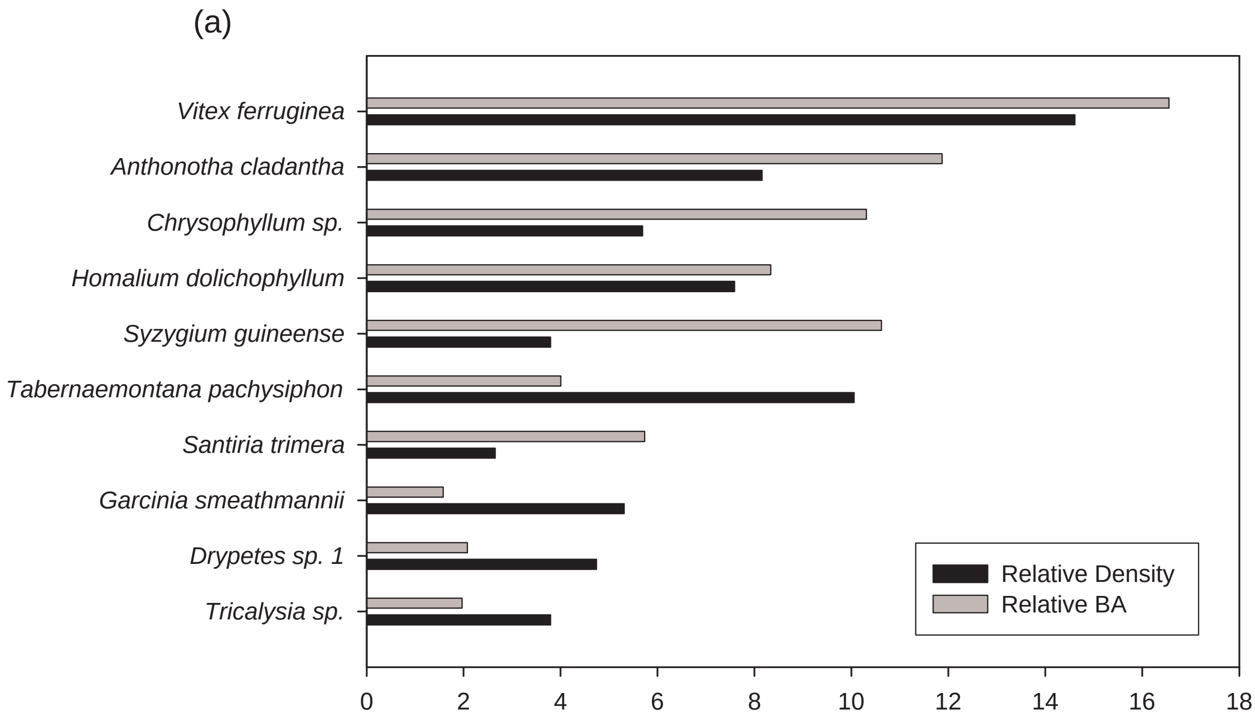
At higher elevations, particularly in the northern part of the Reserve, there is a distinct and perceptible shift in the forest—from strictly lowland forest to mid-elevation and, consequently, montane forest and savannah grassland. The characteristic vegetation of mid-elevation forest is particularly evident in the dramatic alteration in relief from the villages of Matene to Mende, where the forest changes from lowland forest (200 m) to mid-elevation forest (700 m) over a relatively small linear distance.

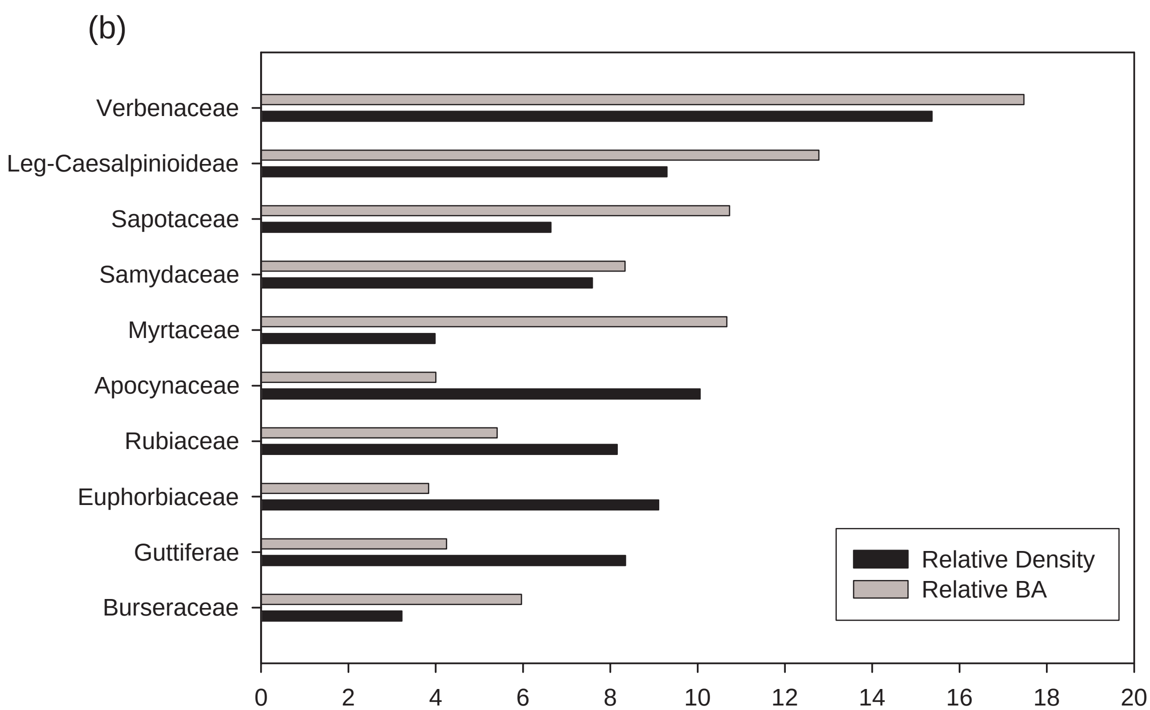
A lower canopy, a denser understory, and an increase of epiphytic flora, particularly Pteridophytes and Orchidaceae, characterize the mid-elevation forest. The tree flora is dominated by of *Vitex doniniana* and *V. ferruginea* (Figure 4), the latter species occurring only in mid-elevation forest. The flora is less diverse than the lowland forest, and the main species include *Anthonotha cladantha, Homalium dolichophyllum, Tabernaemontana pachysiphon, Syzygium guineense, Santiria trimera, Garcinia smeathmannii, Dactyledenia mannii, Allanblackia floribunda, Spondianthus preussii,* and *Xylopia staudtii*. Other species characteristic of this forest formation and not encountered elsewhere in TFR are *Aidia micrantha, Bielschmiedia preussii, Camptostylus mannii, Casearia barteri, Carpolobia lutea, Clausena anisata, Garcinia afzelii, Homalium doligophyllum, Hymenocardia acida, Microdesmis puberula, Ophiobotrys zenkeri, Oricia trifoliolata, Spondianthus sp., Synsepalum msolo, Syzygium guineense,* and *Trichilia heudelotii*.

Not surprisingly, the tree flora of this forest formation contains both lowland and montane elements, including *Strombosia grandifolia*, *Strombosiopsis tetandra, Cola ficifolia, Tabernaemontana pachysiphon, Santiria trimera, Allanblackia floribunda,* and *Garcinia smeathmannii*, which are generally regarded as lowland species, and *Vernonia frondosa, Syzygium guineense, Olea capensis, Psychotria mannii*, and *Schefflera abyssinica*, which are generally found at higher altitudes.

The middle layer of the mid-altitude forest is dominated by *Rinorea dentata, Ixora marcrocarpa,* numerous *Salacia* sp., *Dichranolepis disticha, Campylospermum flavum, C. mannii, C. reticulatum, C. subcordatum, Dichapetalum heudelotii, Idertia axillaris, Massularia acuminata, Ixora nematopoda,* and *Lasianthus batangensis*. The tree fern *Cyathea manniana* also occurs at these altitudes, mostly along streams and ravines. The herbaceous Acanthaceae are well represented (*Acanthus montanus, Crossandrella dusenii*), and many species such as *Brachystephanus nemoralis, Oreocanthus mannii,* and *Brilliantasia owariensis* form dense thickets.

Figure 4. Structure and composition of mid-elevation forest habitat in Takamanda Forest Reserve, Cameroon, from biodiversity plots, showing relative density and relative basal area by (a) species, and (b) family.





Herbaceous flora of this forest formation is particularly diverse and includes *Acanthus montanus, Aframomum pilosum, Marantochloa leucantha, Halopegia azurea, Nephthytis poisonii, Mapania amplivaginata, Impatiens kamerunensis* var. *kamerunensis,* and *Osmunda regalis*, with many species of *Begonia* (*Begonia capillipes, B. ciliobracteata, B. microsperma, B. oxyloba, B. staudtii*).

4.2.4 Montane forest (800-1500 m)

The montane forest formation is characterized by an extremely low and often disjunct canopy, large numbers of trees, a low total basal area, and lower species richness than lowland and mid-elevation forests. The epiphytic flora is also particularly well developed. At their altitudinal limit, these forests tend to be restricted to valley bottoms and water courses where they form distinctive "gallery" forests.

The dominant woody species in the montane forest are *Syzygium guineense* (Figure 5), *Xylopia staudtii, Macaranga occidentalis, Santiria trimera, Harungana madagascariensis, Bridelia micrantha, Anthonotha cladantha, Bridelia grandis, Sapium cornutum, Polyscias fulva,* and *Vernonia conferta*. Other species seemingly restricted to montane forest include *Anthocleista vogelii*, *Barteria nigritiana, Bersama abysinica, Blighia unijugata, Calycosiphonia macroclamys, Craterosiphum montanum, Dactyladenia staudtii, Dracaena arborea, Eugenia spp., Ficus thonningii, F. vogeliana, Hannoa klaineana, Homalium doligophyllum, Hymenocardia acida, Maranthes glabra, Margaritaria discoidea, Olea capensis, Psychotria mannii, P. camptopus, Sapium cornutum, Sapium ellipticum, Schefflera abyssinica, Sericanthe* sp., *Synsepalum brevipes, Trichilia monodelpha*, *Vernonia conferta,* and *Xylopia acutiflora*.

The herbaceous layer is dominated by many members of the Costaceae (particularly *Costus lucanusianus*) and the Zingiberaceae (*Aframomum pilosum* and *A. arundinaceum*) as well as *Dracaena phrynoides*.

4.2.5 High-altitude grassland

This unique vegetation community forms a small part of TFR plant communities and as such does not warrant a detailed discussion for purposes of this chapter. Significant work has been undertaken on vegetation of Obudu Plateau in Nigeria, just across the border, and a number of checklists and vegetation descriptions of this high-altitude grassland have been published (Tuley 1966, Hall and Medler 1975a and b, Medler and Hall 1975, Keay 1979, Chapman and Chapman 2001). The transition zone between montane forest and grassland is comprised of large herbs and woody shrubs such as *A. arundinaceum, Brilliantasia lamium,* and *Dichaetanthera africana*. The bracken *Pteridium aquilinum* subsp. *aquilinum* is also a common component of this transition zone, as is the spectacular *Lobelia columnaris*.

The grassland is composed of a number of gregarious Graminae: *Hyparrhenia diplandra, H. familiaris, H. rufa, H. bracteata, Andropogon auriculatus, Setaria anceps, Monocymbium ceeresiiforme, Loudetia camerunensis, Panicum hochstetteri, Eragrostis tenuifolia,* and *E. cameroonensis*. Colonists include many small herbs and woody shrubs, notably *Ageratum* sp., *Aspilia africana, Bartsia petitiana, Desmodium repandum, Oldenlandia sp. Cyanotis barbata,* and *Kyllinga*. In the small peaty hollows of exposed rocks, the tiny insectivorous *Utricularia mannii* is also relatively common.

5 Discussion

5.1 Montane Forest Zones

As has been observed elsewhere (for example, Morton 1986), Takamanda forests are divided into different vegetation types characterized by elevation and degree of exposure. The upper reaches of Takamanda Forest Reserve give way to grassland at an elevation of 1500 m. Though this comprises a low total area of the reserve, it is interesting to note the low altitude at which it occurs. At Mount Cameroon, the grassland habitat does not start until 2000 m (Richards 1963b), a characteristic observed

Figure 5. Structure and composition of montane forest habitat in Takamanda Forest Reserve, Cameroon, from biodiversity plots, showing relative dentity and relative basal area by (a) species, and (b) family.

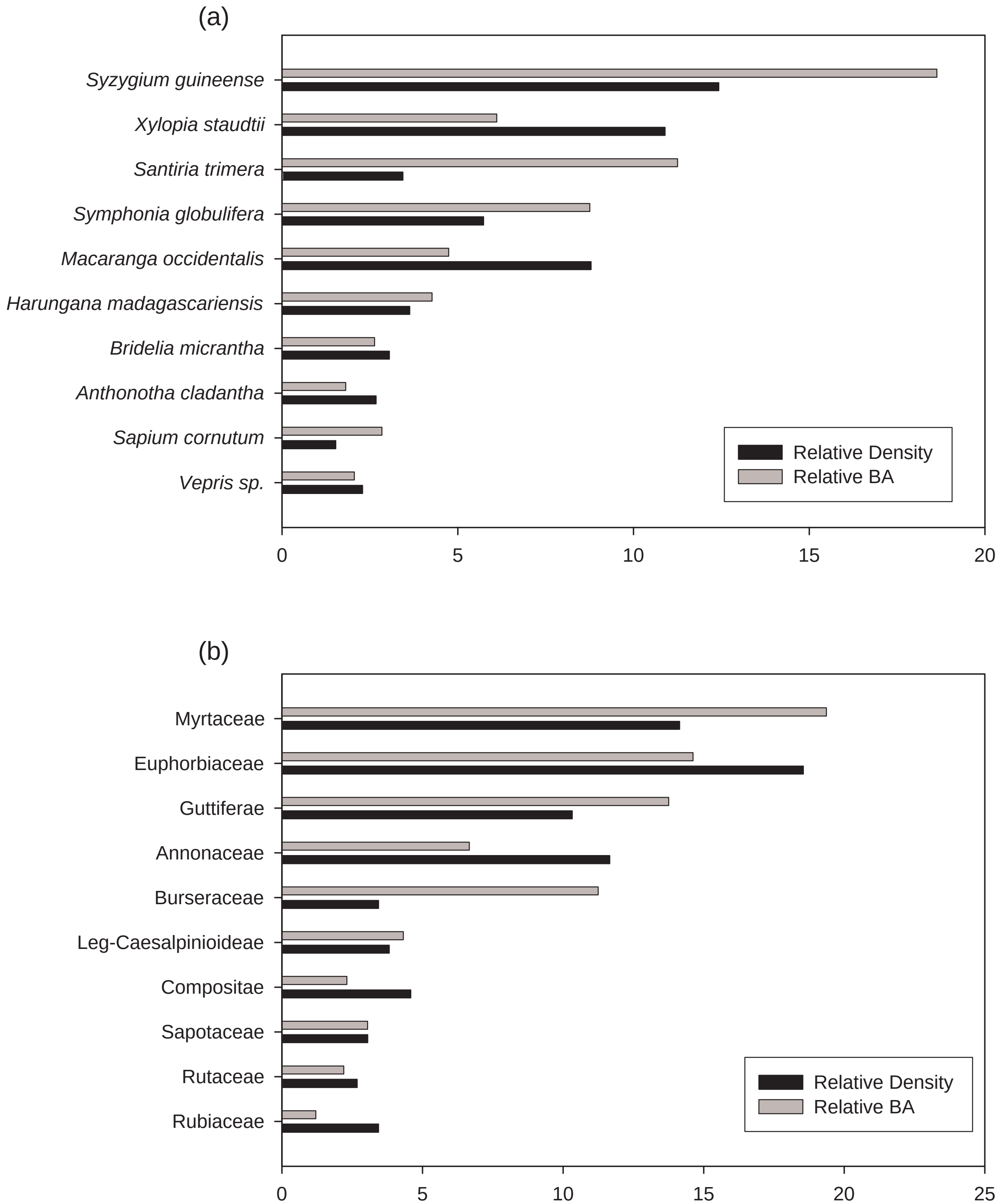


Table 3. Comparison of structure and diversity of Takamanda Forest Reserve biodiversity plots with other biodiversity plots in Cameroon and Nigeria.

	Takamanda									
Plot #	6	7	8	9	10	11	12	13	14	15
# of trees	491	498	527	523	414	428	426	477	406	438
# of species	103	98	64	74	90	113	93	118	83	91
Mean dbh (cm)	30.0	32.2	24.4	21.3	29.7	25.4	30.9	29.3	35.6	31.1
Total BA (m^2/ha)	34.7	42.1	24.6	18.6	28.7	21.7	32.0	32.1	40.5	33.2

	Campo			Ejagham		Akampka	Okwangwo
Plot #	1	2	3	4	5	N2	N3
# of trees	397	402	394	525	526	471	467
# of species	74	81	74	71	80	128	82
Mean dbh (cm)	28.8	30.6	26.0	28.5	27.8	21.2	26.9
Total BA (m^2/ha)	30.8	30.0	35.0	33.2	34.0	16.8	26.5

elsewhere in West Africa's montane forests (Morton 1986). The lower montane forest occurs at higher elevations elsewhere in the region than was observed in Takamanda. Nevertheless, the proximity of the Okwangwo region of Nigeria and the Obudu Plateau means that the two areas are similar in relation to altitudinal zonation of vegetation types (Hall and Medler 1975, Keay 1979).

5.2 Species Richness and Diversity

The forests of southwestern Cameroon are generally known to contain a rich species diversity because of their location in an area of high rainfall. It is also believed that the area formed a Pleistocene refugium during the last glacial advance, becoming isolated and allowing for the development of regional endemic species (Lawson 1996). The forests of Takamanda appear to be even more diverse than those of surrounding areas. The number of species in the lowland forest plots ranged from 83 to 113 species/ha, with the riverine plots containing between 93 and 118 species/ha, and the ridge forests between 98 and 103 species/ha (Table 3). To the south of Takamanda lies the Ejagham Forest Reserve, where richness in biodiversity plots reached 80 species/ha. The 50-ha Smithsonian forest dynamics plot at Korup averaged 86 species greater than 10 cm dbh per ha (Songwe *et al.* in press, Thomas *et al.* 2003). The Nigerian plots had lower species richness values in the Okwangwo region, while the highest species richness of all plots compared to the study area was the Akampka site in the Oban region (128 species/ha).

TFR's relatively high levels of diversity are undoubtedly due to the intricate mosaic of vegetation types and forest formations found along the Reserve's altitudinal gradients. While it is agreed that species richness generally decreases with increasing altitude, this correlation is not significant at TFR and only becomes marked in the transition between the lowland forests (including the ridge forest) and the mid-elevation and montane forest. Species diversity does show a slight but significant decline with altitude ($r^2 = 0.436$, $P = 0.038$). Likewise, tree density shows a significant increase with elevation ($r^2 = 0.618$, $P = 0.07$; Figure 6). These trends are in line with what has been observed at other sites.

5.3 Vegetation Similarities

Based on Sorensen's coefficient, TFR's montane and mid-altitude vegetation share more species than montane/lowland and lowland/mid-altitude vegetation. Comparable results were obtained from Jaccard's coefficient of similarity. The shared taxa might be due to continuous vegetation belts that these habitats share. Interestingly, despite the unique composition of TFR

Table 4. Similarity of Takamanda plots to other plots in Cameroon.

	Sorensen's Coefficient	Jaccard's Coefficient
Takamanda/ Campo	0.277	0.161
Takamanda / Ejagham	0.308	0.182
Campo / Ejagham	0.491	0.325

habitats, some taxa were recorded at every assessment site, ranging from lowland forest to montane forest. These include *Protomegabaria stapfiana, Santiria tremira*, *Hypnodaphnis zenkeri, Xylopia staudtii*, *Tabernaemontana crassa*, *Strombosia grandifolia, Strombosia pustulata*, *Strombosiopsis tetandra,* and *Treculia oboviodea.*

5.4 Floristic Affinities

The Reserve encompasses a unique region that includes the full altitudinal vegetation range found in this part of Cameroon. From our surveys, it is clear that vegetation of the area is somewhat distinctive and concurs with studies from the Nigerian side of the border (Hall and Medler 1975, Keay 1979). As evidence of this uniqueness, the

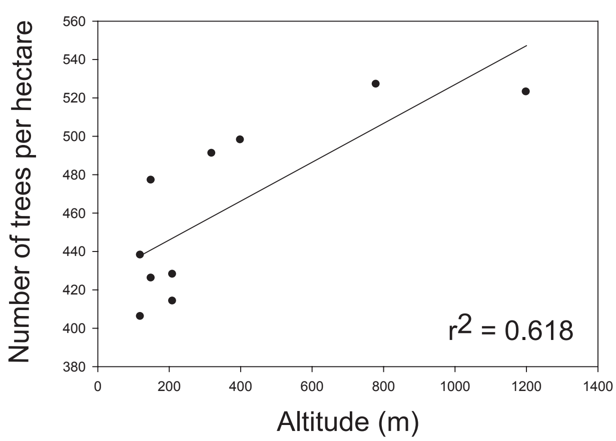


Figure 6. Relationship between altitude and tree density in the biodiversity plots of Takamanda Forest Reserve, Camerooon.

Caesalpinaceae are relatively poorly represented in TFR lowland forests, unlike the Ejagham and Korup forests to the south and the majority of forested areas in Southwest Province. Rather, TFR lowland forests possess a far richer tree flora than these other forests. Indeed, diversity decreases significantly as one moves from Takamanda (H′=4.61) to Ejagham (H′=3.69).

This uniqueness is also evident when floristic similarities and evenness at TFR are compared to the Ejagham forest, also in the Southwest Province, and the Campo region in southern Cameroon. It came as a surprise that the geographically disjunct Campo/Ejagham shared more species than Takamanda/Ejagham and Takamanda/Campo (Table 4).

For the montane forest and high-altitude grassland, however, the floristic affinities are more complex, resulting from climatic change and phytogeographical variance. Hall (1981) suggests that the montane forest flora of the Obudu area represents "an impoverished variant of the flora of the lowland forest of the Oban hills," a known Pleistocene refuge, with the addition of an Afromontane element. The presence (if not dominance) of many lowland species in TFR montane forest, along with Afromontane taxa, supports this hypothesis and suggests that:

- The "montane" forest is influenced by anthropogenic interventions such as burning of high-altitude grassland that is reducing its altitudinal extent and ability to regenerate; hence, the tree line is gradually reducing. This accounts for the significant numbers of lowland forest species in this forest formation.

- At lower altitudes (<1500 m), the grassland can be regarded as "derived savannah" despite showing considerable species richness (although many of these species have migrated from higher altitudes).

5.5 Economic Potential and Forest Exploitation

A number of studies undertaken concurrently with this vegetation assessment present information with regard to the economic importance of TFR flora (for example, Zapfack 2001, Sunderland *et al.* this volume). These studies show clear evidence that lowland forests in the area provide the greatest economic benefit to villagers in and around TFR because of their value as a repository of timber and non-timber species. Hence, there is far less emphasis on exploitation of mid-elevation and montane forests for their plants (see also Schmidt-Soltau 2001). However, knowledge of the density, abundance, and spatial distribution for many of these taxa is, at best, patchy.

The picture with regard to timber is still far from complete. Not surprisingly, this study found that mid-elevation and montane forest formations contain few individual species of timber value. In contrast, the relatively unexploited lowland forests are relatively well stocked with timber species, but by far the most valuable areas for timber potential are the lowland ridge forests that contain large numbers of highly merchantable timber species. The inaccessibility of these forests, particularly those in the Kekpani/Basho hills, suggest that these "timber reservoirs" may remain untouched in the foreseeable future. Of greater concern are the more accessible forest areas, particularly those along navigable waterways where timber exploitation is already under way in the immediate vicinity of TFR and possibly within the Reserve's boundaries (particularly in the forest areas around Takamanda village). It should be a management priority to delineate clear guidelines for the timber resource as was recently done for non-timber forest products.

5.6 Species of Conservation Priority

Due to their restricted range, biological uniqueness, or over-exploitation, a number of TFR taxa have been identified for varying degrees of conservation priority (Table 5 and Appendix 2). Of particular note is the presence of many timber species that have become endangered elsewhere through exploitation. As discussed above, the inaccessibility of many areas in TFR has precluded attempts at logging, and currently the stocking of merchantable timber species throughout the area remains high. Furthermore, many taxa recorded below as possessing conservation value have restricted ranges, and their presence in TFR supports the observation that the levels of endemism recorded in the Cameroon highlands are represented at TFR.

Although the majority of the taxa of conservation value and importance occur mostly in the intricate mosaic of lowland and ridge forest formations, the ecological fragility and anthropogenic pressure on the montane forest and high-altitude grassland suggest these ecotypes are of considerable conservation value. In this latter ecosystem, the presence of many species more commonly associated with the East African highlands (see Hedberg 1964) make this entire region of particular floristic interest.

In summary, the main taxa of conservation importance within the TFR include:

Afzelia africana. **Vulnerable**. Although a widespread species of drier forest, it has declined significantly through over-exploitation for timber to supply international markets. In TFR, it is found in lowland forests around Obonyi I.

Afzelia pachyloba. **Vulnerable**. A rainforest species that is heavily exploited for its commercial timber value, *Afzelia pachyloba* is found in TFR lowland forest around Takamanda and Obonyi I and in the Kekpani/Basho hills.

Ancistrocladus letestui. **Vulnerable**. This extremely rare forest climber is restricted to the forests of Cameroon and Gabon. The two records (Kekpani/Basho hills and Mende hill) from TFR are significant.

Anopyxis klaineana. **Vulnerable**. This monotypic genus has notably poor regeneration. In TFR, it was recorded only from the Basho hills.

Antrocaryon micraster. **Vulnerable**. Scattered throughout semi-deciduous forests in tropical Africa, this emergent species is heavily exploited for its timber value. The species regenerates well in canopy gaps, and its fruit is an important food source for mammals (it is found commonly in gorilla dung in TFR). It is still present in significant numbers in TFR lowland forest.

Brachystegia kennedyi. **Vulnerable**. Restricted to southeastern Nigeria and southwestern Cameroon, this species is a tall, straight timber tree with reputed local cultural importance. The species is in some decline due to land conversion in Nigeria and exploitation for its timber value. The largest and most stable population occurs in Cross River National Park in Nigeria, which makes those populations in TFR of particular value. We recorded it only from the Mboh-Matene area.

Commelina cameroonensis. **Gold star rated**. A herb of the forest/savannah interface restricted to the uplands of Cameroon, Bioko, and southeastern Nigeria, *Commelina cameroonensis* is threatened by annual burning of grassland.

Dacryodes iganganga. **Vulnerable**. This species of limited distribution (Cameroon and Gabon) has been logged in large numbers for timber. Habitat destruction is also affecting its regeneration. However, this species is relatively abundant in the lowland forest formations of TFR.

Diospyros crassiflora. **Endangered**. This species, restricted to the Guineo-Congolian forest, has been virtually eradicated throughout much of its range for ebony wood. It is present only in remote areas such as TFR, where it is present in the Magbe and Takamanda areas of the Reserve.

Drypetes preussii. **Vulnerable**. A rare species confined to forest patches in southeastern Nigeria and southwestern Cameroon (notably Cross River and Korup national parks), *Drypetes preussii* was recorded in TFR lowland forest formations.

Eremospatha tessmanniana. **Vulnerable**. This extremely rare species of rattan palm is known from only three localities—Ebolowa in southern Cameroon, Ebebiyin in Equatorial Guinea, and the Basho hills of TFR.

Eremospatha quinquecostulata. **Vulnerable**. An uncommon species of rattan palm restricted to the closed canopy forests of southeastern Nigeria and southwestern Cameroon, this tree is relatively abundant throughout TFR.

Gossweilerodendron balsamiferum. **Endangered**. Endemic to the Guineo-Congolian forests of Central Africa, this species is declining rapidly becuase of heavy exploitation and habitat loss. It occurs only in undisturbed forest and was encountered only in the Mboh-Matene area of TFR.

Microberlinia bisulcata. **Critically endangered**. This species is restricted to the coastal forests of Cameroon extending to the Oban hills in southeastern Nigeria. Large-scale habitat decline and exploitation for timber have caused a significant population decline. Within TFR, it was recorded only from farmbush in the vicinity of Takamanda village.

Oricia trifoliolata. **Vulnerable**. A small forest tree previously recorded only from Korup National Park and the forests around Mount Cameroon, *Oricia trifoliolata* was recorded from the Basho hills in TFR.

Palisota lagopus. **Gold star rated**. A rare species of Commelinaceae, known from very few collections and restricted to Cameroon, *Palisota lagopus* was collected alongside the Magbe River in TFR.

5.7 Current Threats to Vegetation

In general, TFR vegetation is subject to relatively little disturbance. The lack of significant encroachment greatly enhances the potential for management and conservation efforts within the area. However, current activities by villagers in and outside the Reserve pose a long-term threat to TFR's biological integrity as summarized below.

Table 5. Summary of taxa of conservation priority in Takamanda Forest Reserve, Cameroon.

Family	Species	Conservation status
ACANTHACEAE	*Pseuderanthemum tunicatum*	Endangered (Oldfield *et al.* 1998)
ANACARDIACEAE	*Antrocaryon micraster*	Vulnerable (Oldfield *et al.,* 1998)
ANCISTROCLADACEAE	*Ancistrocladus letestui*	Vulnerable (Oldfield *et al.* 1998)
ANNONACEAE	*Uvariodendron connivens*	Lower risk, but conservation dependent (Oldfield *et al.* 1998)
BORAGINACEAE	*Cordia platythyrsa*	Vulnerable (Oldfield *et al.* 1998)
BURSERACEAE	*Dacryodes igaganga*	Vulnerable (Oldfield *et al.* 1998)
CAESALPINIACEAE	*Afzelia africana*	Vulnerable (Oldfield *et al.* 1998)
	A. bipindensis	Vulnerable (Oldfield *et al.* 1998)
	A. pachyloba	Vulnerable (Oldfield *et al.* 1998)
	Brachystegia kennedyi	Vulnerable (Oldfield *et al.* 1998)
	Dialium bipindensis	Lower risk, near threatened (Oldfield *et al.* 1998)
	Gossweilerodendron balsamiferum	Endangered (Oldfield *et al.* 1998)
	Microberlinia bisulcata	Critically endangered (Oldfield *et al.* 1998)
CELASTRACEAE	*Salacia volubilis*	Gold Star rated (Cable and Cheek, 1998)
COMBRETACEAE	*Terminalia ivorensis*	Vulnerable (Oldfield *et al.,* 1998)
COMMELINACEAE	*Commelina camerunensis*	Gold Star rated (Cable and Cheek, 1998)
	Palisota lagopus	Gold Star rated (Cable and Cheek 1998)
COMPOSITAE	*Crassocephalum boughyanum*	Black star rated (Cable and Cheek 1998)
EBENACEAE	*Diospyros crassiflora*	Endangered (Oldfield et al. 1998)
EUPHORBIACEAE	*Drypetes preussii*	Vulnerable (Oldfield et al. 1998)
	Uapaca vanhouttei	Gold Star rated (Cable and Cheek 1998)
GUTTIFERAE	*Garcinia kola*	Vulnerable (Oldfield *et al,* 1998)
LENTIBULARIACEAE	*Utricularia mannii*	Gold Star rated (Cable and Cheek 1998)
MELIACEAE	*Entandrophragma angolense*	Vulnerable (Oldfield *et al,* 1998)
	Guarea cedrata	Vulnerable (Oldfield *et al.* 1998)
	G. thomsonii	Vulnerable (Oldfield *et al,* 1998)
	Lovoa trichilioides	Vulnerable (Oldfield *et al,* 1998)
MENISPERMACEAE	*Penianthus camerunensis*	Gold Star rated (Cable and Cheek 1998)
OCHNACEAE	*Campylospermum mannii*	Gold Star rated (Cable and Cheek 1998)
	C. subcordatum	Gold Star rated (Cable and Cheek 1998)
	Lophira alata	Vulnerable (Oldfield *et al.* 1998)
PALMAE	*Eremospatha quinquecostulata*	Vulnerable (Sunderland 2001)
	E. tessmanniana	Vulnerable (Sunderland 2001)
	Oncocalamus tuleyi	Vulnerable (Sunderland 2001)
RHIZOPHORACEAE	*Anopyxis klaineana*	Vulnerable (Oldfield *et al.* 1998)
RUBIACEAE	*Nauclea diderichii*	Vulnerable (Oldfield *et al.* 1998); scarlet star rated (Cable and Cheek 1998)
	Pavetta longibracteata	Gold Star rated (Cable and Cheek 1998)
	P. owariensis	Gold Star rated (Cable and Cheek 1998)
	Petiticodon parviflorum	Gold Star rated (Cable and Cheek 1998)
	Psychotria biferia var. biferia	Black Star rated (Cable and Cheek 1998)
	P. camptopus	Gold Star rated (Cable and Cheek 1998)
	Tarenna lasiorachis	Gold Star rated (Cable and Cheek 1998)
RUTACEAE	*Oricia trifoliolata*	Vulnerable (Oldfield *et al.* 1998)
STERCULIACEAE	*Cola flaviflora*	Gold Star rated (Cable and Cheek 1998)
	C. semecarpophylla	Lower risk, but conservation dependent (Oldfield *et al.* 1998)
	Pterygota macrocarpa	Vulnerable (Oldfield *et al.* 1998)
THYMELIACECEAE	*Dicranolepis glandulosa*	Gold Star rated (Cable and Cheek 1998)

- Agricultural encroachment in TFR has affected patches of forest vegetation, some of which are extensive, particularly in the lowland forest formation that contains the greatest floristic diversity.

- Uncontrolled and destructive harvesting of non-timber forest products is having a deleterious effect on the populations of certain high-value plants (particularly *Carpolobia* spp. and *Massularia acuminata*). This exploitation will undoubtedly increase as access is "improved" through current road-building plans.

- Although very little timber exploitation has occurred within TFR, intensive logging activities undertaken in places such as the Kekukusem-Takamanda area suggest this might not be the case for much longer.

- Intensive hunting is having an as-yet unquantified effect on the remaining flora of the area. Elimination of the faunal agents of pollination and seed dispersal will affect the regeneration potential of many plant species over the long term.

- Annual burning of high-altitude grassland by nomadic cattle herders to provide fresh grazing land is having a negative impact on the remaining areas of montane forest. The fires often spread into the forest, seriously affecting regeneration and thereby causing the forest to shrink and the tree line to recede. Burning is also destroying the transition zone—often the habitat of many unique plant species—between forest and grassland to the extent that there is little, if any, transition zone. The forest abruptly ends, and grassland begins.

6 Conclusion and Recommendations for Conservation

Broadly speaking, TFR forest formations are species rich and diverse, qualities that are enhanced by the confluence of several habitat types in the area. The Reserve is special in that it represents a sharp gradation from lowland forest to sub-montane (highland) forest with intact associated floristic variations. These forests are home to a wide range of other biological taxa that also exhibit remarkable diversity.

The unique biological and socio-economic nature of the region makes implementation of applied conservation and sustainable management strategies a priority. Establishment of a focused, long-term monitoring and research program will determine the efficacy of such efforts (Comiskey and Dallmeier this volume).

Based on the findings of this report, key recommendations for the conservation and management of TFR are:

- In relation to floristic conservation priority, our surveys indicate that all areas are of equal importance. While lowland forest formations, notably the ridge forest, contain the greatest levels of diversity, the occurrence of taxa of greater conservation need lie at higher altitudes. In short, the presence of an intricate mosaic of forest types within each vegetation classification provides a patchwork of highly diverse, yet unique, habitats within the entire TFR area. In addition, there are few protected areas remaining in Cameroon that exhibit the full range of vegetation gradients from lowland forests to high-altitude grassland. Therefore, TFR is of extreme national and international conservation interest. The implication of these findings is that conservation and management efforts should focus on the vegetation of TFR in its entirety.

- To "measure" the efficacy of conservation and management initiatives within TFR, it is imperative to monitor over time any changes in vegetation and floristic composition. Such a vegetation assessment provides a baseline from which the monitoring program can be further developed. The 10 BDPs should be reassessed in 2004 and at subsequent five-year intervals. **These guidelines should form the basis of a long-term strategy for vegetation monitoring.** It is important to develop the monitoring program in close collaboration with MINEF.

- To provide a macro-level assessment of vegetation changes over time, **monitoring should incorporate the periodic examination of satellite images** (every three to five years). This monitoring effort, additional to that undertaken at the field level, will help determine changes in land cover (both natural and anthropomorphic) over time and will enable the evaluation over the long term of the effectiveness of future management interventions.

- **Existing agricultural encroachment into TFR should be controlled** through enforced respect of the demarcated Reserve boundaries. Agricultural encroachment is a particular problem around the communities of Takamanda, Obonyi, Mfakwe, and Matene. Residents of these communities should be made fully aware of the location of the boundaries and encouraged to respect them.

- **Current uncontrolled exploitation of species used for non-timber forest products must be addressed immediately**. Recommendations in the recent GTZ-commissioned study conducted by Sunderland *et al.* (this volume) provide relevant guidelines.

- **There is an urgent need to assess stocking of the timber resource** in and around TFR and provide institutional, technical, and logistical support to **ensure that exploitation is undertaken in as sustainable a manner as possible**. Immediate management interventions should include: (a) a community-based inventory of the existing and potential (through regeneration studies) timber resources of the lowland forest areas; (b) a review of the institutional issues surrounding timber exploitation, particularly aimed at encouraging local communities to control exploitation of timber by outsiders; and (c) the provision of guidelines (and perhaps technical support) to allow small-scale exploitation of timber—based on sound ecological and social considerations—by villagers in and around TFR for direct marketing and sale.

- **Burning of high-altitude grassland needs to be assessed and reviewed**. A pilot study on the Obudu Plateau by the non-governmental organization Development in Nigeria (DIN) has shown that grassland protected from burning exhibits greater species diversity through maintenance of the forest-to-savannah transition zone. Reductions in burning also enable the fragile montane forest to regenerate and maintain itself.

- When compared to other highly diverse areas in Cameroon, TFR vegetation is considerably under-represented in "indicator groups;" that is, specialist taxa such as orchids, ferns, and fern allies and some key families of higher plants (for example, Violaceae and Lauraceae). **Additional field-based research is urgently needed to further evaluating vegetation diversity and species richness.** The focus of future activities should be on the continued collection of fertile voucher specimens. Hiring local parataxonomists proved extremely useful in garnering specimens, while also providing gainful employment for villagers. Identification of herbarium specimens and additional floristic analysis could be undertaken in collaboration with either the National Herbarium in Yaounde or the herbarium at Limbe Botanic Garden.

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Appendix 1. Plant species recorded in Takamanda Forest Reserve, Cameroon.

DICOTYLEDONS

Acanthaceae

Acanthus montanus (Nees) T. Anders.
Anisotis sp.
Asystasia sp.
Brachystephanus nemoralis S. Moore
Brillantaisia lamium (Nees) Benth.
Brillantaisia owariensis P. Beauv.
Brillantaisia vogeliana (Nees) Benth.
Brillantaisia sp. 1
Brillantaisia sp. 2
Crossandra guineensis Nees.
Crossandrella dusenii (Lindau) S. Moore
Dicliptera verticillata (Forsk) C. Christus
Dischistocalyx grandifolius C.B. Cl.
Eremomastax speciosa (Hochst.) Cufod.

Hypoestes arisata (Vahl) Soland. ex Roem. & Schult.
Justicia extensa T. Anderson
Justicia sp.
Lankesteria brevior C.B. Cl.
Phaulopsis ciliata (Willd.) Hepper
Pseuderanthemum tunicatum (Afzel) M.-Redh.
Stenandrium guineense (Nees) Vollesen
Thomandersia hensii De Wild. & Th. Dur.

Alangiaceae

Alangium chinense (Lour.) Harms

Amaranthaceae

Cyathula prostrata Blume

Anacardiaceae

Antrocaryon klaineanum Pierre
Antrocaryon micraster A. Chev. & Guill.
Pseudospondias microcarpa (A. Rich.) Engl.
Pseudospondias sp.
Sorindeia grandifolia Engl.
Sorindeia sp. 1
Sorindeia sp. 2
Trichoscypha acuminata Engl.
Trichoscypha arborea (A. Chev.) A. Chev.
Trichoscypha sp.

Ancistrocladaceae

Ancistrocladus letestui Pellegrin

Anisophylleaceae

Anisophyllea polyneura Floret
Anisophyllea sp.
Poga oleosa Pierre

Annonaceae

Annickia chlorantha (Oliv.) Setten & Maas
Annickia sp.
Annona sp.
Anonidium mannii (Oliv.) Engl. & Diels
Artobotrys sp.
Cleistopholis patens (Benth.) Engl. & Diels
Friesodielsa sp.
Hexalobus crispiflorus A. Rich.
Isolona hexaloba (Pierre) Engl. & Diels.
Monodora sp.
Monodora tenuifolia Benth.
Polyalthia sauveolens Engl. & Diels
Popowia sp.
Uvaria sp
Uvariodendron connivens (Benth.) R.E. Fries
Uvariodendron molundense R.E. Fries
Uvariodendron sp. 1
Uvariodendron sp. 2
Ghesq.
Uvaropsis sp.
Xylopia acutiflora (Dunal) A. Rich.
Xylopia aethiopica (Dunal.) A. Rich
Xylopia hypolampra Mildbr.
Xylopia parviflora (A. Rich.) Benth.
Xylopia quintasii Engl. & Diels.
Xylopia staudtii Engl. & Diels.
Xylopia sp.

Apocynaceae

Alstonia boonei De Wild.
Alstonia congensis Engl.
Baissea multiflora A.DC.
Baissea sp
Funtumia elastica (Preuss) Stapf
Funtumia sp.
Hunteria umbellata (K. Schum.) Hallier f.
Landolphia robustior (K.Schum.) Persoon
Landolphia sp. 1
Landolphia sp. 2
Picralima nitida (Stapf.) Th. Dur.
Picralima sp. 1
Picralima sp. 2
Pleiocarpa mutica Benth.
Pleiocarpa rostrata Benth.
Pleiocarpa sp.
Rauvolfia caffra Sond.
Rauvolfia mannii Stapf
Rauvolfia vomitoria Afzel.
Strophanthus hispidus DC.
Strophanthus sp.
Tabernaemontana pendulifolia K.Schum.
Tabernaemontana crassa Benth.
Tabernaemontana eglandulosa Stapf
Tabernaemontana grandulosa (Stapf) Pichon
Tabernaemontana pachysiphon Stapf
Voacanga africana Stapf

Voacanga bracteata Stapf
Voacanga psilocalyx Pierre ex Stapf
Voacanga sp. 1
Voacanga sp. 2

Araliaceae
Polyscias fulva (Hiern) Harms
Schefflera abyssinica (Hochst.) Harms

Aristolochiaceae
Pararistolochia promissa (Mast.) Keay
Pararistolochia sp.

Ascelpiadaceae
Kanahia laniflora (Forsk.) R. Br.
Gongronema latifolium Benth.
Mondia sp.

Balanophoraceae
Thonningia sanguinea Vahl

Balsaminaceae
Impatiens irvingii Hook.f.
Impatiens kamerunensis var. kamerunensis Warb.
Impatiens niamnamensis Gilg

Begoniaceae
Begonia capillipes Gilg
Begonia ciliobracteata Warb.
Begonia microsperma Warb.
Begonia oxyloba Welw. ex Hook.f
Begonia quadrialata subsp. quadrialata Warb.
Begonia staudtii Gilg
Begonia sp. 1

Bignoniaceae
Newbouldia laevis (P. Beauv.) Seem. ex Bureau

Bombacaceae
Ceiba pentandra (L.) Gaertn.

Boraginaceae
Cordia platythyrsa Baker

Burseraceae
Canarium schweinfurthii Engl.
Dacryodes edulis (G. Don.) H.J. Lam.
Dacryodes igaganga Aubr. & Pellegr.
Dacryodes klaineana (Pierre) H.J. Lam.
Santiria trimera Oliv.

Cecropiaceae
Musanga cecropioides R. Br.
Myrianthus arboreus P. Beauv.
Myrianthus preussii Engl.

Celastraceae
Salacia alata De. Wild.
Salacia erecta (G.Don) Walp.
Salacia lehmbachii Loes.
Salacia loloensis Loes.
Salacia loloensis Loes.
Salacia pyriformoides Loes.
Salacia staudtiana Halle
Salacia talbotii Bak.f.
Salacia volubilis Loes. & Winkl.
Salacia sp. 1
Salacia sp. 2
Salacia sp. 3
Salacia sp. 4
Salacia sp. 5
Salacighia letestuana (Pellegr.) Blakelock

Chrysobalanaceae
Dactyladenia lujae (De Wild.) Prance & F. White
Dactyladenia mannii (Oliv.) Prance & F.White
Dactyladenia staudtii (Engl.) Prance & F.White
Dactyladenia sp. 1
Dactyladenia sp. 2
Maranthes glabra (Oliv.) Prance
Maranthes sp. 1
Maranthes sp. 2 Blume
Parinari excelsa Sabine
Parinari glabra Oliv.
Parinari sp.

Combretaceae
Combretum bracteatum (Laws.) Engl. & Diels
Combretum cuspidatum Planch ex Benth
Combretum hispidum Laws.
Combretum latialatum Engl. Ex Engl. & Diels
Combretum orophilum Liben
Combretum sp. 1
Combretum sp. 2
Combretum sp. 3
Pteleopsis hylodendron Mildbr.
Strephonema mannii Hook.f.
Strephonema sp.
Terminalia ivorensis A.Chev.
Terminalia superba Engl. & Diels

Compositae
Ageratum conyzoides L.
Ageratum sp.
Aspilia africana (Pers.) C.D. Adams
Cassinia sp.
Conyza bonariensis (L.) Cronq.
Crassocephalum bougheyanum C.D. Adams
Gutenbergis nigritiana Sch. Bip.
Spilanthes uliginosa Sw.
Syndrella nodiflora Gaertn.
Vernonia amygdalina Delile
Vernonia biafrae Oliv. & Hearn
Vernonia conferta Benth.
Vernonia frondosa Oliv. & Hiern

Connaraceae
Agelaea obliqua (P. Beauv.) Baill.

Agelaea pentagyna (Lam.) Baill.
Agelaea sp. 1
Agelaea sp. 2
Cnestis aurantica Gilg.
Cnestis ferruginea DC.
Cnestis macrophylla Gilg. ex. Schellenb.
Cnestis tomentosa Hepper
Cnestis sp. 1
Cnestis sp. 2
Cnestis sp. 3
Connarus sp.
Jollydora duparquetiana (Baill.) Pierre

Convulvulaceae

Neuropeltis acuminata (P. Beauv.) Benth.

Cucurbitaceae

Momordica cissoides Planch ex Benth.
Momordica sp.

Dichapetalaceae

Dichapetalum choristilum Engl.
Dichapetalum heudelotii (Planch ex Oliv.) Baill.
Dichapetalum insigne Engl.
Dichapetalum madagascariense Poir
Dichapetalum pallidum (Oliv.) Engl.
Dichapetalum rudatisii Engl.
Dichapetalum tomentosum Engl.
Dichapetalum sp. 1
Dichapetalum sp. 2
Dichapetalum sp. 3
Dichapetalum sp. 4
Dichapetalum sp. 5
Tapura africana Oliv.

Dilleniaceae

Tetracera alnifolia Willd.

Ebenaceae

Diospyros conocarpa Gurke & K. Schum.
Diospyros crassiflora Hiern.
Diospyros hoyleana subsp. hoyleana F. White
Diospyros iturensis (Gurke) Letouzey & F. white
Diospyros monbuttensis Gurke
Diospyros physocalycina Gurke
Diospyros preussii Gurke
Diospyros sanza-minika A. Chev.
Diospyros simulans F. White
Diospyros suaveolens Gurke
Diospyros zenkeri (Gurke) F. White
Diospyros sp.

Erythroxyllaceae

Erythroxylum mannii Oliv.

Euphorbiaceae

Alchornea floribunda Mull. Arg.
Alchornea hirtella Benth.
Antidesma laciniatum var laciniatum Mull. Arg.
Antidesma membranaceum Mull. Arg.
Antidesma venosum Mull. Arg.
Antidesma vogelianum Mull. Arg.
Antidesma sp.
Bridelia grandis Pierre
Bridelia micrantha (Hochst.) Baill.
Bridelia sp.
Crotonogyne preussii Pax.
Crotonogyne sp.
Cyrtogonone argentea (Pax) Prain
Dichostemma glaucescens Pierre
Discoclaoxylon hexandrum (Mull. Arg.) Pax & K. Hoffm.
Discoglypremna caloneura (Pax) Prain
Drypetes gossweileri S. Moore
Drypetes leonensis Pax
Drypetes molunduana Pax & K. Hoffm.
Drypetes preussii (Pax) Hutch.
Drypetes sp. 1
Drypetes sp. 2
Drypetes sp. 3
Drypetes sp. 4
Erythrococca anomala (Juss. ex Poir) Prain
Grossera major Pax
Hymenocardia acida Tul.
Hymenocardia heudelotii Mull. Arg.
Hymenocardia lyrata Tul.
Leptopus sp. Sprague & Hutch.
Macaranga barteri Mull. Arg.
Macaranga hurifolia Beille
Macaranga monandra Mull. Arg.
Macaranga occidentalis (Mull. Arg.) Mull. Arg
Macaranga spinosa Mull. Arg.
Macaranga sp. 1
Macaranga sp. 2
Maesobotrya dusenii (Pax) Hutch.
Maesobotrya staudtii (Pax) Hutch.
Maesobotrya sp.
Mallotus oppositifolius (Geiseler) Mull. Arg.
Manniophyton fulvum Mull. Arg.
Maprounea membranacea Pax & K. Hoffm.
Mareya micrantha Mull. Arg.
Mareya sp.
Mareyopsis longifolia (Pax) Pax & K. Hoffm.
Margaritaria discoidea (Baill.) Webster
Phyllanthus discoides Mull. Arg
Phyllanthus mannianus Mull. Arg.
Plagiostyles africana (Mull. Arg.) Prain
Protomegabaria stapfiana
Protomegabaria sp. (Beille) Hutch.

Pycnocoma cornuta Mull. Arg.
Pycnocoma macrophylla Benth.
Sapium cornutum Pax
Sapium ellipticum (Hochst.) Pax
Sapium guineensis (Kuntze) Benth.
Sapium sp.
Spondianthus preussii Engl.
Spondianthus sp.
Tetracarpidium conophorum (Mull. Arg.) Hutch. & Dalz.
Tetrorchidium didymostemon (Baill.) Pax & K. Hoffm.
Thecacoris batesii Hutch.
Thecacoris leptobotyra (Mull. Arg.) Brenan
Thecacoris stenopetala (Mull. Arg.) Mull. Arg.
Thecacoris sp.
Tragia sp.
Uapaca acuminata (Hutch.) Pax & K.Hoffm.
Uapaca guineensis Mull. Arg.
Uapaca paludosa Aubr. & Landri
Uapaca staudtii Pax
Uapaca vanhouttei De Wild.

Flacourticaceae

Caloncoba glauca (P. Beauv.) Gilg
Caloncoba sp.
Camptostylus mannii (Oliv.) Gilg
Casearia barteri Mast.
Casearia sp.
Homalium letestui Pellegr.
Homalium sp.
Lindackeria dentata (Oliv.) Gilg.
Ophiobotrys zenkeri Gilg
Scottellia coriacea Chev.
Scottellia klaineana Pierre
Scottellia mimfiensis Gilg.
Scottellia sp.

Guttiferae

Allanblackia floribunda Oliv.
Allanblackia sp.
Garcinia afzeli Engl.
Garcinia gnetoides Hutch. & Dalziel
Garcinia kola Heckel
Garcinia mannii Oliv.
Garcinia punctata Oliv.
Garcinia smeathmannii (Planch. & Triana) Oliv.
Garcinia sp. 1
Garcinia sp. 2
Harungana madagascariensis Lam ex Poir
Mammea africana Sabine
Pentadesma butyracea Sabine
Pentadesma grandifolia Bak.f.
Symphonia globulifera L.

Huaceae

Afrostyrax kamerunensis Perkins & Gilg.

Hypericaceae

Endodesmia calpophylloides Benth.
Endodesmia sp.

Icacinaceae

Alsodeiopsis mannii Oliv.
Alsodeiopsis poggei var. robynsii Boutique
Alsodeiopsis weissenborniana J. Braun & K. Schum
Chlamydocarya thomsoniana Baill.
Chlamydocarya sp.
Lasianthera africana P. Beauv.
Lavigeria macrocarpa (Oliv.) Pierre
Lavigeria sp.

Irvingiaceae

Desbordesia glaucescens Tiegh
Irvingia gabonensis (Aubry-Lecomte ex O' Rorke) Baill.
Irvingia grandifolia (Engl.) Engl.
Irvingia robur Mildbr.
Irvingia smithii Hook.f.
Klainedoxa gabonensis Pierre

Ixonanthaceae

Ochthocosmus calothyrsus (Mildbr.) Hutch. & Dalz.
Ochthocosmus sessiflorus (Oliv.) Baill.

Labiatae

Ocimum gratissimum L.
Ocimum sp.
Platostoma africanum P. Beauv.
Plectranthus decurrens (Gurke) J.K. Morton
Solenostemon mannii (Hook.f.) Baker

Lauraceae

Beilschmiedia annacardioides (Engl. & K. Krauss) Robyn & Wilczek
Beilschmiedia obscura Engl.
Beilschmiedia preussi Engl.
Beilschmiedia sp.
Hypodaphnis zenkeri (Engl.) Stapf.

Lecythidaceae

Napoleonaea talbotii Bak.f.
Napoleonaea sp.
Petersianthus africanus (Welw. ex Benth. & Hook.f) Merr
Petersianthus macrocarpus (P. Beauv.) Liben

Leeaceae

Leea guineensis G. Don

Leguminosae

Abrus precatorius L.
Afzelia africana Sm.
Afzelia bipindensis Harms

Afzelia pachyloba Harms
Albizia adianthifolia (Schum.) W.F. Wright
Albizia glaberrima (Schum. & Thonn.) Benth.
Albizia zygia (DC.) J.F. Macbr.
Albizia sp.
Amphimas ferrugineus Pellegr.
Amphimas pterocarpoides Harms.
Amphimas sp.
Angylocalyx oligophyllus (Bak.) Bak.f.
Angylocalyx zenkeri Harms
Angylocalyx talbotii Bak.f.
Angylocalyx sp.
Anthonotha cladantha (Harms) J. Leonard
Anthonotha fragrans Exell & Hill.
Anthonotha macrophylla P. Beauv.
Anthonotha sp. 1
Anthonotha sp. 2
Aubrevillea kerstingii (Harms.) Pellegr.
Baphia laurifolia Baill.
Baphia leptobotrys Harms.
Baphia nitida Lodd.
Baphia sp.
Berlinia bracteosa Benth.
Berlinia craibiana Bak.f.
Brachystegia kennedyi Hoyle
Calpocalyx dinklagei Harms.
Copaifera mildbraedii Harms
Crudia gabonensis Pierre ex Harms
Cylicodricus gabunensis Harms
Cynometra hankei Harms
Cynometra mannii Oliv.
Cynometra sanagaensis Aubr.
Cynometra sp. 1
Cynometra sp. 2
Desmodium repandum (Vahl.) DC.
Detarium macrocarpum Harms
Dialium bipidensis Harms
Dialium dinklagei Harms
Dialium guineensis Willd.
Dialium pachyphyllum Harms.
Dialium zenkeri Harms
Dialium sp.
Didelotia africana Baill.
Erythrophleum ivorense A. Chev.
Erythrophleum sauveolens (Guill.&Perr.) Brenan
Erythrophleum sp.
Gilbertiodendron brachystegioides (Harms) J. Leonard.
Gilbertiodendron dewevrei (De Wild.) J.Leonard.
Gilbertiodendron sp.
Gossweilerodendron balsamiferum (Vermosen) Harms
Gossweilerodendron joveri Normand ex Aubr.
Hylodendron gabunense Taub.
Hymenostegia afzelii (Oliv.) Harms
Isoberlinia sp.
Leonardoxa africana Aubrev.
Leucomphalos capparideus Benth. ex Planch
Microberlinia bisulcata A. Chev.
Millettia barteri (Benth.) Dunn
Millettia mannii Baker.
Millettia sanagana Harms
Millettia sp. 1
Millettia sp. 2
Monopetalanthus letestui Pellegr.
Monopetalanthus microphyllus Harms
Mucuna flagellipes T. Vogel ex Hook.f.
Newtonia grandifolia J.F. Villiers
Newtonia griffoniana (Baill.) Bak.f.
Newtonia sp.
Oddoniodendron normandii Aubr.
Ormocarpum sennoides (Willd.) D.C.
Ormocarpum sp.
Parkia bicolor A. Chev.
Pentaclethra macrophylla Benth.
Piptadeniastrum africanum (Hook.f.) Brenan
Plagiosiphon longitubus (Harms) J. Leonard.
Plagiosiphon multijugus (Harms) J. Leonard.
Pterocarpus osun Craib.
Pterocarpus soyauxii Taub.
Rhynchosia mannii Baker
Rhynchosia sp.
Senna alata L.
Stachyothrsus sp.
Tephrosia vogelii Hook.f.
Tetrapleura tetraptera (Schum & Thonn) Taub.
Zenkerella capparidecea (Taub.) J.Leonard
Zenkerella sp.

Lentibulariaceae
Utricularia mannii Oliv.

Lepidobotryaceae
Lepidobotrys staudtii Engl.

Lobeliaceae
Lobelia columnaris Hook.f.

Loganiaceae
Anthocleista obanensis Wernham
Anthocleista schweinfurthii Gilg.
Anthocleista vogelii Planch.
Mostuea brunonis Didr.
Strychnos asterantha Leeuwenb
Strychnos boonei De. Wild.
Strychnos camptoneura Gilg & Busse.
Strychnos asterantha Leeuwenb.

Strychnos phaeotricha Gilg
Strychnos staudtii Gilg
Strychnos sp. 1
Strychnos sp. 2
Strychnos sp. 3
Usteria guinneensis Willd.

Malvaceae

Urena lobata L.

Medusandraceae

Soyaneia sp,
Soyauxia gabonensis Oliv.

Melastomataceae

Dichaetanthera africana (Hook.f.) Jac. Fel.
Dinophora spenneroides Benth.
Dissotis rotundifolia (Sm.) Triana
Melastomastrum sp.
Memecylon engleranum Cogn.
Tristemma littorale Benth.

Meliaceae

Carapa procera D.C.
Carapa sp.
Ekebergia sp.
Entandrophragma angolense (Welw.) C. DC.
Guarea cedrata (A. Chev) Pellegr.
Guarea glomerulata Harms
Guarea thompsonii Sprague & Hutch.
Lovoa trichilioides Harms.
Trichilia dregeana Sond.
Trichilia gilgiana Harms.
Trichilia heudelotii Planch.
Trichilia monodelpha (Thonn.) J.J. de Wilde
Trichilia rubescens Oliv.
Trichilia tessmannii Harms.
Trichilia welwitschii C. DC.
Trichilia sp. 1
Trichilia sp. 2

Melianthaceae

Bersama abyssinica Fresen.

Menispermaceae

Cissampelos owariensis P. Beauv. ex D.C.
Jateorhiza macrantha Excell & Mendonca
Penianthus camerounensis A. Dekker.
Penianthus longifolius Miers
Penianthus sp.
Stephania laetificata (Miers) Benth.
Tiliacora funifera (Miers) Oliv.
Tiliacora lehmbachii Engl.
Tiliacora sp.

Moraceae

Antiaris africana Engl.
Dorstenia africana (Baill.) C.C. Berg
Dorstenia barteri var barteri Bureau
Dorstenia barteri var multiradiata (Engl.) Hijman & C.C. Berg
Dorstenia ciliata Engl.
Dorstenia mannii Hook.f.
Dorstenia turbinata Engl.
Dorstenia sp. 1
Dorstenia sp. 2
Ficus thonningii Blume
Ficus vogeliana (Miq.) Miq.
Ficus sp.
Neosleotiopsis kamerunensis
Treculia africana Decne
Treculia obovoidea Decne
Treculia sp.
Trilepisium madagascariense DC.

Myristicaceae

Coelocaryon preussii Warb.
Pycnanthus angolensis (Welw.) Warb
Scyphocephalium mannii (Benth.) Warb.
Staudtia kamerunensis Warb.
Staudtia stipitata Warb.
Staudtia sp.

Myrsinaceae

Ardisia staudtii Gilg.
Ardisia sp.
Maesa lanceolata Forsk.

Myrtaceae

Eugenia sp. 1
Eugenia sp. 2
Psidium guajava L.
Syzygium guineense (Willd.) DC.
Syzygium rowlandii Sprague
Syzygium sp.

Nyctaginaceae

Boerhavia sp.

Ochnaceae

Campylospermum elongatum (Oliv.) Tiegh

Campylospermum flavum (Schum & Thonn.) Farron
Campylospermum mannii (Oliv.) Tiegh
Campylospermum reticulatum P. Beauv.
Campylospermum subcordatum (Stapf) Farron
Campylospermum sp. 1
Campylospermum sp. 2
Campylospermum sp. 3
Campylospermum sp. 4
Idertia axillaris (Oliv.) Farron
Lophira alata Banks
Rhabdophyllum affine (Hook.f.) Tiegh
Rhabdophyllum calophyllum (Hook.f.) Tiegh

Rhabdophyllum sp.

Olacaceae

Aptandra zenkeri Engl.
Diogoa zenkeri (Engl.) Exell & Mendonca
Heisteria parvifolia Sm.
Olax latifolia Engl.
Olax mannii Oliv.
Olax subscorpoidea Oliv.
Ongokea gore (Hua) Pierre.
Strombosia grandifolia Hook.f.
Strombosia pustulata Oliv.
Strombosia scheffleri Engl.
Strombosia zenkeri Engl.
Strombosia sp. 1
Strombosia sp. 2
Strombosia sp. 3
Strombosiopsis tetrandra Engl.

Oleaceae

Olea capensis L.

Opiliaceae

Opilia sp.

Oxalidaceae

Biophytum umbraculum Welw.
Biophytum zenkeri Guillaumin

Pandaceae

Microdesmis pierlotiana J. Leonard
Microdesmis puberula Hook.f.
Microdesmis zenkeri Pax
Microdesmis sp.
Panda oleosa Pierre.

Passifloraceae

Adenia cissampeloides (Planch. ex Benth.) Harms
Barteria fistulosa Mast.
Barteria nigritiana Hook.f.

Piperaceae

Peperomia fernandopoiana C. DC.
Piper guineense Schum. & Thonn.

Polygalaceae

Carpolobia alba G. Don
Carpolobia lutea G. Don

Primulaceae

Vitaliana sp.

Rhamnaceae

Lasiodiscus marmoratus C.H. Wright
Maesopsis eminii Engl.

Rhizophoraceae

Anisophyllea polyneura Floret
Anopyxis klaineana (Pierre) Engl.
Poga oleosa Pierre

Rosaceae

Rubus pinnatus var afrotropicus (Engl.) C.E. Gust.

Rubiaceae

Aidia micrantha (K. Schum.) White
Aidia sp.
Aoranthe cladantha (K. Schum.) Somers
Argocoffeopsis rupestris Robbrecht
Atractogyne bracteata (Wernham) Hutch. & Dalz.
Aulacocalyx talbotii (Wernham) Keay
Aulacocalyx sp. 1
Aulacocalyx sp. 2
Belonophora talbotii (Wernham) Keay
Bertiera breviflora Hiern
Bertiera arctistipula N. Halle
Bertiera iturensis K. Krause
Bertiera laxa Benth.
Bertiera racemosa (G. Don) K.Schum
Bertiera sp.
Brenania brieyi (De Wild) Petit
Calycosiphonia macroclamys (K. Schum.) J.F. Leroy
Canthium arnoldianum (De. Wild. & Th. Dur.) Heppe
Canthium sp.
Chassalia cristata (Hiern) Bremek.
Chazaliella sciadephora (Hiern) Petit & Verde.
Chazaliella oddonii (De Wild.) Petit & Verde.
Chazaliella sp.
Coffea sp. 1
Coffea sp. 2
Colletoecema sp. 1
Colletoecema sp. 2
Corynanthe pachyceras K. Schum.
Corynanthe sp.
Crateristermum aristatum Wernham
Cremaspora thomsonii Hiern
Cuviera subulifera Benth.
Euclinia longifolia Salisb.
Gaertnera fissistiplua (K. Schum & K. Krause) Petit
Gaertnera paniculata Benth.
Gardenia imperialis K. Schum.
Gardenia vogelii Hook.f. ex Planch.
Geophila afzelii Hiern
Geophila repens (L.) I.M. Johnston
Geophila sp. 1
Geophila sp. 2
Heinisa crinita (Afzel.) G. Tayl.
Hekistocarpa minutiflora Hook.f.
Hymenocoleus sp.
Hymenodictyon biafranum Hiern
Ixora coccinea L.
Ixora guineensis Benth.
Ixora nematopoda K. Schum.
Ixora sp. 1
Ixora sp. 2

Lasianthus batangensis K. Schum.
Massularia acuminata (G. Don) Bullock ex Hoyle
Mitracarpus scaber Zucc.
Mitragyna ciliata Aubr. & Pellegr.
Mitriostigma sp.
Morinda lucida Benth.
Mussaenda elegans Schum. & Thonn.
Mussaenda sp.
Mussaenda tenuiflora Benth.
Nauclea diderrichii (De Wild. & Th. Dur.) Merr.
Nauclea pobeguinii (Pob. ex Pellegr.) Merr. ex Petit
Oldenlandia lancifolia (Schumach.) DC.
Oldenlandia sp.
Oxyanthus laxiflorus K. Schum. ex Hutch. & Dalz.
Oxyanthus formosus Hook.f. ex Planch
Oxyanthus gracilis Hiern
Pauridiantha canthiiflora Hook.f.
Pauridiantha venusta N. Halle
Pauridiantha viridiflora (Schweinf.) Hepper
Pausinystalia macroceras (K. Schum.) Pierre
Pausinystalia sp.
Pavetta staudtii Hutch. & Dalz.
Pavetta longibracteata Bremek.
Pavetta owariensis P. Beauv.
Pavetta sp. 1
Pavetta sp. 2
Pentodon pentandrus (Schum. & Thonn.) Vatke
Petitiocodon parviflorum
Poecilocalyx schumannii Bremek.
Polysphaeria macrophylla K. Schum.
Porterandia cladantha (K.Schum.) Keay
Psychotria biferia var biferia Hiern
Psychotria camptopus Verdc.
Psychotria ceratalabastron K. Schum.
Psychotria gabonica Hiern
Psychotria globosa Hiern
Psychotria mannii Hiern
Psychotria peduncularis (Salisb.) Systerm.
Psychotria sp. 1
Psychotria sp. 2
Psychotria sp. 3
Psychotria sp. 4
Psychotria sp. 5
Psychotria sp. 6
Psychotria sp. 7
Psychotria sp. 8
Psychotria sp. 9
Rothmannia hispida (K. Schum.) Fagerlind
Rothmannia lujae (De.Wild.) Keay
Rothmannia sp. 1
Rothmannia sp. 2
Rutidea hispida Hiern
Sabicea calycina Benth.
Schumanniophyton magnificum (K. Schum) Harms
Sericanthe sp.
Sherbournia zenkeri Hua
Tarenna thomasii Hutch. & Dalz.
Tarenna eketensis Wernham
Tarenna fusco-flava (K. Schum.) N. Halle
Tarenna lasiorachis (K. Schum. & K.Krauss) Bremek.
Tarenna sp.
Temnocalyx sp.
Tricalysia sp. 1
Tricalysia sp. 2
Tricalysia sp. 3
Virectaria sp. 1
Virectaria sp. 2

Rutaceae

Citropsis articulata (Willd. ex Spreng) Swingle & M. Kellerm.
Clausena anisata (Willd.) Hook.f.
Clausena sp.
Oricia sp. 1 Pierre
Oricia sp. 2
Oricia trifoliolata (Engl.) Verdoorn
Vepris sp.
Zanthoxylum gillettii (De Wild.) P.G. Waterman
Zanthoxylum heitzii (Aubr. & Pellegr.) P.G. Waterman
Zanthoxylum poggei (Engl.) P.G. Waterman
Zanthoxylum sp. 1
Zanthoxylum sp. 2

Samydaceae

Homalium dolichophyllum Gilg.

Sapindaceae

Allophylus africanus P. Beauv.
Allophylus bullatus Radlk.
Blighia sapida K.D. Koenig
Blighia unijugata Bak.
Blighia welwitschii (Hiern) Radlk.
Blighia sp.
Chytranthus macrobotrys (Gilg.) Exell & Mendonca Hauman
Chythranthus sp.
Eriocoelum macrocarpum Gilg
Laccodiscus ferrugineus (Baker) Radlk.
Lecaniodiscus cupanioides Planch.
Majidea fosteri (Sprague) Radlk.
Pancovia sp. Willd.
Paullinia pinnata L.
Placodiscus glandulosus Radlk.

Sapotaceae

Aningeria altissima (A. Chev.) Aubr. & Pellegr.

Aningeria robusta (A. Chev.) Aubr. & Pellegr.
Chrysophyllum beguei Aubr. & Pellegr.
Chrysophyllum boukokoensis Aubr. & Pellegr.
Chrysophyllum sp. L.
Englerophytum sp. K. Krause
Omphalocarpum elatum Miers
Omphalocarpum procerum P. Beauv.
Pouteria alnifolia (Baker) Roberty
Synsepalum brevipes (Baker) T.D. Penn.
Synsepalum msolo (Engl.) T.D. Penn.

Scrophulariaceae

Bartsia petitiana (A. Rich.) Hemsl.
Torenia thouarsii (Cham. & Scltdl.)
Veronica abyssinica Fresen.

Scytopetalaceae

Oubanguia alata Bak.f.
Rhaptopetalum coriaceum Oliv.
Rhaptopetalum sp.

Simaroubaceae

Hannoa klaineana Pierre & Engl.

Sterculiaceae

Melochia sp.
Cola acuminata (P. Beauv.) Schott & Endl.
Cola anomala K. Schum.
Cola ballayi Cornu ex Heckel
Cola chlamydantha K. Schum.
Cola digitata Mast.
Cola ficifolia Mast.
Cola flaviflora Engl. & K. Krauss
Cola flavo-velutina K. Schum.
Cola lepidota K. Schum.
Cola millenii K. Schum.
Cola nitida (Vent) Schott & Endl.
Cola rostrata K. Schum.
Cola semecarpophylla K. Schum.
Cola verticillata (Thonn.) Stapf
Cola sp. 1
Cola sp. 2
Cola sp. 3
Leptonychia multiflora K.Schum.
Leptonychia sp.
Pterygota macrocarpa K. Schum.
Pterygota sp.
Scaphopetalum sp.
Sterculia oblonga. Mast
Sterculia subviolacea K. Schum.
Sterculia tragacantha Lindl.
Sterculia sp. 1
Sterculia sp. 2

Thymeliaceae

Dicranolepis disticha Planch.
Dicranolepis glandulosa Engl.

Tiliaceae

Ancistrocarpus densispinosus Oliv.
Ancistrocarpus sp.
Desplatsia chrysochlamys (Mildbr. & Burret) Mildbr. & Burret
Desplatsia dewevrei (De Wild. & Th. Dur.) Burret
Duboscia macrocarpa Bocq.
Glyphaea brevis (Spreng.) Monach.
Glyphaea sp.
Grewia coriacea Mast.
Grewia pubescens P. Beauv.
Triumfetta sp.

Ulmaceae

Celtis tessmannii Rendle.
Celtis zenkeri Engl.
Trema orientalis (L.) Blume

Urticaceae

Pilea angolensis (Hiern.) Rendle
Pilea sp.

Verbenaceae

Clerodendron dusenii Gurke
Clerodendron grandifolium Gurke
Clerodendrum globuliferum B. Thomas
Clerodendrum splendens G. Don
Clerodendrum umbellatum Poir.
Clerodendrum sp. 1
Clerodendrum sp. 2
Clerodendrum sp. 3
Vitex doniana Sweet
Vitex ferruginea Schum. & Thonn.
Vitex grandifolia Gurke
Vitex rivularis Gurke
Vitex sp.

Violaceae

Allexis sp.
Rinorea dentata (P. Beauv.) Kuntze
Rinorea oblongifolia (C.H. Wright) Marquand ex Chipp
Rinorea welwitschii (Oliv.) Kuntze
Rinorea kamerunensis Engl.
Rinorea sp. 1
Rinorea sp. 2
Rinorea sp. 3
Rinorea sp. 4
Rinorea sp. 5

Vitaceae

Ampelocissus cf cavicaulis (Baker) Planchon
Cissus dinklagei Gilg. & Brandl.

Vochysiaceae

Erismadelphus exsul Mildbr.

MONOCOTYLEDONS

Amaryllidaceae

Scadoxus cinnabarinus (Decaisne) Friis & Nordal
Scadoxus pseudocaulus (Bjornst & Friis) Friis

Araceae

Anchomanes difformis (Blume) Engl.
Anubias barteri Schott.
Cercestis camerunensis (Ntepe-Nyame) Bogner
Cercestis dinklagei Engl.
Cercestis kamerunianus (Engl.) R. Br.
Cercestis mirabilis (N.E. Br.) Bogner
Culcasia dinklagei Engl.
Culcasia scandens P. Beauv.
Culcasia striolata Engl.
Culcasia sp. 1
Culcasia sp. 2
Nephthytis poissonii (Engl.) N.E. Br.
Nephthytis sp.
Rhaphidophora africana N.E. Br.
Stylochaeton sp.

Commelinaceae

Aneilema beniniense (P. Beauv.) Kunth
Aneilema sp.
Coelotrype laurentii K. Schum.
Commelina camerunensis J.K. Morton
Commelina sp.
Cyanotis barbata D. Don
Palisota ambigua (P. Beauv.) C.B. Cl.
Palisota barteri Hook.
Palisota capitata Benth.
Palisota hirsuta (Thunb.) K. Schum.
Palisota lagopus Mildbr.
Palisota mannii C.B. Cl.
Palisota sp.
Pollia condensata C.B. Cl.
Polyspatha paniculata Benth.
Polyspatha sp.

Costaceae

Costus fissiligulatus Gagnepain
Costus englerianus K. Schum.
Costus lucanusianus J. Braun & K. Schum.

Cyperaceae

Carex echinochloë Kunze
Cyperus reduncus Hoechst ex Boeck
Cyperus tenuis Sw.
Kyllinga sp.
Mapania amplivaginata K. Schum.
Mapania macrantha (Boeck) H. Pfeiffer

Dioscoreaceae

Dioscorea mangenotiana J. Miege
Dioscorea sp.

Dracaenaceae

Dracaena camerooniana Baker
Dracaena phrynoides Hook.
Dracaena sp.

Graminae

Centotheca lappacea (L.) Desr.
Leptapsis zeylanica Nees
Panicum sp.
Guaduella sp.
Melinis sp.
Olyra latifolia L.
Setaria megaphylla Th. Dur. & Schinz.

Liliaceae

Chlorophytum sparsiflorum Bak.
Chlorophytum sp.
Gloriosa superba L.

Marantaceae

Aetinidia conferta (Benth.) Milne-Redh.
Halopegia azurea (K. Schum.) K. Schum.
Marantochloa filipes (Benth.) Hutch
Marantochloa leucantha (K.Schum.) Milne-Redh.
Marantochloa sp. 1
Marantochloa sp. 2
Marantochloa sp. 3
Megaphrynium sp. 1
Megaphrynium sp. 2
Megaphrynium trichogynum Koechlin
Megaphrynium macrostachyum (Benth.) K. Schum.
Sarcophrynium brachystachyum var brachystachyun (Benth.) K. Schum.
Sarcophrynium priogonium var priogonium (K.Schun K. Schum.
Sarcophrynium sp.
Thaumatococcus daniellii (Benn.) Benth.
Trachyphrynium braunianum (K.Schum.) Bak.

Orchidaceae

Ancistrochilus thomsonianus (Rchb.f.) Rolfe
Ancistrorhynchus capitatus (Lindl.) Summerh.
Angraecum angustipetalum Rendle
Angraecum aporoides Summerh.
Angraecum birrimense Rolfe
Brachycorythis macrantha (Lindl.) Summerh.
Cyrtorchis arcuata (Lindl.) Schltr.
Cyrtorchis chailluana (Hook.f) Schltr.
Diaphananthe bueae (Schltr.) Schltr.
Diaphananthe pellucida (Lindl.) Schltr.
Diaphananthe plehniana (Schltr.) Schltr.
Diaphananthe sp.
Eurychone rothschildiana (O' Brien) Schltr.
Graphorkis lucida (Sw.) O. Kuntze
Liparis sp.

Nervilia sp.
Plectrelminthus caudatus (Lindl.) Summerh.
Polystachya albescens Ridl.
Polystachya odorata Lindl.
Polystachya sp.
Solenangis scandens (Schltr.) Schltr.

Palmae

Elaeis guinensis Jacq.
Eremospatha macrocarpa (G. Mann & H. Wendl.) H. Wendl.
Eremospatha quinquecostulata Becc.
Eremospatha tessmanniana Becc.
Eremospatha wendlandiana Dammer ex Becc.
Eremospatha sp.
Laccosperma opacum (G. Mann & H. Wendl.) Drude
Laccosperma robustum (Burr.) J. Dransf.
Laccosperma secundiflorum (P.Beauv.) Kuntze
Laccosperma sp. nov.
Oncocalamus tuleyi Sunderland
Raphia hookeri G. Mann & H. Wendl.

Smilacaeae

Smilax kraussiana Meisn.
Smilax anceps Willd.

Zingiberaceae

Aframomum alboviolaceum (Ridley) K.Schum.
Aframomum arundinaceum (Oliv. & Hanb.) K. Schum
Aframomum citratum (Piereira) K.Schum.
Aframomum flavum Lock
Aframomum pilosum (Oliv. & Hanb.) K. Schum
Aframomum sp. 1
Aframomum sp. 2
Aframomum sp. 3
Aframomum sp. 4
Renealmia africana (K. Schum.) Benth.
Renealmia cincinnata (K. Schum.) Baker
Renealmia polypus Gagnepain
Renealmia sp.

GYMNOSPERMS

Gnetaceae

Gnetum africanum Welw.

FERNS & allies

Aspleniaceae

Asplenium sp.

Cyatheaceae

Cyathea manniana Hook.

Dennstaedtiaceae

Pteridium aquilinum subsp aquilinum (L.) Kuhn

Dryopteridaceae

Filix sp.
Lastreopsis barteriana (Hook.) Tardieu

Hymenophyllaceae

Osmunda regalis L.

Lomariopsidaceae

Bolbitis sp.
Lomariopsis guineensis (Underw.) Alston.
Lomariopsis sp. 1
Lomariopsis sp. 2

Marattiaceae

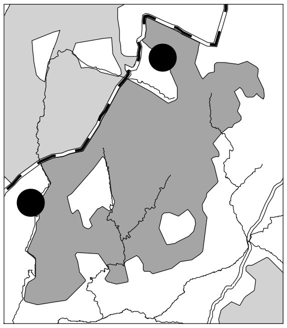
Marattia fraxinea J. Sm.

Selaginellaceae

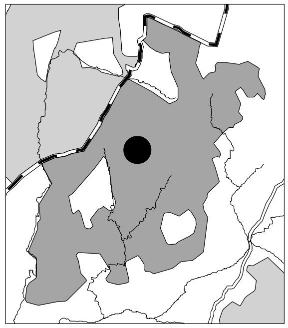
Selaginella myosurus (SW) Alston
Selaginella sp. 1
Selaginella sp. 2

Appendix 2. Conservation priority speicies in Takamanda Forest Reserve, Cameroon.

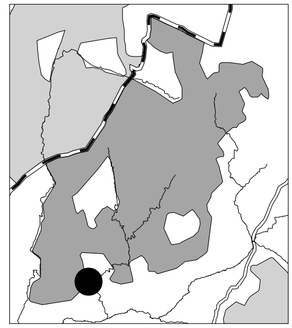
Ancistrocladus letestui
(Ancistrocladaceae)



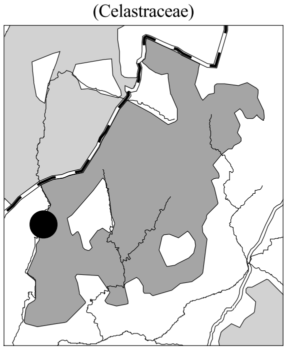
Gossweilerodendron balsamiferum
(Caesalpiniaceae)



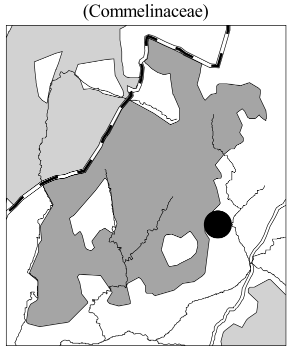
Microberlinia bisulcata
(Caesalpiniaceae)



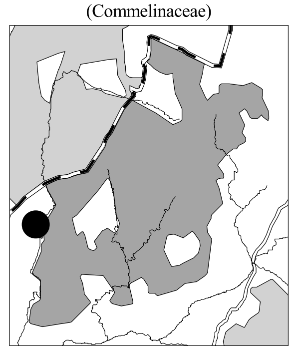
Salacia volubilis
(Celastraceae)



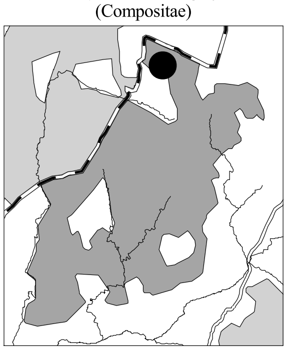
Commelina camerunensis
(Commelinaceae)



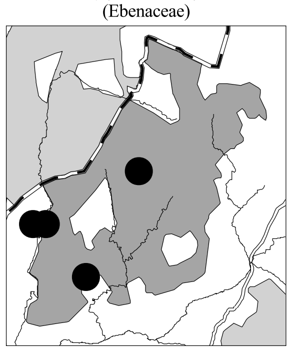
Palisota lagopus
(Commelinaceae)



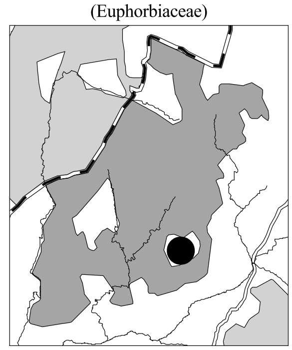
Crassocephalum boughyanum
(Compositae)



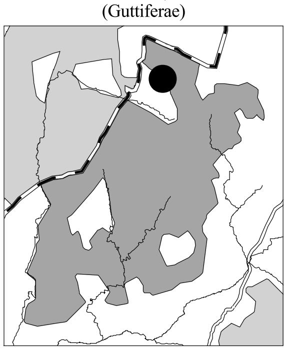
Diospyros crassiflora
(Ebenaceae)



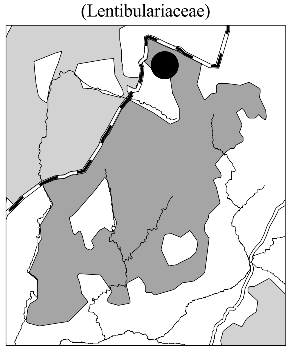
Uapaca vanhouttei
(Euphorbiaceae)



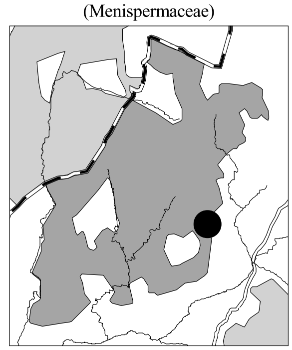
Garcinia afzelii
(Guttiferae)



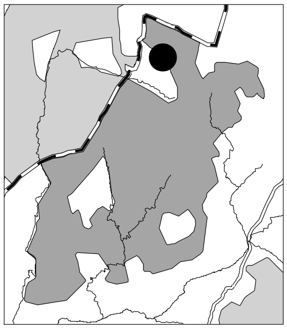
Utricularia mannii
(Lentibulariaceae)



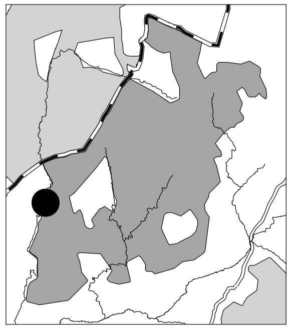
Penianthus camerunensis
(Menispermaceae)



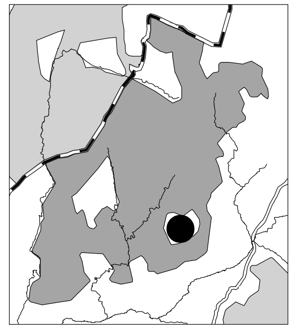
Campylospermum subcordatum
(Ochnaceae)



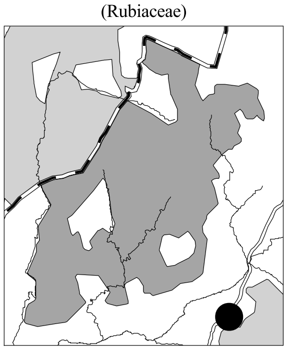
Pavetta longibracteata
(Rubiaceae)



Pavetta owariensis
(Rubiaceae)



Petiticodon parviflorum
(Rubiaceae)



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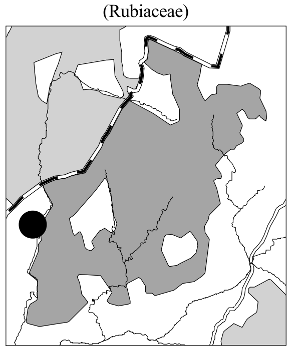
(Rubiaceae)



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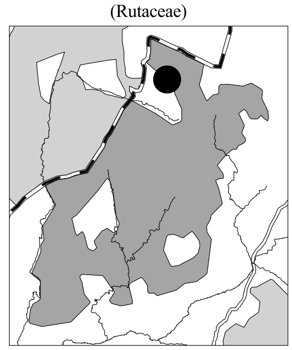

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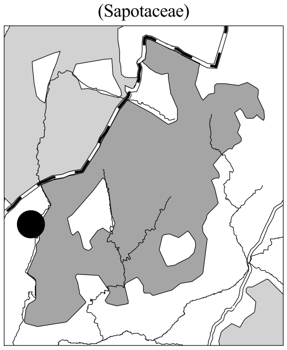

Pterygota macrocarpa
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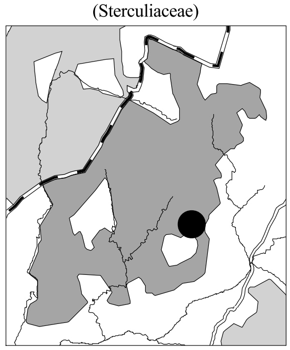
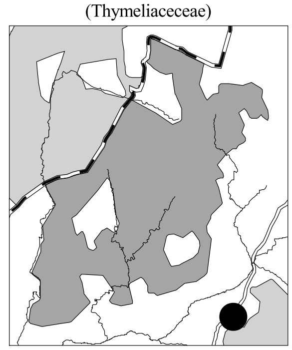


Dicranolepis glandulosa
(Thymeliaceceae)



Vitex ferruginea
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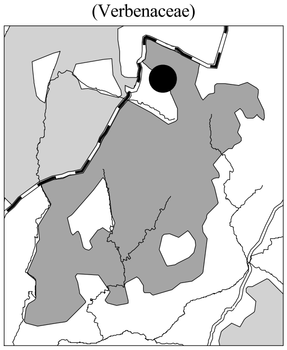

Butterfly Fauna of Takamanda Forest Reserve, Cameroon

Ebwekoh Monya O' Kah

1 Introduction

Butterflies (order Lepidoptera) constitute about 1% of all named insects (Larsen 1996) and are one of the most intensively studied groups (Borror *et al.* 1989). Their comparatively large size and bright colors, species distributions and abundances, and the relative ease in rearing some species in captivity has led to a considerable amount of research—and some very interesting findings. As example, it was genetic information from research on the polymorphic Swallow Tail (Larsen 1996), which in Cameroon is represented by *Papilio dardanus*, that uncovered the Rhesus factor in human blood. Other important advances made possible in part by research on butterflies include studies on the evolution of plant-herbivore interactions (Ehrlich and Raven 1964, Johnson 1994).

From the human perspective, butterflies are both beneficial and harmful. In the beneficial category, some species of butterflies are prolific plant pollinators, and many of these creatures have relatively high economic value as they are used for entertainment, decorative art, and collections (Johnson 1994, Spiers 1990). The fact that some butterflies exhibit a high host specificity makes them a potential biological control agent.

On the other hand, Lepidoptera such as the gypsy moth (*Lymantria dispar*) can defoliate trees across large tracts of forest (Work and McCullough 2000), while others are crop pests (Haile and Hofsvang 2001).

Of the 17,280 species of butterflies already described worldwide (Shields 1989), about 3,600 occur in Africa (Carcasson *et al.* 1995)—many in the Guineo-Congolian tropical rainforest, part of a larger region that contains the "greatest density of butterfly species" and is one of the richest units of butterfly diversity, mainly because of humid and warm climatic conditions that allow several broods and a "consequent rapid evolution" (Carcasson *et al.* 1995).

Takamanda Forest Reserve (TFR) in Southwest Province of Cameroon is included in this diverse rainforest. While the Reserve is expected to harbor a highly diverse butterfly fauna, no systematic study had been undertaken for this group (Fomete Nembot and Tchanou 1998) until the research that forms the basis for this paper. An assessment of Lepidoptera at the Reserve took place during 21 days between April and June 2001. The objective was to obtain initial data on the composition of the butterfly fauna and elaborate the first-ever checklist for TFR.

2 Methods

Specimens were collected using 20 locally constructed aerial bait traps (Davies, 1994) placed at 16 survey sites that ranged between 200 and 800m above sea level, many of which were also used for vegetation, mammal, and bird surveys at Takamanda. All sites were geo-referenced, using a Garmin 12XL GPS (Figure 1, Table 1).

The traps were set at different heights in the canopy to capture and record species that typically feed at progressively higher levels. Bait (rotten fruit and dog faeces) was changed daily, and the traps were checked twice daily. Trapped butterflies were collected and identified.

Sweep-netting was also carried out along forest paths at the sites where the aerial traps were placed and while traveling among the sampling locations.

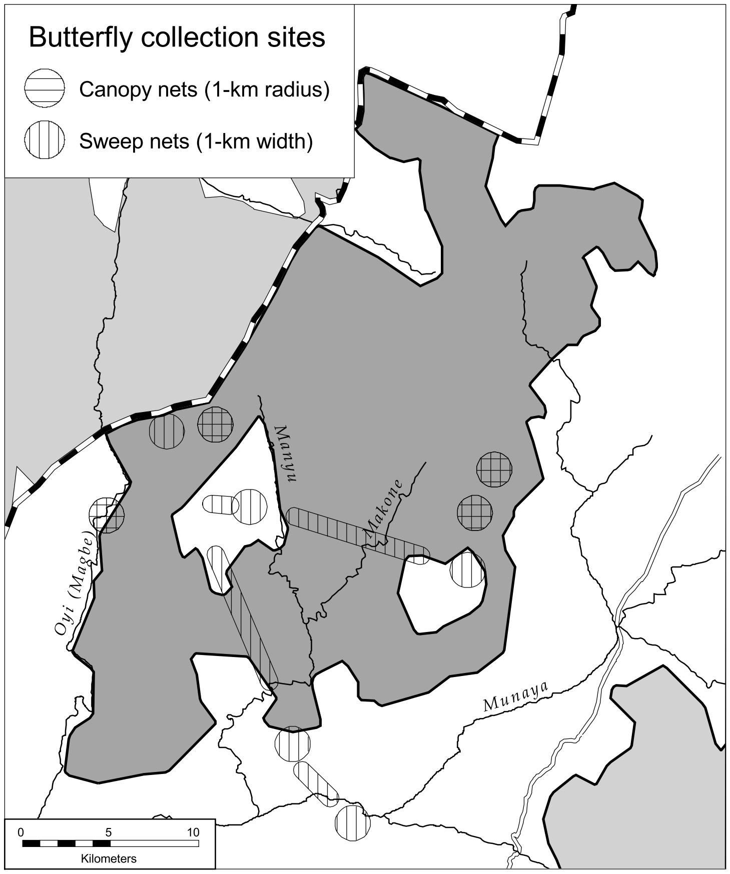

Figure 1. Sampling locations of butterflies in Takamanda Forest Reserve, Cameroon

Specimens were placed in butterfly envelopes and preserved in airtight containers with mothballs to prevent deterioration and protect the specimens from invading insects. Information on collection site, date, collector, and method of trapping (SN = Sweep Netting and CN = Canopy Netting) was documented.

Identification was completed in Limbe, using identification keys and manuals as well as color plates as suggested by Larsen (1996). Where possible, specimens were identified to family, sub-family, species, and race. Classification followed that of the Afrotropical Catalogue (Carcasson *et al.* 1995). Specimens whose full identification was not possible on site were sent to specialists. Specimens will be deposited primarily in the Limbe Botanic and Zoological Gardens, Cameroon.

3 Results and Discussion

A total of 111 species representing 4 families were identified from the 384 specimens collected (Appendix 1), with 79 specimens identified to species (Appendices 1 and 2).

The majority (78%) of specimens were collected using sweep netting, while the canopy traps accounted for 22% of the collection. During the survey 85 (22%) of individuals were trapped using canopy traps, while 298 (78%) individuals were captured using sweep-nets. Canopy traps are known to attract only those species that prefer fruits. This method is best used during the dry season when the butterflies can forage freely over longer distances. The difference between capture rates in the canopy

Table 1. Study sites locations in Takamanda Forest Reserve, Cameroon.

Study sites	Altitude (m)	Site code	Forest Type
Between Obonyi I & Assam	<400	1	Lowland forest
Kekpane	<400	2	Lowland forest
Obonyi I Hills (Camp)	600 – 800	3	Lowland ridge forest
Kekpane Camp	<400	4	Riverine forest
Takamanda Camp	250	5	Lowland forest
Between Okpambe & Assam	<400	6	Lowland forest
Obonyi I Hills	600 – 800	7	Lowland ridge forest
Between Assam & Obonyi I	<400	8	Lowland forest
Kekpane Camp XI	<400	9	Lowland forest
Assam	<400	10	Lowland forest
Between Obonyi III & Kekpane	<400	11	Lowland forest
Between Obonyi I & III	<400	12	Lowland forest
Obonyi I Magbe	550	13	Riverine forest
Obonyi I Camp	<400	14	Lowland forest
Matene Camp	400 – 800	15	Mid-elevation forest
Takamanda	250	16	Lowland forest

trapping and sweep-netting results from the relative difficulty that butterflies encounter in moving through the canopy during the wet season. The result should therefore be interpreted as an issue of seasonal variation rather than a sampling inefficiency of the canopy traps, and further highlights the need to conduct year round data collecting in TFR.

Many of the species identified for the area (for example, *Leptosia alcesta inalcesta*, *Catuna crithea conjuncta*, and *Cymothoe hobarti hobarti*) are typical forest species that have a strong preference for dense, wet forest conditions. Most other species, which may not be restricted to dense forest, are generalists largely associated with secondary forest. These findings indicate that the forest is still relatively undisturbed. Five species—*Argyrocheila inundifera*, *Graphium (Arisbe) policenoides liponesco*, *Graphium (Arisbe) ucalegon ucalegon*, *Pseudopontia paradoxa*, and *Triclema nigeriae*—generally considered rare,

Table 2. Lists 10 most and 10 least abundant species in the Takamanda Forest Reserve, Cameroon

	10 most abundant Species	# of individuals		10 least abundant Species	# of individuals
1	*Eurema (Terias) senegalensis*	17	1	*Neptis melicerta*	1
2	*Catuna sp1*	16	2	*Neptis nicobule*	1
3	*Hypolimnas salmacis*	15	3	*Papilio (Princeps) dardanus*	1
4	*Euphaedra medon fraudata*	13	4	*Papilio (Princeps) jacksoni*	1
5	*Nepheronia argia argia*	13	5	*Papilio sp1*	1
6	*Euphaedra orientalis*	11	6	*Papilio sp2*	1
7	*Euphaedra rex*	11	7	*Pseudacraea lucretia protracta*	1
8	*Phalanta eurytis*	11	8	*Sallya sp1*	1
9	*Catuna sp3*	10	9	*Triclema nigeriae*	1
10	*Graphium sp.*	10	10	*W sp1*	1

Table 3. Species found in intact forest formations Takamanda Forest Reserve, Cameroon

Species
1. *Pseudopontia paradoxa* (wet forest)
2. *Graphium (Arisbe) latreillianus* (moist forest)
3. *Aterica galene galene*
4. *Bicyclus mesogena*
5. *Catuna crithea conjuncta*
6. *Harma theobene blassi*
7. *Hypolimnas dinarcha*
8. *Hypolimnas salmacis*
9. *Neptis clarei*
10. *Euxanthe (Euxanthe) eurinome elgonae*
11. *Eurema (Terias) senegalensis*
12. *Epitola viridana*

Table 4. Summary of Butterfly conservation status for Takamanda Forest Reserve, Cameroon.

	# of Spp.
Rare	5
Common	76
Primary forest species	56
Disturbance tolerant species	25
Total no. of species fully identified	81

were identified in our samples. It is not certain whether these species are threatened in Takamanda Forest Reserve and face local extinction if precautions are not taken. However, the presence of these rare species may indicate undetermined qualities of their habitats, which underscores the need for their conservation and additional research.

Table 2 presents the relative abundance of the 10 most frequent and 10 least frequent species in TFR. Most of the common species are typical of forests (Appendix 2), and their abundance here indicates that the vegetation is characteristic of a nondegraded rainforest. The Takamanda area is dominated by primary forest (see Sunderland *et al.* this volume), a condition verified by the proliferation of butterfly species such as *Neptis clarei*, *Leptosia alcesta inalcesta*, and *Catuna crithea conjuncta* that will disappear at the first sign of forest disturbance (Larsen 1992). The least common species are also forest dwellers, but are more prone to disturbed and/or open forest formations, which comprise just a small portion of the Takamanda area (see Slayback this volume).

Table 3 shows the degree of intactness of the Takamanda forest through the much higher number of primary forest-dependent species (56, or 69% of all identified species) compared to disturbance tolerant species (25, or 31%). The majority of the species found were common within the forest reserve (Table 4). This is probably explained by the fact that the forest is generally conducive to their survival.

The Nymphalidae is the dominant family in the area (Table 5), with 260 (68%) specimens of the total 384 collected and 74 (67%) of the 111 identified to

Table 5. Butterfly families represented with their respective number of specimens in the Takamanda Forest Reserve, Cameroon.

Family	*No. of specimens collected*	*% specimens*	*No. of species*	*% species*
Papilionidae	35	9	12	11
Pieridae	60	16	14	13
Lycaenidae	13	3	6	5
Nymphalidae	260	68	74	67
Unidentified	16	4	5	5
Total	**384**	**100**	**111**	**100**

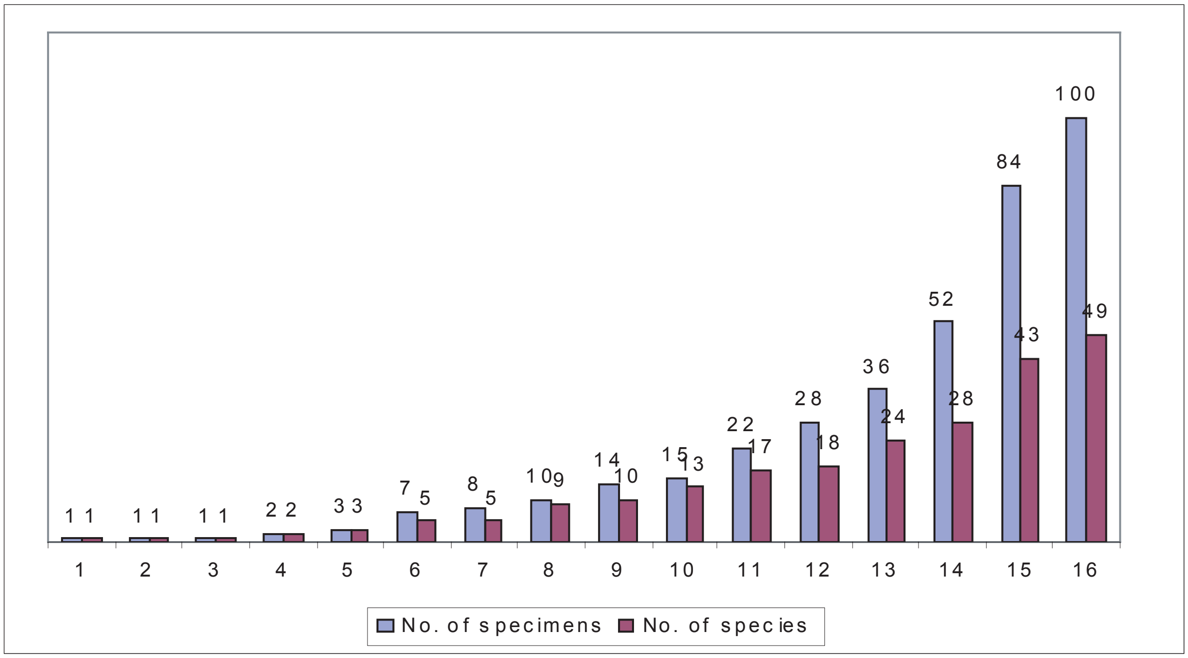

Figure 2. Species richness of study sites expressed as species abundance in relation to the number of individuals sampled for Takamanda Forest Reserve, Cameroon (see Table 1 for site codes).

species. Lycaenidae were the least common, accounting for 13 (3%) of all specimens and 6 (5%) of identified species. These findings are not surprising; the Nymphalidae are among the most successful families in Africa at 1,517 species (Carcasson *et al.* 1995). Most members of the family are known to adapt to a variety of habitats, and species diversity within the group is high. The family consists of many sub-taxa that were originally considered separate families, while the danaids, satyrids, libytheids, and riodinids were once deemed to be the same family (Feltwell 1993).

While Lycaenidae is a larger family than the Nyphalidae, it was far surpassed by the latter in specimens collected. This can probably be explained by collector bias; Lycaenids are generally smaller in size and less colourful than the Nymphalids, and hence less likely to be seen. Therefore, it is possible that the study area contains more species of all families collected from this survey and, if the bias is addressed in future studies, the checklist of butterflies for Takamanda may be much longer.

Figure 2 illustrates the species richness of each site in relation to the number of individuals sampled and the species that were identified. Takamanda, Matene Camp, and Obonyi I Camp were the three richest sites both in identified species and specimens collected. The least rich sites were Obonyi, Assam, Kekpane, and Obonyi I Camp Hills. The vegetation composition of a particular area will determine whether butterflies will inhabit or visit the area and also their population density at any point in time. Thus, it can be inferred that Takamanda, Matene Camp, and Obonyi I Camp are more productive for and conducive to butterfly survival.

Although species indicating forest disturbance, like those listed in Table 6 (for example, *Junonia oenone oenone*), are present in the study area, their numbers are sufficiently low enough to suggest failure in effectively colonizing the area. This can only be explained by the fact that the forest does not provide conditions for their survival. Moreover, most of the species encountered are forest generalists rather than disturbed forest species. The generalists prefer forest clearings, forest edges, and forest paths, all of which occur throughout TFR.

Table 6. Indicators of secondary or disturbed forest in Takamanda Forest Reserve, Cameroon.

Species	***Sites occurring***
1. Eurema (Terias) hecabe solifera	B/W Obonyi I & III, Matene Camp, Takamanda areas
2. Danaus (Anosia) chrysippus aegyptius	Assam, Obonyi I Magbe and Takamanda
3. Junonia oenone oenone	Assam and Takamanda Camp areas
4. Junonia terea elgiva	Assam, Matene Camp, Obonyi I Magbe

Using butterflies as indicators of forest quality suggests that Assam is the most degraded site, as nearly all species that occur there prefer secondary habitat. Takamanda, Matene Camp, and Obonyi I Magbe also show signs of degradation. Even though the sampling sites were located in undisturbed areas away from the camps, the species composition indicates that some unseen factor is influencing species composition in favor of butterflies that are adapted to degraded habitats. Three of the four campsites sampled in the study are popular with such species.

Table 7. Indicators of secondary or disturbed forest and their sites of occurrence in Takamanda Forest Reserve, Cameroon.

Species	***Sites occurring***
1. Papilio (Princeps) dardanus	Obonyi I Camp
2. Nepheronia argia argia	Matene Camp, Kekpani Camp XI and Takamanda
3. Leptosia alcesta inalcesta	B/W Obonyi III and Kekpani, Obonyi I Camp and Obonyi I Magbe.
4. Euphaedra medon fraudata	B/W Obonyi III & Kekpani, B/W Okpambe & Assam, Kekpani Camp XI, Obonyi I Camp, Obonyi I Hills, Obonyi I Magbe, & Takamanda

In short, our findings may demonstrate that TFR is an intact forest in the initial stages of degradation. This was not directly apparent from field observations, but analysis of the results of this study point to the fact that butterfly composition is more sensitive to changes and thus may provide a good indicator of future conditions. Still, we found species that are common throughout the Reserve in different habitat types (Table 7).

Though very little work has been undertaken on the butterfly fauna of Cameroon, the immediate neighboring forests between Korup (including the Rumpi Hills) and Oban Hills in Nigeria have been studied (Obot and Ogar 1997). A cursory analysis of the results from these areas and those from our studies reveals an association in the butterfly fauna. About 40% of the species identified for TFR were also found to occur in Korup and/or the Oban Hills. Genera such as Eurema, Junonia, Bicyclus, Charaxes, Acrea, Euphaedra, are all represented in the communities of each site. There are, however, some common species (e.g. *Papilio lormieri, Belenois sudanensis)* that one would expect to find in the Korup list, but that curiously do not appear. The affinities between Korup and TFR are explained by the fact that the two forests are virtually contiguous and share similar physical and biological characteristics. Many of the butterfly species of both forests are migrant species, some local migrants, and hence should be able to move between the two areas. Thus, it is likely attributed to the less degraded conditions in Takamanda Forest Reserve compared with Korup.

4 Conclusion

Because little data are available on butterfly distribution in Cameroon (Larsen 1997), the results of this study will contribute to:

- a better understanding of the natural history of different butterfly species,
- their range, distribution, and affinity for different habitat types,

Table 8. Species common to all forest categories occurring in Takamanda Forest Reserve, Cameroon.

Species		Sites occurring
1.	*Papilio (Princeps) dardanus*	Obonyi I Camp
2.	*Nepheronia argia argia*	Matene Camp, Kekpani Camp XI and Takamanda
3.	*Leptosia alcesta inalcesta*	B/W Obonyi III and Kekpani, Obonyi I Camp and Obonyi I Magbe.
4.	*Euphaedra medon fraudata*	B/W Obonyi III & Kekpani, B/W Okpambe & Assam, Kekpani Camp XI, Obonyi I Camp, Obonyi I Hills, Obonyi I Magbe, & Takamanda

- a checklist of species for Takamanda Forest Reserve, and
- baseline information needed to monitor the success of conservation measures that use butterflies as indicators.

This study represents an important first step in identifying likely sites to concentrate conservation efforts, based on the changing composition of species within the butterfly community. Areas where degradation has occurred or is beginning to take place should be targeted for initial conservation measures.

The study can be improved through additional research over longer periods time to cover seasonal ranges within the variety of habitat types. A key question that remains to be answered is whether or not using butterflies as indicators will enable researchers to predict the presence of other taxa and thereby contribute immensely to studies of overall ecosystem health at TFR.

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Appendix 1. Checklist of Butterflies of the Takamanda Forest Reserve, Cameroon (after Carcasson *et al.* 1995)

Genus	Species	Race	Authority and Year of publication
PAPILIONIDAE			
Papilio			Linnaeus, 1758
Papilio (Princeps)	*dardanus*		Brown
Papilio (Princeps)	*echerioides*	*zoroastres*	Druce, 1878
Papilio (Princeps)	*hesperus*	*hesperus*	Westwood, 1843
Papilio (Princeps)	*jacksoni*		Sharpe
Papilio (Princeps)	*lormieri*		Distant
Papilio	*sp1*		
Papilio	*sp2*		
Graphium			Scopoli, 1777
Graphium (Arisbe)	*latreillianus*	*theorini*	(Aurivillius), 1881
Graphium (Arisbe)	*leonidas*	*leonidas*	(Fabricius), 1793
Graphium (Arisbe)	*policenoides*	*liponesco*	Suffert, 1904
Graphium (Arisbe)	*porthaon*		(Hewitson)
Graphium (Arisbe)	*ucalegon*	*ucalegon*	(Hewitson), 1865
PIERIDAE			
Pseudopontia			Plôtz, 1870
Pseudopontia	*paradoxa*		(Felder and Felder)
Eurema			Hubner, 1819
Eurema (Terias)	*hapale*		(Mabille)
Eurema (Terias)	*hecabe*	*solifera*	(Butler), 1875
Eurema (Terias)	*senegalensis*		(Boisduval)
Nepheronia			Butler, 1870
Nepheronia	*argia*	*argia*	(Fabricius), 1775
Colotis			Hubner, 1819
Colotis	*sp1*		
Belenois			Hubner, 1819
Belenois	*sudanensis*		(Talbot)
Dixeia			Talbot, 1932
Dixeia	*orbona*	*vidua*	(Butler), 1900
Appias			Hubner, 1819
Appias (Glutophrissa)	*epaphia*	*orbona*	(Boisduval), 1833
Appias (Glutophrissa)	*sabina*	*phoebe*	(Butler), 1901
Mylothris			Hubner, 1819
Mylothris	*continua*	*continua*	Talbot, 1944
Mylothris	*sp1*		
Leptosia			Hubner, 1818
Leptosia	*alcesta*	*inalcesta*	Bernardi, 1959
Leptosia	*nupta*	*nupta*	(Butler), 1873

Continued

Appendix 1 (cont.). Checklist of Butterflies of the Takamanda Forest Reserve, Cameroon (after Carcasson *et al.* 1995)

Genus	Species	Race	Authority and Year of publication
NYMPHALIDAE			
Acraea			Fabricius, 1807
Acraea (Acraea)	*aganice*	*ugandae*	(van Someren), 1936
Acraea (Acraea)	*tellus*	*tellus*	(Aurivillius), 1893
Acraea (Actinote)	*conradti*	*conradti*	Oberthur, 1893
Acraea (Actinote)	*sotikensis*		Sharpe
Acraea	*sp1*		
Acraea	*sp2*		
Acraea	*sp3*		
Acraea	*sp4*		
Acraea	*sp5*		
Danaus			Kluk, 1802
Danaus (Anosia)	*chrysippus*	*aegyptius*	(Schreber), 1759
Amauris			Hubner, 1816
Amauris (Amauris)	*niavius*	*niavius*	(Linnaeus), 1758
Bicyclus			Kirby, 1871
Bicyclus	*mesogena*		(Karsch)
Bicyclus	*smithi*		(Aurivillius)
Bicyclus	*sp1*		
Bicyclus	*sp2*		
Bicyclus	*sp3*		
Lachnoptera			Doubleday, 1847
Lachnoptera	*anticlia*		(Hubner)
Phalanta			Horsfield, 1829
Phalanta	*eurytis*		(Doubleday)
Kallimoides			Shirôzu & Nakanishi , 19
Kallimoides	*rumia*		(Doubleday)
Hypolimnas			Hubner, 1819
Hypolimnas	*anthedon*	*anthedon*	Doubleday, 1845
Hypolimnas	*dinarcha*		(Hewitson)
Hypolimnas	*salmacis*		(Drury), 1773
Hypolimnas	*sp1*		
Salamis			Boisduval, 1833
Salamis	*anacardii*		(Linnaeus)
Junonia			Hubner, 1819
Junonia	*oenone*	*oenone*	(Linnaeus), 1758
Junonia	*sophia*	*infracta*	Butler, 1888
Junonia	*stygia*	*gregorii*	Butler, 1896
Junonia	*terea*	*elgiva*	Hewitson, 1864
Junonia	*sp1*		

Continued

Appendix 1 (cont.). Checklist of Butterflies of the Takamanda Forest Reserve, Cameroon (after Carcasson *et al.* 1995)

Genus	Species	Race	Authority and Year of publication
Sallya			Hemming, 1964
Sallya	*amulia*	*rosa*	(Hewitson), 1877
Sallya	*sp1*		
Cyrestis			Boisduval, 1832
Cyrestis (Azania)	*camillus*	*camillus*	(Fabricius), 1781
Neptis			Fabricius, 1807
Neptis	*agouale*		Pierre-Baltus
Neptis	*carcassoni*		van Son, 1959
Neptis	*clarei*		Neave
Neptis	*laeta*		Overlaet
Neptis	*melicerta*		(Drury)
Neptis	*nicobule*		Holland
Neptis	*strigata*		Aurivillius
Harma			Doubleday, 1848
Harma	*theobene*	*blassi*	(Weymer), 1892
Cymothoe			Hubner, 1819
Cymothoe	*caenis*		(Drury)
Cymothoe	*fumana*		(Westwood)
Cymothoe	*hobarti*	*hobarti*	Butler, 1900
Cymothoe	*sp1*		
Pseudoneptis			Snellen, 1882
Pseudoneptis	*bugandensis*	*bugandensis*	Stoneham, 1935
Pseudacraea			Westwood, 1850
Pseudacraea	*lucretia*	*protracta*	(Butler), 1874
Euriphene			Boisduval, 1847
Euriphene (Euriphene)	*saphirina*	*saphirina*	(Karsch), 1894
Euriphene (Euryphura)	*chalcis*		(Felder and Felder)
Euriphene	*sp1*		
Euphaedra			Hubner, 1819
Euphaedra	*eupalus*		(Fabricius)
Euphaedra	*medon*	*inaequabilis*	Thurau, 1904
Euphaedra	*orientalis*		Rothschild
Euphaedra	*rex*		Stoneham
Euphaedra	*sp1*		
Euphaedra	*sp2*		
Euphaedra	*sp3*		
Bebearia			Hemming, 1960
Bebearia	*chriemhilda*		(Staudinger)
Bebearia	*mardania*	*mardania*	(Fabricius)
Bebearia	*sophus*	*audeoudi*	(Riley), 1936
Bebearia	*sp1*		

Continued

Appendix 1 (cont.). Checklist of Butterflies of the Takamanda Forest Reserve, Cameroon (after Carcasson *et al.* 1995)

Genus	Species	Race	Authority and Year of publication
Bebearia	*sp2*		
Bebearia	*sp3*		
Aterica			Boisduval, 1833
Aterica	*galene*	*galene*	(Brown), 1776
Cynandra			Schatz, 1887
Cynandra	*opis*		(Drury)
Catuna			Kirby, 1871
Catuna	*crithea*	*conjuncta*	Aurivillius, 1922
Catuna	*sp1*		
Catuna	*sp2*		
Catuna	*sp3*		
Catuna	*sp4*		
Charaxes			Ochsenheimer, 1816
Charaxes	*etheocles*		(Cramer)
Charaxes	*lucretius*	*intermedius*	van Someren, 1971
Euxanthe			Hubner, 1819
Euxanthe (Euxanthe)	*eurinome*	*birbirica*	Ungemach, 1932
Euxanthe (Hypomelaena)	*trajanus*		(Ward)
Libythea			Fabricius, 1807
Libythea	*labdaca*	*labdaca*	Westwood, 1851
LYCAENIDAE			
Argyrocheila			Staudinger, 1892
Argyrocheila	*inundifera*		Hawker-Smith
Epitola			Westwood, 1851
Epitola	*viridana*		Joicey and Talbot
Hypolycaena			C. & R. Felder, 1862
Hypolycaena	*hatita*	*ugandae*	Sharpe, 1904
Anthene			Doubleday, 1847
Anthene	*larydas*		(Cramer)
Triclema			Karsch
Triclema	*nigeriae*		(Aurivillius)
Azanus			Moore, 1881
Azanus	*ubaldus*		(Stoll)
UNIDENTIFIED			
V	*sp1*		
W	*sp1*		
X	*sp1*		
y	*sp1*		
Z	*sp1*		

Appendix 2. Butterfly species ecological and conservation status and their distribution/abundance at study sites in Takamanda Forest Reserve, Cameroon.Note: With contributions from Ngalame Ebenezar who collected the specimens.

	Genus	Species	Race	Abundance	Primary forest	Secondary forest	Assam	B/W Assam & Obonyi I	B/W Obonyi I & Assam	B/W Obonyi I & III	B/W Obonyi III & Kekpani	B/W Okpambe & Assam	Kekpani	Kekpani Camp	Kekpani Camp XI	Matene Camp	Obonyi I Camp	Obonyi I Camp Hills	Obonyi I Hills	Obonyi I Magbe	Takamanda	Takamanda Camp	Species distribution
1	*Acraea*	*sp1*																		x			1
2	*Acraea*	*sp2*														x							1
3	*Acraea*	*sp3*																			x		1
4	*Acraea*	*sp4*															x						1
5	*Acraea*	*sp5*															x						1
6	*Acraea (Acraea)*	*tellus*	*tellus*	c							x										x		2
7	*Acraea (Acraea)*	*aganice*	*ugandae*	c		x		x													x		2
8	*Acraea (Actinote)*	*conradti*	*conradti*	c		x														x			1
9	*Acraea (Actinote)*	*sotikensis*		c		x	x																1
10	*Amauris (Amauris)*	*niavius*	*niavius*	c		x	x																1
11	*Anthene*	*larydas*		c	x											x							1
12	*Appias (Glutophrissa)*	*epaphia*	*orbona*	c	x		x													x			2
13	*Appias (Glutophrissa)*	*sabina*	*phoebe*	c	x										x					x			2
14	*Argyrocheila*	*inundifera*		r	x											x					x		2
15	*Aterica*	*galene*	*galene*	c	x						x					x	x				x		4
16	*Azanus*	*ubaldus*		c		x										x							1
17	*Bebearia*	*chriemhilda*		c		x															x		1
18	*Bebearia*	*mardania*	*mardania*	c	x						x								x				2
19	*Bebearia*	*sophus*	*audeoudi*	c		x														x			1
20	*Bebearia*	*sp1*																			x		1
21	*Bebearia*	*sp2*															x						1
22	*Bebearia*	*sp3*																			x		1
23	*Belenois*	*sudanensis*		c	x										x	x							2

	Genus	Species	Race	Abundance	Primary forest	Secondary forest	Assam	B/W Assam & Obonyi I	B/W Obonyi I & Assam	B/W Obonyi I & III	B/W Obonyi III & Kekpani	B/W Okpambe & Assam	Kekpani	Kekpani Camp	Kekpani Camp XI	Matene Camp	Obonyi I Camp	Obonyi I Camp Hills	Obonyi I Hills	Obonyi I Magbe	Takamanda	Takamanda Camp	Species distribution
24	*Bicyclus*	*mesogena*		c	x											x							1
25	*Bicyclus*	*smithi*		c	x											x							1
26	*Bicyclus*	*sp1*						x															1
27	*Bicyclus*	*sp2*														x							1
28	*Bicyclus*	*sp3*																			x		1
29	*Catuna*	*crithea*	*conjuncta*	c	x									x		x	x			x	x		5
30	*Catuna*	*sp1*							x	x						x	x			x			5
31	*Catuna*	*sp2*															x						1
32	*Catuna*	*sp3*									x	x					x						3
33	*Catuna*	*sp4*															x						1
34	*Charaxes*	*etheocles*		c		x															x		1
35	*Charaxes*	*lucretius*	*intermedius*	c	x																x		1
36	*Colotis*	*sp1*									x												1
37	*Cymothoe*	*caenis*		c	x					x	x											x	3
38	*Cymothoe*	*fumana*		c	x			x		x						x	x			x	x		6
39	*Cymothoe*	*hobarti*	*hobarti*	c	x						x							x		x	x		4
40	*Cymothoe*	*sp1*		c							x												1
41	*Cynandra*	*opis*		c	x			x		x													2
42	*Cyrestis (Azania)*	*camillus*	*camillus*	c	x																x		1
43	*Danaus (Anosia)*	*chrysippus*	*aegyptius*	c		x	x													x	x		3
44	*Dixeia*	*orbona*	*vidua*	c	x											x							1
45	*Epitola*	*viridana*		c	x											x							1
46	*Euphaedra*	*eupalus*		c		x				x	x						x						3
47	*Euphaedra*	*medon*	*inaequabilis*	c	x						x	x			x		x		x	x	x		7

48	*Euphaedra*	*orientalis*		c	x			x	x	x	x		x			x	x		7
49	*Euphaedra*	*rex*		c	x			x	x			x		x			x		5
50	*Euphaedra*	*sp1*									x								1
51	*Euphaedra*	*sp2*								x									1
52	*Eupheadra*	*sp3*												x					1
53	*Eurema (Terias)*	*hapale*			x								x				x		2
54	*Eurema (Terias)*	*hecabe*	*solifera*	c		x			x				x				x		3
55	*Eurema (Terias)*	*senegalensis*		c	x		x					x	x			x	x		5
56	*Euriphene*	*sp1*												x			x		2
57	*Euriphene (Euriphene)*	*saphirina*	*saphirina*	c	x				x					x			x		3
58	*Euriphene (Euryphura)*	*chalcis*		c	x											x			1
59	*Euxanthe (Euxanthe)*	*eurinome*	*birbirica*	c	x				x										1
60	*Euxanthe (Hypomelaena)*	*trajanus*		c	x					x									1
61	*Graphium (Arisbe)*	*latreillianus*	*theorini*	c	x								x				x		2
62	*Graphium (Arisbe)*	*leonidas*	*leonidas*	c		x							x			x	x		3
63	*Graphium (Arisbe)*	*policenoides*	*liponesco*	r	x								x				x		2
64	*Graphium (Arisbe)*	*porthaon*		c	x												x		1
65	*Graphium (Arisbe)*	*ucalegon*	*ucalegon*	r	x												x		1
66	*Harma*	*theobene*	*blassi*	c	x		x		x				x		x				4
67	*Hypolimnas*	*anthedon*	*anthedon*	c		x							x				x		2
68	*Hypolimnas*	*dinarcha*		c	x												x		1
69	*Hypolimnas*	*salmacis*		c	x		x	x			x		x	x		x	x		7
70	*Hypolimnas*	*sp1*															x		1
71	*Hypolycaena*	*hatita*	*ugandae*	c	x								x						1
72	*Junonia*	*sp1*							x										1
73	*Junonia*	*stygia*	*gregorii*	c		x	x		x							x	x		4
74	*Junonia*	*terea*	*elgiva*	c		x	x						x			x			3
75	*Junonia*	*oenone*	*oenone*	c		x	x											x	2
76	*Junonia*	*sophia*	*infracta*	c		x	x						x						2
77	*Kallimoides*	*rumia*		c	x		x		x				x				x		4
78	*Lachnoptera*	*anticlia*		c	x								x			x	x		3
79	*Leptosia*	*alcesta*	*inalcesta*	c	x	x				x				x		x			3
80	*Leptosia*	*nupta*	*nupta*	c	x				x							x	x		3

	Genus	Species	Race	Abundance	Primary forest	Secondary forest	Assam	B/W Assam & Obonyi I	B/W Obonyi I & Assam	B/W Obonyi I & III	B/W Obonyi III & Kekpani	B/W Okpambe & Assam	Kekpani	Kekpani Camp	Kekpani Camp XI	Matene Camp	Obonyi I Camp	Obonyi I Camp Hills	Obonyi I Hills	Obonyi I Magbe	Takamanda	Takamanda Camp	Species distribution
81	*Libythea*	*labdaca*	*labdaca*	c	x															x			1
82	*Mylothris*	*continua*	*continua*	c	x						x					x					x		3
83	*Mylothris*	*sp1*		c												x							1
84	*Nepheronia*	*argia*	*argia*	c	x	x									x	x					x		3
85	*Neptis*	*agouale*		c	x		x									x				x	x		4
86	*Neptis*	*carcassoni*		c	x																x		1
87	*Neptis*	*clarei*		c	x											x							1
88	*Neptis*	*laeta*		c	x											x							1
89	*Neptis*	*melicerta*		c	x											x							1
90	*Neptis*	*nicobule*		c	x											x							1
91	*Neptis*	*strigata*		c	x															x	x		2
92	*Papilio*	*sp1*													x								1
93	*Papilio*	*sp2*													x								1
94	*Papilio (Princeps)*	*dardanus*		c		x											x						1
95	*Papilio (Princeps)*	*echerioides*	*zoroastres*	c	x								x								x		2
96	*Papilio (Princeps)*	*hesperus*	*hesperus*	c	x					x						x					x		3
97	*Papilio (Princeps)*	*jacksoni*		c	x											x							1
98	*Papilio (Princeps)*	*lormieri*		c	x																x		1
99	*Phalanta*	*eurytis*		c		x				x						x	x			x	x		5
100	*Pseudacraea*	*lucretia*	*protracta*	c		x														x			1
101	*Pseudoneptis*	*bugandensis*	*bugandensis*	c	x					x							x				x		3
102	*Pseudopontia*	*paradoxa*		r	x			x											x	x			3
103	*Salamis*	*anacardii*		c		x		x													x	x	3

104	*Sallya*	*amulia*	*rosa*	c		x														x	x		2
105	*Sallya*	*sp1*		c												x							1
106	*Triclema*	*nigeriae*		r		x										x							1
107	*V*	*sp1*												x	x								2
108	*W*	*sp1*													x								1
109	*X*	*sp1*									x					x	x		x				4
110	*Y*	*sp1*									x						x						2
111	*Z*	*sp1*															x						1
			TOTAL		55	25	13	9	1	18	17	5	1	2	10	43	24	1	5	28	49	3	

Biodiversity Assessment of the Odonate Fauna of Takamanda Forest Reserve, Cameroon

Graham S. Vick

1 Introduction

Dragonflies (Odonata) are attractive insects which are ideal for biodiversity studies. They are sensitive to pollution and habitat disturbance. They are excellent indicators of ecological health. Their present-day distributions are the result of past geological events and climatic fluctuations. There are approximately 6500 species worldwide, classified in about 600 genera, but the African dragonfly fauna, with about 900 species and 125 genera, is generally considered to be impoverished compared with that of South-East Asia or Central and South America. This is probably caused by the long periods of aridity which occurred during the Pleistocene. Only drought-adapted species could survive in large areas of the continent. The upland mountain chain which runs into the Gulf of Guinea, receives very high rainfall; up to 10,000 mm (400”) in the vicinity of Mount Cameroon, and over 3,000 mm at Mamfe (Vick 1999) and the dry season is short (usually at least 50 mm of rain even in the driest month). The natural vegetation is evergreen ‘Biafran’ rainforest. During the Pleistocene when the rainforest in Africa was drastically reduced; a few areas persisted as lowland rainforest refuges. These are generally near the coast and in areas which have the heaviest rainfall now. Botanical evidence suggests that the Cameroon/Nigeria border area is one of these refugia (Mayr and O’Hara 1986), possibly the richest in Africa, and this survey was conducted to investigate the dragonfly fauna and determine whether this also held true for Odonata.

The Cameroon Dragonfly Project (CDP) was established in 1995 by Graham Vick and David Chelmick of England and Otto Mesumbe of Cameroon. Professor Philip Corbet is the president. It is the first long-term dragonfly project in tropical Africa. The initial concentration of effort has been in the Southwest Province as this region appears to be an important biodiversity hotspot. The objectives are to describe the fauna taxonomically and produce a species list; to produce an identification key to adults (completed by Graham Vick); to describe the larvae and write larval keys (completed by David Chelmick); and finally, to identify areas of greatest conservation importance. Perhaps the most important of all is to gain the interest and cooperation of local people.

2 Methods

The main recording effort of the CDP is based upon obtaining samples of the adult dragonflies using a standard 38 cm diameter butterfly net. Specimens were preserved dry. When acetone was available, the samples were soaked for 12 hours prior to drying to preserve colour. Efforts were made to examine all possible habitats: ponds, streams and larger rivers. Careful searching is necessary for some of the most elusive species which breed in small trickles, in seepages, and in one case, in the waterfilm flowing over rocks near waterfalls. The species composition depends upon the degree of shade offered by the waterside vegetation and the proximity of extensive areas of forest for maturation and feeding. Undoubtedly the quality of the forest cover is crucial, and the most of the endemics appear to need extensive areas of primary forest. Other species can tolerate more open habitats; disturbed forest and farmland must be examined thoroughly if a full species list is to be obtained.

One of the most significant challenges encountered when attempting to sample Odonata in tropical forests is that the adults on which the specific identity depends are extremely elusive, can be difficult to catch, and

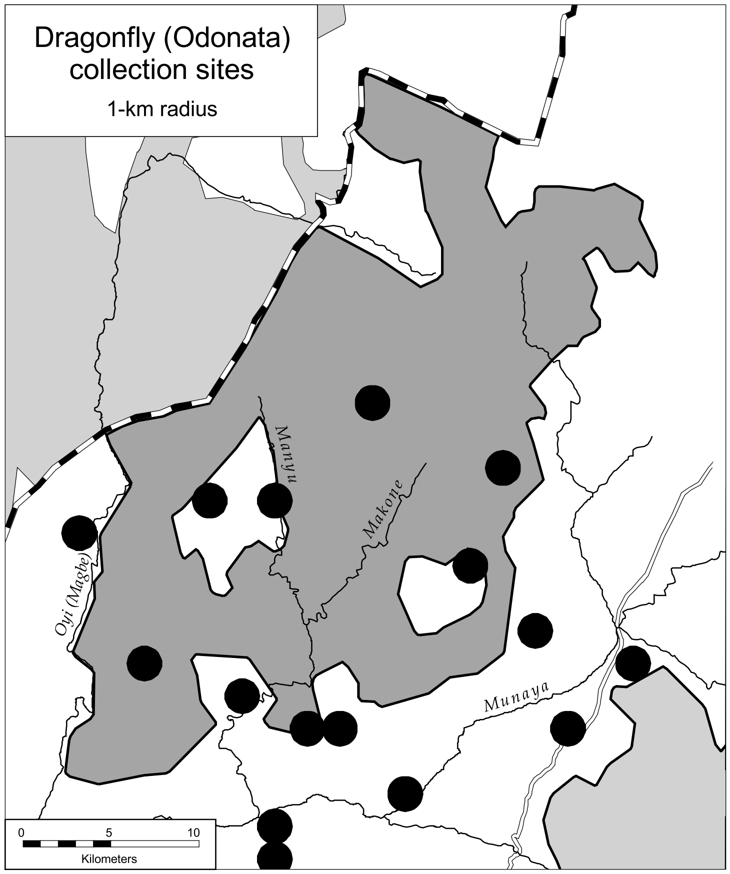

Figure 1. Odonata sampling locations in Takamanda Forest Reserve, Cameroon

frequently have behaviour patterns which mean that they only visit water rarely. Feeding and mating often take place in the tree canopy, and females only descend for oviposition. Larvae are surprisingly easy to find in the small streams and rainforest pools which the rarest species occupy. The breeding of larvae to adulthood therefore provides us with an unequivocal determination and is often the only way to build up data for larval keys. We have already produced keys to African *Anax* spp. (Chelmick 1999) and to African *Aeshna* spp. (Chelmick 2001), and descriptions of larvae of three of the most interesting damselflies (*Nubiolestes diotima*, *Stenocnemis pachystigma* and *Pentaphlebia stahli*; Vick 1998). A provisional version of the larval key is presently being tested in the field (Chelmick in prep). Once keys are available it will be relatively easy for non-experts and para-taxonomists to improve odonate site databases. Breeding also provides records of species which are never seen as adults. Another method which has been very successful is the use of emergence traps which are placed over trickles and seepages in the forest; adults are discovered with the larval shucks and this provides another method of associating the two stages. The larval work has been one of the most productive aspects of the Project and it is an excellent way of involving local people who enjoy the practical side of the work and the wonder of seeing such a beautiful creature emerge from a drab aquatic 'grub'. The research conducted in Takamanda is a collaborative effort between CDP, the Smithsonian Institution and the World Wildlife Fund.

Table 1. Collection locations within the Takamanda and Mone Forest Reserves and the Mbulu Forest, 1997-2001. (TFR = Takamanda Forest Reserve; MFR = Mone Forest Reserve: MF = Mbulu Forest

AREA CODE / DESCRIPTION	CO-ORDINATE / ALTITUDE
01 Akwa Village, MFR	9˚29'E, 6˚03'N, 98m
02 Ashunda Hill, MF	9˚35'E, 6˚10'N, <1610m
03 Bache Village, South of the TFR	9˚18'E, 5˚57'N, 200m
04 Bancho Village, MF	9˚35'E, 6˚06'N
05 Bandolo Village (Ote), MF	9˚32'E, 6˚09'N, 170m
06 Forest Stream Okpambe Village, South of the TFR	9˚22'E, 5˚59'N
07 Kekpane Village, TFR	9˚24'E, 6˚06'N, 155m
08 Kekpane Camp 11, TFR	9˚25'E, 6˚09'N, <642m
09 Kekpane Makone River (stream), TFR	350m
10 Matene (Akwoveli, Etanya, Kakwa & Yasonge streams), TFR	400m
11 Matene Camp, TFR	9˚21'E, 6˚11'N, 170m
12 Mbu Forest, MFR	9˚32'E, 5˚59'N
13 Mbu Village, MFR	9˚27'E, 6˚01'N
14 Memume stream	No data
15 Mfakwe Village, TFR	9˚26'E, 6˚04'N, 200m
16 Munaya river & Menume stream, South of TFR	9˚18'E,5˚58'N
17 Obony 1 Camp, TFR	9˚16'E, 6˚08'N, 100m
18 Obony III, TFR	9˚18'E, 6˚08'N, 115m
19 Okpambe/Assam, TFR	9˚19'E, 6˚01'N, 140m
20 Olulu Village, MFR	9˚35'E, 6˚10'N c. 900m
21 Takamanda Camp, TFR	9˚14'E, 6˚03'N, 568m
22 Takamanda Oyi River east, TFR	9˚12'E, 6˚07'N 200m
23 Takamanda Village, TFR	9˚17'E, 6˚02'N
24 Takpe Village, TFR	9˚20'E, 6˚01'N, <500m

3 Results

Sampling efforts in Takamanda Forest Reserve between 1997 and 2001 have yielded 67 species in 11 families. The Libellulidae was the most speciose family with 27 species. The most species rich sites included Obony III (21 species), Matene Camp (17), Obony I (16), and Takamanda Camp (15); the least diverse with one species at each site included Bache Village, Bancho Village, Olulu Village, and Takamanda Oyi River. None of the species were widespread throughout the area, with 29 of the species occuring at only one of the sites 13 species occuring at two sites, and five occuring at three sites. Two species, *Umma longistigma* and *Sapho orichalcea*, were present in 11 of the sampling sites, while *Allorhizucha klingi* and *Ellatoneura pruinosa* were found at nine and twelve sites respectively.

The complete list of species collected along with brief notes on habitat requirement are listed in Appendix 1. All of the information is stored on a much larger database which covers all records for the Southwest Province. These date back to 1880, when specimens were collected by the first German colonists, and continue to the present day. However, no surveying took place in Takamanda before 1997 and the area is virgin territory for dragonfly research.

The sites which have been surveyed in the period since 1997 are presented in Table 1.

4 Discussion

4.1 The Southwest province is a diversity 'hotspot'

The greatest priority for the conservation of Odonata in Western Africa lies in Cameroon and the adjacent regions of Nigeria, Equatorial Guinea and Gabon (Dijkstra and Vick, in press). Both the highland and lowland rainforests have an odonate diversity that is unrivalled elsewhere in Africa. This diversity seems to be especially high in the Southwest Province of Cameroon, a mountainous region adjacent to the eastern Nigerian border. The African dragonfly fauna may be less rich than that of tropical Asia and the neotropics but our recent work has discovered that Southwest Cameroon has species diversities that are almost as high (Vick 1999). The total number of species recorded in this province alone stands at 182; the number of forest-adapted species with restricted ranges are particularly high, and many of the widespread species of the African savannah are absent (Vick 1999).

As more sampling takes place in the region to the west, extending from Guinea to Ghana, it appears that odonate species richness approaches that of Southwest Cameroon; for example the richest is in the Ivory Coast with 175 species recorded. However, these species totals are made up of a greater number of taxa which are characteristic of the African savannah (O'Neill and Paulson 2001); many of these taxa are widespread and occur over a huge area which extends from Senegal to the southern Africa.

The province also stands out from other species-rich areas of West Africa in terms of the number of phylogenetically interesting taxa present, such as those with affinities to the fauna of South America or Madagascar. It is also a center of diversity, possibly the most important in Africa, for many forest-stream specialists such as the Calopterygidae (Vick in prep.).

The Cameroon Dragonfly Project surveys between 1995 and 2001 have focused on the areas around Mount Cameroon, Mount Kupe, the lowlands in the vicinity of Kumba, the Bakossi Highlands, and Takamanda. All of our recording has been in the Southwest Province, except for a limited amount in Littoral Province on the east of Kupe.

4.2 Subsets of the fauna

In Southwest Cameroon there is a marked faunal break at around 700m. In the lowlands there is a rich representation of the Guineo-Congolian fauna, but a limited degree of endemism. On the other hand, there is a distinct submontane fauna above 700m which breeds in the rapid rocky-bedded streams of the forested uplands, together with associated marshes, seepages and waterfalls. Most of the phylogenetically interesting taxa which have broader geographic affinities occur above 700m in undisturbed forest. In fact, there is a characteristic suite of these species which are susceptible to disturbance and opening of the canopy; these have the potential to be used as indicators of forest quality.

Apart from the altitudinal break mentioned, there is some evidence to suggest that there may be two slightly different faunas which may be associated with distinct Pleistocene refugia (or at least parts of one refugium which have perhaps been separated in the past into two rainforest 'islands'). North of the Cross River, in Takamanda, there are interesting faunal elements which appear to be lacking to the south. The converse appears to also be true but further work is needed to establish this.

Takamanda appears to be of major importance for odonate diversity. Surveying is at an early stage in the region and has only been carried out on the Cameroon side of the border, however initial results indicate a rich fauna, which is distinct from that further south in the Province. To date, 67 species have been recorded, compared with 182 from the Province as a whole (Vick 1999).

4.3 Important relict elements in the fauna

In the Southwest Province there are relict genera with tropical American affinities. Pentaphlebia (only three species extant in the subfamily - two species in the Cameroon and Nigeria border region and one species in the Guyana Highlands). The larvae are adapted to cling to the undersides of boulders in cold torrential streams. The species *P. stahli* occurs both north (including Takamanda) and south of the Cross River, and it is essentially the indicator species of submontane streams flowing through undisturbed forest. There is another species, *P. gamblesi*, which is only known from Obudu, Nigeria (only one specimen has ever been found) and this could be expected in higher altitude forests in Takamanda. Its larva awaits discovery and its relationships will be fascinating to discern.

Nubiolestes diotima is the only African species of a small family, the Perilestidae, which is otherwise neotropical. The discovery of its larva at Kupe and the observation of synapomorphisms has added strength to its placement in the family (Vick 1998). It has been found at Takamanda. It occurs in backwaters of submontane streams which flow through dense forest.

Genera with affinities with the Madagascar fauna are in the Megapodagrionidae: *Nesolestes* and *Neurolestes*. *Neurolestes* is represented by one species, trinervis, which appears to be relatively common in Takamanda (and less so to the south); *Nesolestes* is known from across the border in Obudu, Nigeria, and at Mount Oku in Northwest Province, and could be expected in Takamanda, perhaps occurring with *Pentaphlebia gamblesi* at higher elevations than *Pentaphlebia stahli* and *Neurolestes trinervis*.

Other biogeographical puzzles occur in the area such as *Stenocnemis* a platycnemidid not closely related to any other taxon (Vick 1998) and *Tragogomphus* (three species endemic to Cameroon and Nigeria).

4.4 African demoiselles: the Calopterygidae

The Southwest Province is a hotspot for calopterygid diversity. Three genera are present, and in the Province alone there are 12 species (including two ‘forms’ which appear to be specifically distinct) present in the genera *Umma*, *Phaon*, and *Sapho*. In contrast, sampling to date in Ghana has revealed four species, while Uganda and Kenya share two; even Congo (DRC) only has five (O’Neill and Paulson 2001, Clausnitzer 2001). Most taxa are rainforest-stream specialists. There appears to be a difference between the fauna of Takamanda, north of the Cross River, and that of the area to the south. Widespread taxa (i.e. occurring north and south of the Cross River) are *Umma mesostigma* (see below) and *Sapho orichalcea* (mostly in submontane rainforest). *Phaon iridipennis* is a common African taxon which occurs in disturbed habitat in the region. A much more localised taxon, *Phaon camerunense* occurs from Guinea to Cameroon and it appears to be confined to lowland rainforest. Both species of *Phaon* have been found in Takamanda and the areas to the south.

In the genus *Sapho*, we have two taxa present to the south (possibly a third pending verification), but to date in the Takamanda region we have only found the predominantly submontane, or cool-stream lowland species, *Sapho orichalcea*.

In the genus *Umma* we have recorded eight taxa for the SW Province. *Umma mesostigma* is the most widespread species,occurring in Takamanda, and south of the Cross River, in both submontane and lowland habitats, usually in forests, but not necessarily undisturbed. Another species *Umma longistigma* occurs in two forms which may be separate species: one form occurs to the south of the Cross River from the Bakossi mountains southwards, while another form with narrower inferior appendages occurs in Takamanda, Korup, and in adjacent parts of Nigeria. An endemic species *Umma mesumbei* occurs in submontane streams at Kupe and the Bakossi Mountians (Vick 1996). This species has not been recorded within Takamanda.

However, current surveys have rediscovered *Umma purpurea*, described from Mamfe in 1961. The species appears to be absent to the south, but curiously it is locally common on Bioko (Brooks and Jackson 2001). *Umma puella* is another taxon which has only rarely been encountered since its discovery in 1917. The species was found near Mount Cameroon in 1979 and at several sites in Takamanda in the current study. This is an interesting species from a phylogenetic point of view as it does not fit neatly into either genus according to present definitions.

There is only one other calopterygid taxon, *Umma saphirina* known from the Rumpi Hills and adjacent areas of Nigeria.

With seven genera present, the Southwest Province also seems to be one of the centres of diversity for the Tetrathemistinae, a pleisiomorphic subfamily of the worldwide Libellulidae. They are not colourful like most libellulids, their colours being yellow-green and black, and the species are almost entirely confined to streams and ephemeral pools in dense rainforest. This subfamily is of great evolutionary interest as they show a striking diversity of behaviour (Clausnitzer and Lempert 1998). In the majority of libellulid species, the females oviposit in flight by dipping the tip of the abdomen into the water so that they are 'washed' off and sink to the bottom. In the tetrathemistines there is a range of oviposition strategies: species of *Tetrathemis* which breed exclusively in rainforest pools settle and oviposit epiphytically on leaves several metres above the water; *Notiothemis*, *Eothemis*, *Malgassophlebia* and *Micromacromia* which breed in rainforest streams and pools oviposit in flight on banks well above water level; species of *Allorhizucha* oviposit in flight directly into water as in the more 'modern' libellulids. The recent discovery of an apparently endemic tetrathemistine genus and species, *Mesumbethemis takamandensis*, in the Takamanda Forest north of Mamfe illustrates the potential of this region (Vick 2000).

Although surveying is in its preliminary stages in Takamanda, the discoveries so far indicate that the area is likely to be one of the highest importance for odonate diversity in Africa. Although clearly part of the main 'hotspot' in Southwest Cameroon there is some evidence to suggest that its species composition may be different from that in the southern part of the province. As very little sampling has yet taken place above the critical 700m altitude at which most endemics would be expected, I would anticipate some exciting discoveries to be made in the future.

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Appendix 1. Species list and sampling locations in Takamanda Forest Reserve, Cameroon

Family / *Species*	Notes	Locations
Calopterygidae		
Phaon camerunensis Sjöstedt, 1900	very local, shady rainforest streams, mainly lowland	01, 11, 13, 24
Phaon iridipennis (Burmeister, 1839)	widespread open- stream species	11, 13, 18, 24
Sapho orichalcea McLachlan, 1869	rainforest streams, mainly submontane	01, 02, 07, 08, 10, 11, 12, 14, 17, 19, 21
Umma longistigma (Selys, 1869)	narrow inferior appendages rainforest streams, mainly lowland	06, 07, 08, 10, 11, 13, 18, 19, 21, 23, 24
Umma mesostigma (Selys, 1879)	rainforest streams, range of altitudes, fairly tolerant of farmbush	05, 10, 17, 19, 21
Umma puella Sjöstedt, 1917	occurs north of Cross River and near Mount Cameroon- rainforest streams	07, 11, 15, 17, 18, 19, 21
Umma purpurea Pinhey, 1961	possibly two disjunct populations: north of Cross River and Bioko- rainforest streams	01, 05, 18, 21, 24
Amphipterygidae		
Pentaphlebia stahli Förster, 1909	rocky submontane streams, larvae cling to underside of rocks. Related to Rimanella arcana in Venezuela	17
Chlorocyphidae	very colourful, all stream-dwellers, striking courtship behaviour which usually requires some breaks in tree canopy to provide sunny spots for displaying	
Chlorocypha cancellata (Selys, 1879)		01, 12, 14, 21
Chlorocypha curta (Hagen in Selys, 1853)		14, 23
Chlorocypha glauca (Selys, 1879)		07, 18, 23
Chlorocypha rubida (Hagen in Selys, 1853)		11, 17, 23
Chlorocypha selysi Karsch, 1899		9
Platycypha rufitibia (Pinhey, 1961)		23
Perilestidae		
Nubiolestes diotima (Schmidt, 1941)	very local endemic of Cameroon/Nigerian border, backwaters of streams in submontane rainforest. All other perilestids are neotropical	10
Megapodagrionidae		
Neurolestes trinervis Selys, 1885	local endemic - submontane rainforests. Close to Madagascar species in genus Nesolestes	08, 19, 24

Family / *Species*	Notes	Locations
Coenagrionidae	all stream-dwellers, usually tolerant of canopy loss	
Pseudagrion epiphonematicum Karsch, 1891		01, 02, 06, 16, 21
Pseudagrion flavipes Sjöstedt, 1900		11, 18
Pseudagrion melanicterum Selys, 1876		01, 05, 09, 15, 18, 24
Pseudagrion serrulatum Karsch, 1894		13
Pseudagrion sjostedti Förster, 1906		01, 14, 16, 17
*Pseudagrion hamoni** Fraser, 1955		09, 23
Protoneuridae	stream dwellers, usually in rainforest	
Chlorocnemis contraria Schmidt, 1951		12, 16, 17, 19, 21
Chlorocnemis nigripes Selys, 1886		10, 11, 16, 17, 18
Elattoneura balli Kimmins, 1938		11
Elattoneura nigra Kimmins, 1938		11
Elattoneura pruinosa (Selys, 1886)		02, 05, 08, 09, 10, 11, 12, 13, 16, 17, 18, 22
Prodasineura vittata (Selys, 1886)		18, 21
Platycnemididae		
Mesocnemis singularis Karsch, 1891	Streams and larger rivers, usually habitat tolerant	01, 16, 17, 19
Platycnemis rufipes (Selys, 1886)	Stream dwellers, usually in rainforest	24
Gomphidae	Almost all are stream-dwellers in rainforest	
Diastatomma tricolor (Palisot de Beauvois, 1805)		17, 18
Gomphidia gamblesi Gauthier, 1987	Assam - reared specimen from larva	19
Lestinogomphus angustus Martin, 1911		23
Paragomphus genei (Selys, 1841)	Stream-dweller, usually habitat tolerant	3
Paragomphus sp.3		12
Paragomphus sp.4		6
Tragogomphus aurivillii Sjöstedt, 1900	Possibly first record since description in 1900	17
Corduliidae	Stream dwellers, usually in rainforest	
Phyllomacromia bicristulata [Legrand, 1975]		18, 24
Phyllomacromia caneri (Gauthier, 1987)		17, 18
Phyllomacromia funicularia (Martin, 1906)		18

Family / *Species*	Notes	Locations
Libellulidae	Very diverse habitat requirements	
Allorrhizucha klingi Karsch, 1890	Stream dweller, tolerates partial loss of canopy	02, 05, 08, 11, 12, 13, 15, 18, 21
Atoconeura biordinata Karsch, 1899	Rapid streams associated with forested habitats	21
Crocothemis erythraea (Brullé, 1832)	Widespread, avoids rainforest	16
Cyanothemis simpsoni Ris, 1915	Sluggish silty streams in rainforest	6
Eothemis zygoptera Ris, 1909		7
Hadrothemis camarensis Kirby, 1889	Rainforest	12, 17
Hadrothemis versuta (Karsch, 1891)	Rainforest	11
Hemistigma albipuncta (Rambur, 1842)	Widespread and tolerant	02, 07, 18, 19, 23
Mesumbethemis takamandensis Vick, 2000	Described as new species and genus in 2000, known from Assam in Takamanda only, presumably breeding in rainforest streams or pools	19
Micromacromia camerunica Karsch, 1889	Rainforest streams	7
Notiothemis robertsi Fraser, 1944	Shady rainforest pools	24
Orthetrum camerunense Gambles, 1959**	Grassland pools and marshes	5
Orthetrum chrysostigma (Burmeister, 1839)	Widespread	18, 19
Orthetrum julia Kirby, 1900	Widespread in secondary and disturbed rainforest	01, 18, 20, 21, 23
Orthetrum microstigma Ris, 1911		7
Orthetrum stemmale (Burmeister, 1839)	Farmbush and disturbed forest	02, 11, 17,
Palpopleura lucia (Drury, 1773)	Widespread	07, 10, 15, 18
Pantala flavescens (Fabricius, 1798)	Widespread	5
Porpax bipunctus Pinhey, 1966	Possibly forest streams	07, 11, 21
Tetrathemis bifida Fraser, 1941	Shady rainforest pools, tolerates secondary forest	6
Trithemis aconita Lieftinck, 1969	Streams often in farmbush and disturbed forest	19
Trithemis arteriosa (Burmeister, 1839)	Widespread, avoiding rainforest	05, 07, 09, 16, 18, 23
*Porpacithemis sp.**		11
Trithemis dichroa Karsch, 1893	Streams often in farmbush and disturbed forest	04, 18
Trithemis pruinata Karsch, 1899	Streams often in rainforest.	05, 23
Zygonyx flavicosta (Sjöstedt, 1900)	Rapid streams associated with forested habitats	12, 13, 17, 18, 21
Zygonyx speciosa (Karsch, 1891)	Rapid streams associated with forested habitats	11, 21

* = provisional determination - identity at present unconfirmed
**= this is a good species distinct from caffrum in the author's opinion, based upon the very distinctive hamular structure - published in Vick, 1999

Reptiles of Takamanda Forest Reserve, Cameroon

Matthew LeBreton, Laurent Chirio, and Désiré Foguekem

1 Introduction

Cameroon has a rich reptile fauna of more than 265 species (Chirio and LeBreton in prep.), resulting from the country's varied landscape and climate and its center of diversity in the western highlands.

While this diversity is well known and although many unique and characteristic species have been recorded from Cameroon, there are few published local inventories. Most lists were compiled during general expeditions across Cameroon (Sternfeld 1908, 1909; Müller 1910; Neiden 1910a,b; Mertens 1938, 1940, 1968; Monard 1951; Perret and Mertens 1957; Böhme 1975b; Joger 1982; Böhme and Schneider 1987) or through studies of a taxonomic nature based on specimens in European or American museums (e.g., Loveridge 1947, Klaver and Böhme 1992). Notable exceptions include studies of snake fauna from Yaoundé (Gauduin 1970) and western Cameroon (Stucki-Stern 1979) and short-term research on fauna in Campo Fauna Reserve (Ota et al. 1987) and Korup National Park (Lawson 1993).

The non-governmental organization (NGO) CAMHERP has been operating in Cameroon since 1998, compiling an atlas of reptiles and providing regional and local inventories for other NGOs, the government sector, and regional projects. This paper presents the first list of reptiles from Takamanda forest (Takamanda Forest Reserve and adjoining areas), based on four excursions to the area in 2001 and 2002, in cooperation with the Takamanda Forest Surveys Project (GTZ/MINEF PROFAMAMFE) and Wildlife Conservation Society.

2 Study area

The southern border of Takamanda Forest Reserve (TFR) is located approximately 15 km north of Mamfe in the Southwest Province of Cameroon (Figure 1 Chapter 1). The reserve, approximately 67,500 ha in size, follows the Cameroon/Nigeria border for about 30 km.

In a simple breakdown of natural vegetation, four major types can be determined: lowland forest, medium altitude forest, montane forest, and elevated savanna (Sunderland *et al.* this volume). Derived vegetation types include cultivated areas, farm bush, and secondary forest around the reserve. Altitude varies from 100 m to about 1,600 m.

Four field trips were conducted in and around TFR over the course of one year. The first, from 14 - 30 May 2001, focused the areas of Matene and Mende. At Matene, palm plantations, farm bush, dense lowland humid forest, and mid-elevation forest were examined, while at Mende, gallery forest, montane forest, elevated grassland, and farmland were surveyed. The second trip, from 2 - 17 August 2001, centered on the villages of Atolo—where sub-montane forest, ridge forest, farm bush and cocoa farms were the dominant vegetation types—and Tinta, where woodland savanna, moist evergreen forest, and the interface between these vegetation types were assessed. The third and fourth trips, from 6 - 19 December 2001 and 28 – 31 May 2002, examined lowland forest areas in the south of the reserve in the vicinity of the villages of Takamanda, Obonyi 1 and 2, and Kekpane (Figure 2 in Chapter 1).

3 Methods

A team of experienced herpetologists, a graduate student, and field assistants from the Takamanda area carried out the field work. Field searches took place in areas where—and at times when—reptiles were known to be active or detectable, based on the experience of the field researchers. Searchers looked for active reptiles on the ground and in trees and shrubs. Inactive and burrowing reptiles were sought beneath rocks, exfoliating layers of bark, leaf litter, and fallen logs and in dark tree hollows and rock crevices (with the aid of a torch). Some searching was undertaken at night along tracks and in trees and houses, again with a torch. Captured reptiles were kept in cloth bags and small plastic containers lined with moistened moss.

Bottles of 10% unbuffered formalin were left with volunteers in the villages of Mendé and Bidjan (close to Mamfe) from May to August 2001, in Atolo and Tinta from August 2001 to February 2002, and Obonyi 1 and 2, Kekpane, and Takamanda villages from December 2001 to May 2002 (Figure 1). Any reptiles killed in the villages were preserved in the formalin and removed during subsequent field work. Shells, bones, and skins of tortoises and crocodiles were also recorded from some villages.

All specimens were preserved in 10% unbuffered formalin or 70% alcohol. Specimens collected will be deposited in the University of Yaoundé I, Cameroon, and the Museum National d'Histoire Naturelle, Paris, France.

Principal works used in the identification of species include: for geckoes, Loveridge (1947), van den Audenaerde (1967), and Perret (1963, 1986); for *Mabuya*, Hoogmoed (1974) and Chirio and Ineich (2000); for *Panaspis*, Perret (1973); for chameleons, Klaver and Böhme (1992) and Wild (1993); and for snakes, Chippaux (2001), Meirte (1992), Laurent (1964), and unpublished data of Van Wallach.

4 Results

A total of 71 described species from 15 families were identified from TFR and the immediately surrounding area during the field work. The 41 species of snakes made up 59% of all species encountered, and the family Colubridae was the most species-rich family (26 species). Three additional—and possibly undescribed—species were also recorded, two of which have been found in numerous localities in Cameroon's forests, while one is known only from the Takamanda and Furu-Awa areas.

Ten other species, not recorded from Takamanda, have been recorded from the adjacent towns of Mamfe and Bidjan (approximately 15 km to the south) during the current study (three species) or by Stucki-Stern (1979) (seven species). Unfortunately, the specimens collected by Stuki-Stern (1979) were destroyed, and identifications cannot be confirmed (Chris Wild pers.comm.).

Two species—*Chamaeleo montium* and *C. pfefferi*—found in the Takamanda area are endemic to Cameroon, while three other species—*Chamaeleo wiedersheimi*, *Cnemaspis koehleri*, and *Panaspis rohdei*—could be classed as regional endemics because their distribution also includes small areas in Nigeria, Equatorial Guinea, and Gabon.

The tortoises *Kinixys erosa* and *K. homeana* are listed as Data Deficient and the Dwarf Crocodile *Osteolaemus tetraspis* as Vulnerable in the IUCN's Red Lists.

Eleven species included in Appendix II of the CITES convention, which regulates international commerce in wildlife, were recorded from the area, including the terrestrial tortoises and dwarf crocodile noted above and chameleons, monitor lizards, and pythons.

5 Discussion

The number (81) of described reptile species in the Takamanda area is similar to other locations in the volcanic chain mountains of Cameroon (65 species at Korup National Park [Lawson 1993] and 81 non-marine reptile species in the Mount Cameroon area [LeBreton 2002]). Also typical of African forests is the high proportion (62%) of snakes in the species present at

Takamanda; compare to 65% at Korup National Park (Lawson 1993), 53% at Kibale National Park in Kenya (Vonesh 2001), and 56% in the Mount Cameroon area (LeBreton 2002).

5.1 Affinities/relationships with other areas

Seventy-five percent of the 65 reptile species found at Korup (Lawson 1993) and 78% of the 81 non-marine reptile species found in the Mount Cameroon area (LeBreton 2002) are also found at Takamanda. By contrast, the Bouba-Njida National Park area, dominated by savana, in northern Cameroon has only 25% of its 43 species in common with the Takamanda area (unpublished CAMHERP data).

Most of reptile species found at Takamanda are forest dwellers, giving the area an affinity with montane and sub-montane forest in the western parts of the country, including Mount Cameroon and Korup. There are, however, a number of savanna species that appear to reach their southern limit—at least in western Cameroon—in the Takamanda area.

5.2 Species of interest

The chameleons comprise a distinctive portion of the fauna in any part of Cameroon, and Takamanda is no exception. Five species have been recorded from the area, including the Dwarf Chameleon (*Rhampholeon spectrum spectrum*), Crested Chameleon (*Chamaeleo cristatus*), Mountain Chameleon (*C. montium*), Wiedersheim's Chameleon (*C. wiedersheimi*) and Pfeffer's Chameleon (*C. pfefferi*). The latter three species are Cameroon endemics, or near endemics, and are known only from restricted areas in Cameroon.

The presence of Pfeffer's Chameleon at Mendé extends the range of this species west from the Bamenda area where it was recently found (unpublished CAMHERP data); other populations of the species are about 150 km further south in the mountains of Kupe and Manengouba (Wild 1993) and Nlonako (Herrmann et al. 1999).

Two subspecies (*C. w. wiedersheimi* and *C. w. perreti*) of the near-endemic chameleon *C. wiedersheimi* are known from Cameroon, *C. w. perreti* has an extremely restricted distribution and is known only from around the Manengouba Mountains in Cameroon, while *C. w. wiedersheimi*, found at Mendé in the Takamanda area, is much more widespread. The Takamanda individuals bridge the gap between known populations on the Obudu Plateau of Nigeria (Böhme 1975a, Gartshore 1986) and populations at Bafut in Cameroon (Böhme 1975b) and west of Bamenda in Cameroon (unpublished CAMHERP data). This subspecies occurs in grassland and in gallery forests between about 1500 and 2200 m (Gartshore 1986).

The Mountain Chameleon (*C. montium*) was found during the current field work at Tinta to the north of TFR, and there is a single record from nearby Atolo (Klaver and Böhme 1992). While these two locations are close to each other, they are otherwise very isolated from other known populations of Mountain Chameleon at Mt. Cameroon, Mt. Kupe, Manengouba, and Rumpi Hills. Forests to the northeast of Takamanda have not been surveyed, however, and the population may be more extensive in that area. This species is usually found in moderate- to high-altitude forest (500 to 1300 m), often along forest edges and sometimes in cultivated areas (Klaver and Böhme 1992).

A number of geckos, not endemic to Cameroon and known only from scattered localities, were found in the Takamanda area. Three of these species, *Cnemaspis koehleri*, *Hemidactylus echinus*, and *H. intestinalis*, apparently depend on large, old trees where they shelter beneath decorticating bark, among the roots of epiphytes, and in other crevices. This dependency on older trees has perhaps led to a patchy distribution; much of the forest in Cameroon is at least partially exploited, and few large, old trees remain in many areas. Two other gecko species were recorded in this study. *Cnemaspis spinicollis* is found in rocky outcrops in densely forested areas, and *Lygodactylus conraui* is commonly found in palm plantations. Both are known only from scattered locations.

Bothrolycus ater is a non-venomous snake restricted to central African forests, and in Cameroon there are only scattered records from the extensive rainforests of the south and the elevated forests of the west (unpublished CAMHERP data). A single specimen was found during this field work in the elevated forests at Mendé.

5.3 Savanna species

A number of savanna species known from the plains in northern Cameroon were found in the Takamanda area. The Royal Python (*Python regius*) is well known from the northern edge of the Cameroon's Adamawa Plateau north to Waza National Park. It is usually found in drier habitats, including rocky hills and sometimes houses. In Nigeria, it is known from farmland and dryland rainforest (Luiselli and Akani 1999). The records of this species from Bidjan during this study are extremely isolated from the other known locationsities in Cameroon, but are likely contiguous with populations in adjacent Nigeria (e.g., Cross River National Park; Jim Comiskey pers. obs. 2001).

Another savanna species, the egg-eating snake (*Dasypeltis scabra*), was recorded in elevated grassland around Mendé. This species is better known from the dry savanna further north in Cameroon, but has also been recorded from Bamenda (unpublished CAMHERP data) and from elevated savanna in other parts of Africa (Hughes 1983). This was the only snake recorded from the elevated grassland at Mende. All other species are apparently restricted to gallery forests.

Panaspis kitsoni is a small skink commonly found in lowland gallery forests on the Bénoué Plain in northern Cameroon, but it is also known from scattered locations in western Cameroon and from Nigeria. During the current field work, it was found in Takamanda village and at Bidjan. The distribution of this species and its continuity with Nigerian populations is not yet clearly defined in western Cameroon.

5.4 Undescribed species

Three possibly undescribed species were found during these surveys. An Agama, superficially similar to *Agama agama* and found in similar habitats but restricted mostly to the coast and hinterland, was found in four locations in the Takamanda forest area. A species of *Mabuya* allied to *Mabuya affinis* was also recorded. *Mabuya affinis* is found throughout the forests of Cameroon, including some of the gallery forests on the Bénoué Plain. The closely related undescribed species has been recorded from numerous locations throughout the Cameroon and Central African Republic forest block. The third species is a large gecko (*Hemidactylus*), similar to *H. fasciatus* but bigger and with less distinct broad bars on the back. In Cameroon, it has also been recorded from the Furu-Awa area north of Wum near the Nigerian border.

6 Concluding remarks

6.1 Implications for conservation

6.1.1 Endemics and other species with localized or restricted distributions

Much of the Cameroon highlands are being converted to agriculture and settlement. Thus, certain species with restricted distributions are of conservation concern. Species found in areas particularly suitable for intensive grazing or cultivation may be affected by deterioration in habitat quality caused by poor land management such as overgrazing or clearing of habitat (especially elevated forests) for cultivation. These problems have already been identified in the Manengouba and Bamboutos highlands where a number of lizards and frogs are exhibiting sings of stress brought on by human activities (Gartshore 1986). Our recording of a number of these lizards in the area of Takamanda Forest Reserve enhances the potential for conservation.

6.1.2 Red List Species

Numerous undescribed species have recently been discovered in Cameroon, and we are now obtaining increased knowledge of the distribution of other species. It is likely that better understanding of species distribution and the factors that threaten some reptiles will lead to a revision of IUCN's Red Lists. Some species may be removed, while others are added.

As noted above, the Red List species found at Takamanda include the Data Deficient terrestrial tortoises (*Kinixys homeana* and *K. erosa*) and the Vulnerable Dwarf Crocodile (*Osteolaemus tetraspis*). Local people consume these species, but it is not known how this affects populations of these reptiles in the Takamanda area.

6.1.3 Local hunting

The people of the Takamanda area collect several reptile species for food, most often as by-catch in fishing nets or on fishing lines, through encounters during cultivation, and along on forest paths or in villages. Direct hunting is unlikely, except perhaps for crocodile species.

As stated above, many people in Cameroon consume the terrestrial tortoises *Kinixys homeana* and *Kinixys erosa*. They are likely to be captured while walking on forest tracks or during cultivation. Numerous dried shells of both species were seen in local villages during this study. Insufficient data exist regarding distribution and stresses to assess their conservation status, which is why they are listed as Data Deficient in the Red Lists. However, a recent article on hunting pressure in southwestern Cameroon (Lawson 2001) indicated that around some villages and even in reserves, these species are intensely collected, with annual harvests up to 0.7 *Kinixys* per km^2.

Trionyx triunguis, a soft-shelled aquatic tortoise known from scattered locations in Cameroon, inhabits medium to large rivers in both savanna and forest areas. One dried shell of this species, kept after the meat of the animal had been eaten, was found in the village of Obonyi I during this field work.

Larger species of snakes, including the Gabon Viper (*Bitis gabonica*), Horned Viper (*Bitis nasicornis*), Forest Cobra (*Naja melanoleuca melanoleuca*), Green Mamba (*Dendroaspis jamesoni jamesoni*), and African Rock Python (*Python sebae*), are all likely to be consumed by villagers in the Takamanda area. These creatures are probably encountered during cultivation, while walking on forest tracks, or when they enter villages. The aquatic snakes of the genus *Grayia* attain a considerable size and are also likely to be consumed, as in other parts of Cameroon, if they are captured in fishing nets or on fishing lines. However, some of the people inhabiting the area avoid eating snakes for traditional reasons (Jacqui Sunderland-Groves pers. comm.).

The Dwarf Crocodile (*Osteolaemus tetraspis tetraspis*) is locally consumed, as are the other crocodile species (*Crocodylus cataphractus* and *C. niloticus*) that are likely to occur in the area. This factor may contribute to low numbers of crocodiles, but even as early as the 1960s, crocodile populations had been greatly reduced in central Africa (Cott and Pooley 1972) and remain so today (Luiselli *et al.* 2000), probably because of hunting for meat, export of skins, and degradation of habitat in some areas.

6.1.4 Intercontinental Trade Species

Because of the relative inaccessibility of Takamanda Forest Reserve, the collection of species such as chameleons, tortoises, and pythons for intercontinental trade is unlikely to pose a conservation issue in the area.

6.2 Additional study

In reptile research, even a near-comprehensive list of species is difficult to compile. The encounter rates for many snake species are low, and this is further complicated by the large number of secretive, burrowing species found in the forests of Cameroon and variance in weather conditions during field work. For a comprehensive list, extensive field work during different seasons and varying climatic conditions is necessary.

In Cameroon, many traditional beliefs are associated with reptile species, and these beliefs are often extremely localized. Some beliefs preclude the killing or eating of certain species. Management of reserves should therefore be sensitive to such beliefs, embracing those that enhance the conservation of certain species. Given that reptiles are an important part of the forest fauna for the people of Takamanda—as food, in the preparation of medicines, and for traditional rituals—more research related to the relationships between local villagers and reptiles could prove to be an important resource for future management of the forest.

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Appendix 1. Reptiles from the Takamanda Forest Reserve, Cameroon.(a: Klaver and Böhme 1992; b: Stucki-Stern 1979; other records come from the present work)

	Lowland forest sites						Highland sites		Savanna/ forest	
	Takamanda	Obonyi 1	Obonyi 3	Kekpane	Basho 2	Mamfe/Bidjan	Matené	Mendé	Atolo	Tinta
Testudinidae (terrestrial tortoises)										
Kinixys erosa (Schweigger 1812)	✓	✓	✓					✓	✓	✓
Kinixys homeana (Bell 1827)							✓			
Trionychidae (soft-shelled tortoises)										
Trionyx triunguis (Forskål 1775)		✓								
Crocodilidae (crocodiles)										
Osteolaemus tetraspis tetraspis (Cope 1861)	✓									
Gekkonidae (geckoes)										
Cnemaspis koehleri (Mertens 1937)								✓	✓	
Cnemaspis spinicollis (Müller 1907)								✓	✓	
Hemidactylus brookii angulatus (Hallowell 1852)	✓	✓	✓			✓	✓		✓	
Hemidactylus echinus (O'Shaughnessy 1875)		✓								
Hemidactylus fasciatus fasciatus (Gray 1842)	✓								✓	✓
Hemidactylus intestinalis (Werner 1897)		✓	✓				✓		✓	
Hemidactylus mabouia mabouia (Moreau de Jonnès 1818)						✓	✓			
Hemidactylus sp.		✓								
Lygodactylus conraui (Tornier 1902)	✓		✓				✓			
Agamidae (dragon lizards)										
Agama agama (Linnaeus 1758)	✓							✓		
Agama cf. agama	✓	✓					✓		✓	
Agama sylvanus (Macdonald 1981)							✓		✓	
Chamaeleonidae (chameleons)										
Chamaeleo cristatus (Stutchbury 1837)	✓	✓				✓(a)	✓		✓	
Chamaeleo montium (Buchholz 1874)									✓(a)	✓
Chamaeleo pfefferi (Tornier 1900)								✓		
Chamaeleo wiedersheimi wiedersheimi (Nieden 1910)								✓		
Rhampholeon spectrum spectrum (Buchholz 1874)	✓		✓					✓	✓	✓
Lacertidae (lacertid lizards)										
Holaspis guentheri (Gray 1863)	✓		✓							

Continued

Appendix 1 (cont.). Reptiles from the Takamanda Forest Reserve, Cameroon

	Lowland forest sites						Highland sites		Savanna/ forest	
	Takamanda	**Obonyi 1**	**Obonyi 3**	**Kekpane**	**Basho 2**	**Mamfe/Bidjan**	**Matené**	**Mendé**	**Atolo**	**Tinta**
Scincidae (skinks)										
Mabuya affinis (Gray 1838)	✓	✓	✓	✓			✓		✓	
Mabuya cf *affinis*	✓						✓		✓	
Mabuya albilabris (Hallowell 1857)	✓			✓						
Mabuya maculilabris maculilabris (Gray 1845)			✓		✓	✓		✓	✓	
Mabuya polytropis (Boulenger 1903)				✓			✓			
Mochlus fernandi (Burton 1836)						✓	✓		✓	✓
Panaspis breviceps (Peters 1873)	✓	✓	✓				✓		✓	
Panaspis kitsoni (Boulenger 1913)	✓					✓				
Panaspis rohdei (Muller 1910)								✓		
Varanidae (monitor lizards)										
Varanus ornatus (Daudin 1803)				✓			✓		✓	✓
Typhlopidae (blind or worm snakes)										
Typhlops angolensis (Bocage 1866)								✓		
Typhlops congestus (Duméril and Bibron 1844)						✓				
Typhlops steinhausi (Werner 1909)						✓			✓	
Pythonidae (pythons)										
Calabaria reinhardti (Schlegel 1848)						✓(b)				
Python regius (Shaw 1802)						✓				
Python sebae (Gmelin 1788)			✓			✓(b)			✓	✓
Colubridae (colubrid snakes)										
Afronatrix anoscopus (Cope 1861)	✓	✓	✓			✓(b)	✓			
Bothrolycus ater (Günther 1874)								✓		
Buhoma depressiceps depressiceps (Werner 1897)										✓
Dasypeltis fasciata (Smith 1849)	✓			✓						
Dasypeltis scabra (Linnaeus 1758)								✓		✓
Dipsadoboa underwoodi (Rasmussen 1993)		✓								
Dipsadoboa unicolor unicolor (Günther 1858)	✓	✓	✓					✓		
Dipsadoboa viridis (Peters 1869)			✓							
Gonionotophis brussauxi brussauxi (Mocquard 1889)	✓	✓								
Grayia smythii (Leach 1818)						✓(b)				
Hapsidophrys lineatus (Fischer 1856)						✓		✓		✓
Hapsidophrys smaragdina (Schlegel 1837)		✓				✓(b)			✓	✓

Continued

Appendix 1 (cont.). Reptiles from the Takamanda Forest Reserve, Cameroon

	Lowland forest sites						Highland sites		Savanna/ forest	
	Takamanda	**Obonyi 1**	**Obonyi 3**	**Kekpane**	**Basho 2**	**Mamfe/Bidjan**	**Matené**	**Mendé**	**Atolo**	**Tinta**
Lamprophis olivaceus (Duméril 1856)		✓	✓				✓		✓	
Lamprophis virgatus (Hallowell 1854)						✓				
Mehelya capensis savorgnani (Mocquard 1887)		✓							✓	
Mehelya guirali (Mocquard 1887)		✓	✓			✓(b)				✓
Mehelya poensis (Smith 1847)			✓	✓		✓			✓	✓
Mehelya stenophthalmus (Mocquard 1887)	✓					✓(b)		✓		
Meizodon coronatus (Schlegel 1837)										✓
Natriciteres fuliginoides (Günther 1858)	✓					✓(b)				
Natriciteres olivacea (Peters 1854)						✓(b)				
Philothamnus carinatus (Andersson 1901)			✓							
Philothamnus heterodermus (Hallowell 1857)		✓	✓			✓(b)				
Philothamnus heterolepidotus (Günther 1863)						✓(b)				
Philothamnus nitidus (Günther 1863)						✓(b)				
Psammophis phillipsii (Hallowell 1844)						✓				✓
Thelotornis kirtlandi (Hallowell 1844)	✓									
Thrasops aethiopissa (Günther, 1862)		✓								
Thrasops flavigularis (Hallowell 1852)						✓(b)				
Thrasops occidentalis (Parker 1940)			✓			✓(b)				
Toxicodryas blandingii (Hallowell 1844)			✓			✓				✓
Toxicodryas pulverulenta (Fischer 1856)			✓			✓(b)	✓			✓
Elapidae (front-fanged snakes)										
Dendroaspis jamesoni jamesoni (Traill 1843)		✓	✓			✓	✓			✓
Naja melanoleuca melanoleuca Hallowell 1857	✓		✓	✓		✓	✓		✓	✓
Pseudohaje goldii (Boulenger 1895)	✓					✓(b)			✓	
Viperidae (vipers)										
Atheris squamigera (Hallowell 1854)						✓(b)		✓	✓	
Bitis arietans (Merrem 1820)										✓
Bitis gabonica (Duméril and Bibron 1845)			✓	✓		✓(b)			✓	✓
Bitis nasicornis (Shaw 1802)		✓	✓	✓		✓(b)		✓	✓	✓
Causus lichtensteinii (Jan 1859)		✓								
Causus maculatus (Hallowell 1842)						✓				✓

Continued

Appendix 1 (cont.). Reptiles from the Takamanda Forest Reserve, Cameroon

	Lowland forest sites						**Highland sites**		**Savanna/ forest**	
	Takamanda	**Obonyi 1**	**Obonyi 3**	**Kekpane**	**Basho 2**	**Mamfe/Bidjan**	**Matené**	**Mendé**	**Atolo**	**Tinta**
Atractaspididae (burrowing asps)										
Aparallactus modestus (Günther 1859)			✓	✓						
Atractaspis irregularis irregularis (Reinhardt 1843)			✓	✓						✓
Polemon collaris collaris (Peters 1881)		✓						✓		✓
Polemon gabonensis gabonensis (Duméril 1856)						✓(b)				

Birds of Takamanda Forest Reserve, Cameroon

Marc Languy and Francis Njie Motombe

1 Introduction

Cameroon, stretching from the Atlantic Ocean to Lake Chad, boasts a varied topography and many habitats. As a result, the avifauna is particularly rich; 928 species have been recorded to date (Languy *et al.* in press). The Cameroon government and international organizations realize the need to document and protect the country's biological diversity, and a number of field surveys were conducted from 1999 to 2001 to identify sites of high biological—particularly ornithological—value in Cameroon through the Important Bird Area process, coordinated by BirdLife International and implemented by the Cameroon Ornithological Club (COC).

Still, the avifauna of Cameroon is poorly known when compared to countries in eastern and southern Africa as well as some West African countries. During a national workshop organized by BirdLife International and the COC in September 1998, Cameroon's Takamanda region and the area west and north of Mamfe were identified as areas in need of field surveys (COC 1998).

Prior to this study, only a brief survey undertaken by World Wildlife Fund in 1988 (Thomas *et al.* 1989) had been completed in Takamanda vicinity, recording fewer than 50 species. However, even that short list indicated the presence of three sub-montane species—Black-capped Woodland Warbler *Phylloscopus herberti*, Bocage's Akalat *Sheppardia bocagei*, and Crossley's Ground-thrush *Zoothera crossleyi*. This sub-montane component, together with vast areas of lowland forest, point to potentially high bird diversity at Takamanda and, possibly, rare or even threatened species. In recognition of that potential, COC and BirdLife International proposed in 1998 that Takamanda be considered as an Important Bird Area; that is, a site of special conservation value for birds. IBAs are selected using internationally recognized objective, scientific criteria.

A portion of Takamanda is adjacent to Obudu Plateau in Nigeria and thus is part of the Cameroon-Nigeria Mountain range that stretches from Bioko to Tchabal Mababo and Tchabal Ngandaba and includes Mt. Cameroon, Rumpi Hills, Mt. Nlonako, Bakossi Mountains, Mt. Kupé, Mt. Manenguba, and Bamenda Highlands. This mountain range is well known for its high degree of endemism in many taxa. For example, 24 species of birds are restricted to this mountain range. While birds on the ridge are relatively well known, Takamanda is an outlier that deserves attention.

2 Methods

The discovery of three sub-montane bird species by WWF in 1988 prompted us to focus on sampling the highest altitudes of the Takamanda Reserve and check whether afro-montane species occur. At the same time, we recognized that most of the Reserve is covered by lowland forest (see Sunderland *et al.* this volume), and a special effort was made to cover this biome to the extent possible.

Our primary method of investigation was to walk slowly in the forest and to remain sitting quietly at regular intervals to record as many birds as possible, using binoculars. Fourteen sites were sampled in this manner (Table 1 and Figure 1), and many species were identified by their calls or songs. We incorporated the use of field guides, including plates from Borrow and Demey (2002), and color copies of selected plates from Birds of Africa. See Appendix 1 for a list of the species we recorded.

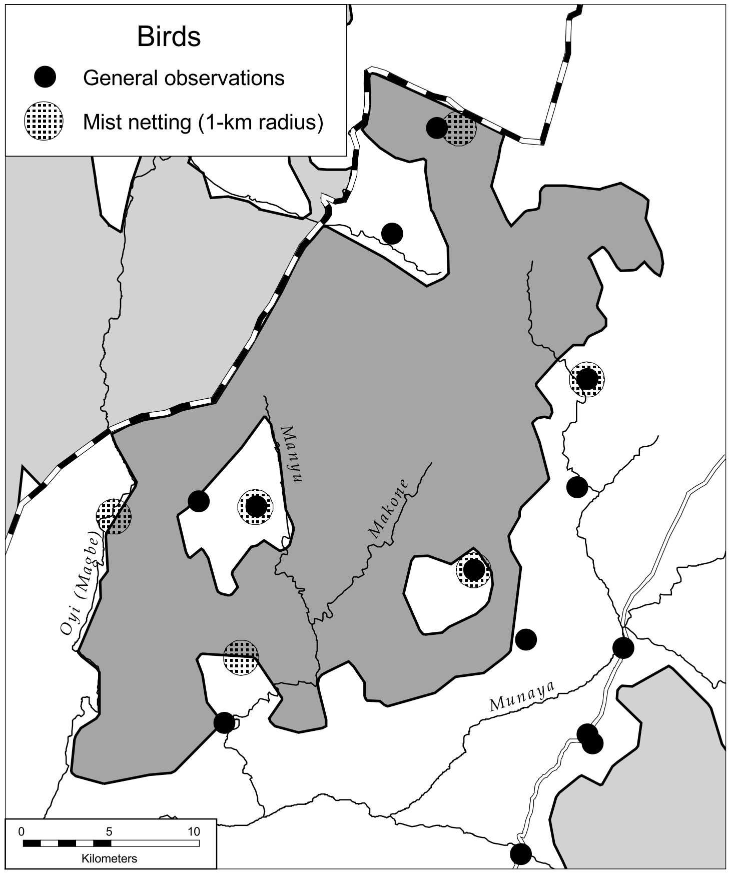

Figure 1. Bird sampling sites in Takamanda Forest Reserve, Camerooon

In addition to general observations, we used mist nets at eight sites (Figure 1 and Table 2) to maximize the chances of recording shy forest species.

The bird survey lasted for a total of 36 field days (excluding transport) and was undertaken during three time intervals: 8-29 January 2001, 10-18 March 2001, and 10-22 December 2001. An experienced bird observer (Njie) was in the field during all three intervals and was responsible for data collection. Assistants from nearby villages acted as guides and also helped in erecting the mist nets.

3 Results

3.1 Species richness

A total of 309 species of birds were recorded during the surveys, not including four species recorded by World Wildlife Fund in 1988 through the use of mist nets. Including those species brings the total to 313 species known to occur in Takamanda—an impressive number when compared to protected areas such as Campo National Park, Dja Faunal Reserve, or Lobeke National Park, which have been more extensively surveyed. We estimate that further surveys at different times of the year and in different sectors (particularly at the highest altitudes) of the Reserve should increase the total number of species.

Table 1. Location of observations in Takamanda Forest Reserve, Cameroon.

Site Name	Coordinates
Kekpani	06˚05'841"N: 09˚23'929"E
Mbu	06˚00'786"N: 09˚27'389"E
Assam	06˚00'501"N: 09˚27'559"E
Mfakwe	06˚03'695"N: 09˚25'520"E
Takamanda	06˚01'146"N: 09˚16'267"E
Takwo	06˚08'157"N: 09˚.36.253"E
Obonyi I	06˚07'938"N: 09˚15'465"E
Obonyi III	06˚07'784"N: 09˚17'233"E
Matene	06˚16'150"N: 09˚21'404"E
Mende	06˚19'385"N: 09˚22'779"E
Mbilishi	06˚11'693"N: 09˚27'401"E
Basho I	06˚08'366"N: 09˚27'091"E
Akwa	06˚03'442"N: 09˚28'500"E
Nyang	05˚57'115"N: 09˚25'364"E

This high diversity is almost certainly the result of the variety of ecosystems found in the Reserve: lowland Guineo-Congolian forest (including forested rivers), montane forests, and high-altitude grasslands. Of special significance is the transition forest between montane and lowland forests, a forest type that suffers from encroachment in Cameroon and Africa in general, but that holds a large variety of birds.

Table 2. Location of mist nets in Takamanda Forest Reserve, Cameroon.

Site Name	Coordinates
Obonyi I forest near Magbe River	06˚07'488"N; 09˚12'888"E
Mende Hills	06˚19'400"N; 09˚23'474"E
Kekpani forest	06˚05'841"N; 09˚23'929"E
Takamanda forest	06˚03'160"N; 09˚16'794"E
Mblishi forest	06˚11'693"N: 09˚27'401"E
Obonyi III forest	06˚07'784"N; 09°17'233"E
Mbu	06˚00'786"N: 09˚27'389"E
Nyang	05˚57'115"N: 09˚25'364"E

3.2 Threatened species

As shown in Table 3, nine threatened species have been recorded so far in Takamanda. Of these, one—the White-throated Mountain Babbler *Kupeornis gilberti*—is considered "endangered." Two—Grey-necked Picathartes *Picathartes oreas* and Bannerman's Weaver *Ploceus bannermani*—are "vulnerable," while six others—Hartlaub's Duck *Pteronetta hartlaubii*, Yellow-casqued Wattled Hornbill *Ceratogymna elata*, Cameroon Montane Greenbul *Andropadus montanus*, Crossley's Ground-thrush *Zoothera crossleyi*, Bangwa Forest Warbler *Bradypterus bangwaensis,* and White-tailed Warbler *Poliolais lopezi*—are "near threatened" (BirdLife International 2000).

The occurrence of these species confirms the global significance of Takamanda Forest Reserve for imperiled bird species.

3.3 Restricted-range/endemic species

A key outcome of the survey was the discovery of 16 species with restricted ranges (Table 4). Restricted-range species have a total world range of less than 50,000 km² and thus are very limited in their distribution. The species are grouped by Endemic Bird Areas (EBA), areas which encompass the overlapping breeding ranges of restrcited-range bird species, such that the complete ranges of at least two restricted-range species are entirely included within the boundary of the EBA (Stattersfield *et al.* 1998). Thirteen of the 16 restricted-range species found in Takamanda are confined to the Cameroon-Nigeria mountain chain, and three are restricted to the Cameroon-Gabon lowlands.

Such a vast array of restricted-range species shows the importance of Takamanda Forest Reserve as a sanctuary for species that are endemic to the Cameroon mountains.

Table 3. Threatened bird species of Takamanda Forest Reserve, Cameroon. EN: endangered; VU: vulnerable; NT: near-threatened.

IUCN	English name	Scientific name
EN	White-throated Mountain Babbler	*Kupeornis gilberti*
VU	Grey-necked Picathartes	*Picathartes oreas*
VU	Bannerman's Weaver	*Ploceus bannermani*
NT	Hartlaub's Duck	*Pteronetta hartlaubii*
NT	Yellow-casqued Wattled Hornbill	*Ceratogymna elata*
NT	Cameroon Montane Greenbul	*Andropadus montanus*
NT	Crossley's Ground-thrush	*Zoothera crossleyi*
NT	Bangwa Forest Warbler	*Bradypterus bangwaensis*
NT	White-tailed Warbler	*Poliolais lopezi*

3.4 Biome-restricted species: Afromontane biome

The survey also discovered a significant component of afro-montane avifauna. Altogether, 28 afro-montane species were recorded (Appendix 1), more than previously believed existed in this area. For many species, their occurrence at Takamanda significantly extends their known range in Cameroon; for some, including *Kupeornis gilberti* and *Poliolais lopezi*, the closest known records in Cameroon are more than 100 km distant. Most montane species at Takamanda are known from the nearby Obudu Plateau in Nigeria (Fishpool and Evans 2001) however, so their presence is not totally unexpected.

3.5 Biome-restricted species: lowland (Guineo-Congolian) forest biome

The occurrence of 139 species restricted to the Guineo-Congolian forest (Appendix 1), although expected, is particularly interesting and confirms that Takamanda Forest Reserve holds a vast component of lowland forest avifauna. Protection of the Reserve would preserve a representative sample of the lowland forest avifauna.

It should be noted that two species—Sun Lark *Galerida modesta* and the Bush Petronia *Petronia dentate*—which are more typical of Guinean savannas were recorded in the grasslands.

3.6 Other interesting records

The survey recorded two species that are new to Cameroon—Ussher’s Flycatcher *Muscicapa ussheri*, observed twice (once in the vicinity of its close relative Sooty Flycatcher *Muscicapa infuscate*) and Grey-headed Bristlebill *Bleda canicapilla*, which was captured in mist nets on two occasions. The discovery of Ussher’s Flycatcher was not totally unexpected, given that there are records of this bird about 50 km from Takamanda in eastern Nigeria (Elgood 1994). Grey-headed Bristlebill reaches its eastern limit at the Cameroon-Nigeria border.

Other species of interest include Tufted Duck *Aythya fuligula* (Bobo *et al.* 2000), recorded on the Magbe River with other aquatic species, and Capuchin Babbler *Phyllanthus atripennis*, recorded at Obonyi 1 and Kepani.

On four occasions, we recorded Kemp’s Longbill *Macrosphenus kempi*, a West African species that is sympatric with Yellow Longbill *Macrosphenus flavicans* as the two species meet along the Cameroon-Nigeria border. The only other site for Kemp’s Longbill in Cameroon is Korup National Park (Rodewald and Bowden 1995).

An interesting record from a biogeographical perspective is the presence of both Red-cheeked Wattle-eye *Dyaphorophyia blisseti* and Black-necked Wattle-eye *Dyaphorophyia chalybea*. These two closely related species replace each other: Red-cheeked Wattle-eye is a West African species reaching its eastern limit in Cameroon, with records around Mt. Cameroon and Kumba (Louette 1981). The two species were not

Table 4. Restricted range (total world range less than 50.000 km²) bird species of Takamanda Forest Reserve, Cameroon. GCL: species confined to the Gabon-Cameroon Lowland Forest Endemic Bird Area; CNM: species confined to the Cameroon-Nigeria Mountain.

EBA	English name	Scientific name
GCL	Forest Swallow	*Hirundo fuliginosa*
GCL	Grey-necked Picathartes	*Picathartes oreas*
GCL	Rachel's Malimbe	*Malimbus racheliae*
CNM	Cameroon Montane Greenbul	*Andropadus montanus*
CNM	Grey-throated Greenbul	*Andropadus tephrolaemus*
CNM	Cameroon Olive Greenbul	*Phyllastrephus poensis*
CNM	Mountain Robin-Chat	*Cossypha isabellae*
CNM	Bangwa Forest Warbler	*Bradypterus bangwaensis*
CNM	Brown-backed Cisticola	*Cisticola discolor*
CNM	Green Longtail	*Urolais epichlora*
CNM	White-tailed Warbler	*Poliolais lopezi*
CNM	Black-capped Woodland Warbler	*Phylloscopus herberti*
CNM	White-throated Mountain Babbler	*Kupeornis gilberti*
CNM	Cameroon Blue-headed Sunbird	*Cyanomitra oritis*
CNM	Yellow-breasted Boubou	*Laniarius atroflavus*
CNM	Bannerman's Weaver	*Ploceus bannermani*

recorded together at the same spot (they were about 3 km apart), but their ranges obviously meet in Takamanda, with possibly an overlap and an ecological separation as shown by Eisentraut (1973) to occur around Mt. Cameroon and Kumba.

The current surveys also extended to the north the range in Cameroon of more than 20 lowland forest species.

Finally, we recorded two adult males of an unidentified Malimbe *Malimbus* species at Obonyi I for more than 15 minutes on a dead tree in farm bush. The description of the birds fits the highly threatened and local Ibadan Malimbe *Malimbus ibadanensis*, which is so far known only from western Nigeria. The birds were vocal, and the song and calls did not fit any other species of Malimbe. Unfortunately, there are no recordings of *M. ibadanensis* for comparison. Because Ibadan Malimbe is very rare and local, we need confirmation of our observation. We also note several unconfirmed records of the closely related Cassin's Malimbe *Malimbus cassini* west of the Sanaga, where this species is not found (Louette 1981, Keen 1993, Williams 1993). We do not rule out the possibility that these records may refer to the unknown species of Malimbe that we recorded or to Ibadan Malimbe.

4 Conclusions

4.1 Takamanda is an Important Bird Area

Takamanda Forest Reserve clearly qualifies as an Important Bird Area, based on the three following criteria: presence of endangered species, presence of restricted-range species, and occurrence of a vast array of biome-restricted species.

4.2 Regional significance of Takamanda Forest Reserve

The montane and sub-montane avifauna of Takamanda is more important than previously thought. The highest sector of Takamanda Forest Reserve must be considered, from a biological point of view, as an extension of the Obudu plateau. The occurrence of a large montane avifauna, with several endangered and endemic species, definitely deserves special attention from a conservation perspective. As noted, of special significance is the mid-altitude transition forest, which suffers from encroachment in Cameroon and Africa in general but holds a large variety of birds.

This study also confirmed that Takamanda holds a large array of lowland forest species. This is an important finding that further emphasizes the conservation value of the area because of its location at the northern limit of the lowland forest block. For many species, Takamanda is the largest forest block at the northern limit of their distribution.

The Reserve also corresponds to the limit of several West African species, some of them being immediately replaced by their Central or East African equivalents. In addition to the conservation value of the Reserve's position at the border between West and Central African avifauna, Takamanda represents an opportunity for field research in biogeography.

5 Recommendations

Following our preliminary surveys, we recommend the following:

1. The highest elevations of Takamanda Forest Reserve should be fully protected, together with a significant proportion of transition forest.

2. Because montane avifauna in Takamanda and Obudu plateau form one biological unit, a trans-boundary conservation measure should be implemented for long-term protection.

3. The lowland sector of the reserve is particularly important because it represents true Guineo-Congolian forest. This sector, at the northern edge of the large Central African forest block, deserves conservation attention.

4. There are approximately10 montane species and 10 to 20 lowland forest species that are likely to be found in Takamanda but that have not yet been recorded. More surveys should be conducted, of at least 10 days duration in the montane sector and two to three weeks duration in the lowland sector. Optimal timing for the surveys is December at the beginning of the breeding season. Both tape recordings (playback) and mist netting should be employed.

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Appendix 1. Checklist of the birds of Takamanda Forest Reserve, Cameroon. **IUCN**: Threatened species, EN: endangered; VU: vulnerable; NT: near-threatened. **RR**: restricted-range species (total world range less than 50.000 km²). **Biome**: Species confined to Afro-montane biome (Montane Forests: MF); Guineo-congolian forest biome (Lowland Forests: LF); Sudan-Guinea Savanna biome (Savanna: SV). **Status**: Status of bird in Takamanda Forest Reserve.

IUCN	RR	Biome	English name	Scientific name	Status	MGR, Status
			Long-tailed Cormorant	*Phalacrocorax africanus*	Uncomm	
			Green-backed Heron	*Butorides striatus*	Uncomm	
			Little Egret	*Egretta garzetta*	Uncomm	
			Hamerkop	*Scopus umbretta*	Frequent	
			Woolly-necked Stork	*Ciconia episcopus*	Rare	
			Hadada Ibis	*Bostrychia hagedash*	Frequent	
NT		LF	Hartlaub's Duck	*Pteronetta hartlaubii*	Uncomm	
			African Pygmy Goose	*Nettapus auritus*	Uncomm	
			Tufted Duck	*Aythya fuligula*	Uncomm	
			Osprey	*Pandion haliaetus*	Uncomm	P. Migrant
			Black-shouldered Kite	*Elanus caeruleus*	Uncomm	
			Black Kite	*Milvus migrans*	Common	Int / African, Migrant
			African Fish Eagle	*Haliaeetus vocifer*	Uncomm	
			Palm-nut Vulture	*Gypohierax angolensis*	Frequent	
			Western Banded Snake Eagle	*Circaetus cinerascens*	Uncomm	
		LF	Congo Serpent Eagle	*Dryotriorchis spectabilis*	Uncomm	
			African Harrier Hawk	*Polyboroides typus*	Common	
			Montagu's Harrier	*Circus pygargus*	Uncomm	P. Migrant
			European Marsh Harrier	*Circus aeruginosus*	Uncomm	P. Migrant
			African Goshawk	*Accipiter tachiro*	Uncomm	
		LF	Chestnut-flanked Sparrowhawk	*Accipiter castanilius*	Uncomm	
		LF	Western Little Sparrowhawk	*Accipiter erythropus*	Rare	
			Black Sparrowhawk	*Accipiter melanoleucus*	Frequent	
		LF	Long-tailed Hawk	*Urotriorchis macrourus*	Uncomm	
			Lizard Buzzard	*Kaupifalco monogrammicus*	Common	
			Red-necked Buzzard	*Buteo auguralis*	Frequent	
			Long-crested Eagle	*Lophaetus occipitalis*		
		LF	Cassin's Hawk Eagle	*Spizaetus africanus*	Uncomm	
			Crowned Eagle	*Stephanoaetus coronatus*	Frequent	
			Crested Guineafowl	*Guttera pucherani*	Uncomm	
			Common Quail	*Coturnix coturnix*	Rare	
		LF	Latham's Forest Francolin	*Francolinus lathami*	Frequent	
			Scaly Francolin	*Francolinus squamatus*	Common	

Continued

Appendix 1 (cont.). Checklist of the birds of Takamanda Forest Reserve, Cameroon.

IUCN	RR	Biome	English name	Scientific name	Status	MGR, Status
			Double-spurred Francolin	*Francolinus bicalcaratus*	Frequent	
		LF	Nkulengu Rail	*Himantornis haematopus*	Rare	
		LF	White-spotted Flufftail	*Sarothrura pulchra*	Common	
			African Finfoot	*Podica senegalensis*	Frequent	
			Rock Pratincole	*Glareola nuchalis*	Rare	
			Common Greenshank	*Tringa nebularia*	Uncomm	P. Migrant
			Green Sandpiper	*Tringa ochropus*	Uncomm	P. Migrant
			Common Sandpiper	*Actitis hypoleucos*	Frequent	
			African Green Pigeon	*Treron calva*	Common	
		LF	Blue-headed Wood Dove	*Turtur brehmeri*	Common	
			Tambourine Dove	*Turtur tympanistria*	Common	
			Blue-spotted Wood Dove	*Turtur afer*	Common	
		LF	Afep Pigeon	*Columba unicincta*	Common	
			Red-eyed Dove	*Streptopelia semitorquata*	Frequent	
		LF	Grey Parrot	*Psittacus erithacus*	Frequent	
		LF	Black-collared Lovebird	*Agapornis swindernianus*	Uncomm	
			Great Blue Turaco	*Corythaeola cristata*	Common	
		LF	Green Turaco	*Tauraco persa*	Common	
		LF	Yellow-billed Turaco	*Tauraco macrorhynchus*	Common	
			Levaillant's Cuckoo	*Oxylophus levaillantii*	Frequent	
			Black Cuckoo	*Cuculus clamosus*	Frequent	
			Olive Long-tailed Cuckoo	*Cercococcyx olivinus*	Common	
			African Emerald Cuckoo	*Chrysococcyx cupreus*	Common	
		LF	Yellow-throated Cuckoo	*Chrysococcyx flavigularis*	Frequent	
			Klaas's Cuckoo	*Chrysococcyx klaas*	Common	
			Didric Cuckoo	*Chrysococcyx caprius*	Frequent	
			Yellowbill	*Ceuthmochares aereus*	Common	
		LF	Black-throated Coucal	*Centropus leucogaster*	Uncomm	
			Senegal Coucal	*Centropus senegalensis*	Common	
			Barn Owl	*Tyto alba*	Uncomm	
			African Scops Owl	*Otus senegalensis*	Uncomm	
		LF	Vermiculated Fishing Owl	*Scotopelia bouvieri*	Rare	
		LF	Red-chested Owlet	*Glaucidium tephronotum*	Rare	
			African Wood Owl	*Strix woodfordii*	Frequent	
		LF	Brown Nightjar	*Caprimulgus binotatus*	Rare	
		LF	Black-shouldered Nightjar	*Caprimulgus nigriscapularis*	Uncomm	
			Standard-winged Nightjar	*Macrodipteryx longipennis*	Frequent	
		LF	Sabine's Spinetail	*Rhaphidura sabini*	Frequent	
		LF	Black Spinetail	*Telacanthura melanopygia*	Rare	
			Mottled Spinetail	*Telacanthura ussheri*	Rare	

Continued

Appendix 1 (cont.). Checklist of the birds of Takamanda Forest Reserve, Cameroon.

IUCN	RR	Biome	English name	Scientific name	Status	MGR, Status
		LF	Cassin's Spinetail	*Neafrapus cassini*	Frequent	
			African Palm Swift	*Cypsiurus parvus*	Common	
			European Swift	*Apus apus*	Common	
		LF	Bates's Swift	*Apus batesi*	Frequent	
			Speckled Mousebird	*Colius striatus*	Uncomm	
		MF	Bar-tailed Trogon	*Apaloderma vittatum*	Uncomm	
			Narina Trogon	*Apaloderma narina*	Frequent	
		LF	Bare-cheeked Trogon	*Apaloderma aequatoriale*	Uncomm	
		LF	Chocolate-backed Kingfisher	*Halcyon badia*	Frequent	
			Grey-headed Kingfisher	*Halcyon leucocephala*	Uncomm	
			Blue-breasted Kingfisher	*Halcyon malimbica*	Frequent	
			Woodland Kingfisher	*Halcyon senegalensis*	Frequent	
		LF	African Dwarf Kingfisher	*Ceyx lecontei*	Rare	
			African Pygmy Kingfisher	*Ceyx picta*	Frequent	
		LF	White-bellied Kingfisher	*Alcedo leucogaster*	Uncomm	
			Malachite Kingfisher	*Alcedo cristata*	Frequent	
			Shining-blue Kingfisher	*Alcedo quadribrachys*	Uncomm	
			Giant Kingfisher	*Megaceryle maxima*	Uncomm	
		LF	Blue-headed Bee-eater	*Merops muelleri*	Rare	
		LF	Black Bee-eater	*Merops gularis*	Uncomm	
			Blue-breasted Bee-eater	*Merops variegatus*	Uncomm	
			White-throated Bee-eater	*Merops albicollis*	Common	Migrant
		LF	Blue-throated Roller	*Eurystomus gularis*	Uncomm	
			Broad-billed Roller	*Eurystomus glaucurus*	Uncomm	
		LF	White-crested Hornbill	*Tockus albocristatus*	Uncomm	
		LF	Black Dwarf Hornbill	*Tockus hartlaubi*	Rare	
		LF	Red-billed Dwarf Hornbill	*Tockus camurus*	Frequent	
		LF	African Pied Hornbill	*Tockus fasciatus*	Common	
		LF	Piping Hornbill	*Ceratogymna fistulator*	Frequent	
		LF	White-thighed Hornbill	*Ceratogymna albotibialis*	Common	
		LF	Black-casqued Wattled Hornbill	*Ceratogymna atrata*	Uncomm	
NT		LF	Yellow-casqued Wattled Hornbill	*Ceratogymna elata*	Rare	
			Grey-throated Barbet	*Gymnobucco bonapartei*	Frequent	
		LF	Bristle-nosed Barbet	*Gymnobucco peli*	Common	
		LF	Naked-faced Barbet	*Gymnobucco calvus*	Frequent	
		LF	Speckled Tinkerbird	*Pogoniulus scolopaceus*	Common	
		MF	Western Green Tinkerbird	*Pogoniulus coryphaeus*	Uncomm	
		LF	Red-rumped Tinkerbird	*Pogoniulus atroflavus*	Frequent	

Continued

Appendix 1 (cont.). Checklist of the birds of Takamanda Forest Reserve, Cameroon.

IUCN	RR	Biome	English name	Scientific name	Status	MGR, Status
		LF	Yellow-throated Tinkerbird	*Pogoniulus subsulphureus*	Common	
			Yellow-rumped Tinkerbird	*Pogoniulus bilineatus*	Common	
		LF	Yellow-spotted Barbet	*Buccanodon duchaillui*	Frequent	
		LF	Hairy-breasted Barbet	*Tricholaema hirsuta*	Frequent	
		LF	Yellow-billed Barbet	*Trachyphonus purpuratus*	Common	
		LF	Spotted Honeyguide	*Indicator maculatus*	Uncomm	
			Lesser Honeyguide	*Indicator minor*	Frequent	
			Thick-billed Honeyguide	*Indicator conirostris*	Uncomm	
			Least Honeyguide	*Indicator exilis*	Rare	
		MF	Tullberg's Woodpecker	*Campethera tullbergi*	Uncomm	
		LF	Buff-spotted Woodpecker	*Campethera nivosa*	Uncomm	
		LF	Brown-eared Woodpecker	*Campethera caroli*	Rare	
			Cardinal Woodpecker	*Dendropicos fuscescens*	Common	
		LF	Fire-bellied Woodpecker	*Dendropicos pyrrhogaster*	Rare	
		LF	Yellow-crested Woodpecker	*Dendropicos xantholophus*	Rare	
			Elliot's Woodpecker	*Dendropicos elliotii*	Uncomm	
		LF	Grey-headed Broadbill	*Smithornis sharpei*	Uncomm	
		LF	Rufous-sided Broadbill	*Smithornis rufolateralis*	Frequent	
		SV	Sun Lark	*Galerida modesta*	Rare	
		LF	Square-tailed Saw-wing	*Psalidoprocne nitens*	Common	
			Black Saw-wing	*Psalidoprocne pristoptera*	Common	
			Grey-rumped Swallow	*Pseudhirundo griseopyga*	Uncomm	
			Red-rumped Swallow	*Hirundo daurica*	Frequent	
	X	LF	Forest Swallow	*Hirundo fuliginosa*	Rare	
		LF	White-throated Blue Swallow	*Hirundo nigrita*	Uncomm	
			Barn Swallow	*Hirundo rustica*	Common	
			House Martin	*Delichon urbica*	Uncomm	
			Yellow Wagtail	*Motacilla flava*	Uncomm	
			Mountain Wagtail	*Motacilla clara*	Uncomm	
			African Pied Wagtail	*Motacilla aguimp*	Uncomm	
			Plain-backed Pipit	*Anthus leucophrys*	Rare	
		LF	Long-legged Pipit	*Anthus pallidiventris*	Uncomm	
			Tree Pipit	*Anthus trivialis*	Common	
			Red-shouldered Cuckoo-Shrike	*Campephaga phoenicea*	Uncomm	
		LF	Petit's Cuckoo-Shrike	*Campephaga petiti*	Uncomm	
			Purple-throated Cuckoo-Shrike	*Campephaga quiscalina*	Rare	

Continued

Appendix 1 (cont.). Checklist of the birds of Takamanda Forest Reserve, Cameroon.

IUCN	RR	Biome	English name	Scientific name	Status	MGR, Status
		MF	Grey Cuckoo-Shrike	*Coracina caesia*	Rare	
		LF	Blue Cuckoo-Shrike	*Coracina azurea*	Common	
NT	X	MF	Cameroon Montane Greenbul	*Andropadus montanus*	Rare	
	X	MF	Grey-throated Greenbul	*Andropadus tephrolaemus*	Frequent	
			Little Greenbul	*Andropadus virens*	Common	
		LF	Little Grey Greenbul	*Andropadus gracilis*	Uncomm	
		LF	Ansorge's Greenbul	*Andropadus ansorgei*	Uncomm	
		LF	Cameroon Sombre Greenbul	*Andropadus curvirostris*	Rare	
			Slender-billed Greenbul	*Andropadus gracilirostris*	Common	
			Yellow-whiskered Greenbul	*Andropadus latirostris*	Common	
		LF	Golden Greenbul	*Calyptocichla serina*	Uncomm	
		LF	Honeyguide Greenbul	*Baeopogon indicator*	Common	
		LF	Sjüstedt's Honeyguide Greenbul	*Baeopogon clamans*	Rare	
		LF	Spotted Greenbul	*Ixonotus guttatus*	Common	
		LF	Simple Greenbul	*Chlorocichla simplex*	Common	
		LF	Swamp Palm Bulbul	*Thescelocichla leucopleura*	Common	
	X	MF	Cameroon Olive Greenbul	*Phyllastrephus poensis*	Uncomm	
		LF	Icterine Greenbul	*Phyllastrephus icterinus*	Common	
		LF	Xavier's Greenbul	*Phyllastrephus xavieri*	Uncomm	
		LF	White-throated Greenbul	*Phyllastrephus albigularis*	Uncomm	
		LF	Grey-headed Bristlebill	*Bleda canicapilla*	Uncomm	
		LF	Red-tailed Bristlebill	*Bleda syndactyla*	Uncomm	
		LF	Green-tailed Bristlebill	*Bleda eximia*	Common	
		LF	Eastern Bearded Greenbul	*Criniger chloronotus*	Common	
		LF	Red-tailed Greenbul	*Criniger calurus*	Common	
			Common Bulbul	*Pycnonotus barbatus*	Common	
		LF	Forest Robin	*Stiphrornis erythrothorax*	Common	
			Bocage's Akalat	*Sheppardia bocagei*	Uncomm	
		MF	White-bellied Robinchat	*Cossyphicula roberti*	Rare	
	X	MF	Mountain Robin-Chat	*Cossypha isabellae*	Rare	
			Snowy-crowned Robin-Chat	*Cossypha niveicapilla*	Uncomm	
		LF	Fire-crested Alethe	*Alethe diademata*	Common	
			Brown-chested Alethe	*Alethe poliocephala*	Uncomm	
		LF	White-tailed Ant Thrush	*Neocossyphus poensis*	Common	
		LF	Rufous Flycatcher-Thrush	*Neocossyphus fraseri*	Common	

Continued

Appendix 1 (cont.). Checklist of the birds of Takamanda Forest Reserve, Cameroon.

IUCN	RR	Biome	English name	Scientific name	Status	MGR, Status
			Common Stonechat	*Saxicola torquata*	Uncomm	
			Whinchat	*Saxicola rubetra*	Uncomm	
NT		MF	Crossley's Ground-thrush	*Zoothera crossleyi*	Uncomm	
			African Thrush	*Turdus pelios*	Uncomm	
NT	X	MF	Bangwa Forest Warbler	*Bradypterus bangwaensis*	Rare	
			Black-faced Rufous Warbler	*Bathmocercus rufus*	Rare	
			African/Eurasian Reed Warbler	*Acrocephalus baeticatus/scirpaceus*	Rare	
			Icterine Warbler	*Hippolais icterina*	Rare	
		LF	Chattering Cisticola	*Cisticola anonymus*	Rare	
	X	MF	Brown-backed Cisticola	*Cisticola discolor*	Uncomm	
			Croaking Cisticola	*Cisticola natalensis*	Uncomm	
			Short-winged Cisticola	*Cisticola brachyptera*	Uncomm	
			Tawny-flanked Prinia	*Prinia subflava*	Frequent	
			Banded Prinia	*Prinia bairdii*	Frequent	
	X	MF	Green Longtail	*Urolais epichlora*	Uncomm	
			White-chinned Prinia	*Schistolais leucopogon*	Frequent	
		MF	Black-collared Apalis	*Apalis pulchra*	Uncomm	
			Black-throated Apalis	*Apalis jacksoni*	Rare	
		LF	Black-capped Apalis	*Apalis nigriceps*	Uncomm	
		LF	Buff-throated Apalis	*Apalis rufogularis*	Common	
			Grey Apalis	*Apalis cinerea*	Uncomm	
NT	X	MF	White-tailed Warbler	*Poliolais lopezi*	Rare	
			Grey-backed Camaroptera	*Camaroptera brachyura*	Common	
		LF	Yellow-browed Camaroptera	*Camaroptera superciliaris*	Common	
		LF	Olive-green Camaroptera	*Camaroptera chloronota*	Common	
		LF	Yellow Longbill	*Macrosphenus flavicans*	Common	
		LF	Kemp's Longbill	*Macrosphenus kempi*	Uncomm	
		LF	Grey Longbill	*Macrosphenus concolor*	Common	
		LF	Rufous-crowned Eremomela	*Eremomela badiceps*	Common	
		LF	Green Crombec	*Sylvietta virens*	Common	
			Willow Warbler	*Phylloscopus trochilus*	Frequent	P. Migrant
			Wood Warbler	*Phylloscopus sibilatrix*	Uncomm	P. Migrant
	X	MF	Black-capped Woodland Warbler	*Phylloscopus herberti*	Rare	
			Garden Warbler	*Sylvia borin*	Uncomm	P. Migrant
		LF	Green Hylia	*Hylia prasina*	Common	
		LF	Cassin's Flycatcher	*Muscicapa cassini*	Common	

Continued

Appendix 1 (cont.). Checklist of the birds of Takamanda Forest Reserve, Cameroon.

IUCN	RR	Biome	English name	Scientific name	Status	MGR, Status
			African Dusky Flycatcher	*Muscicapa adusta*	Uncomm	
		LF	Yellow-footed Flycatcher	*Muscicapa sethsmithi*	Uncomm	
		LF	Dusky-blue Flycatcher	*Muscicapa comitata*	Uncomm	
		LF	Sooty Flycatcher	*Muscicapa infuscata*	Uncomm	
			Ussher's Flycatcher	*Muscicapa ussheri*	Frequent	
			Grey Tit-Flycatcher	*Myioparus plumbeus*	Frequent	
			European Pied Flycatcher	*Ficedula hypoleuca*	Uncomm	P. Migrant
		LF	Chestnut-capped Flycatcher	*Erythrocercus mccallii*	Common	
			African Blue Flycatcher	*Elminia longicauda*	Common	
		LF	Dusky Crested Flycatcher	*Elminia nigromitrata*	Uncomm	
		MF	White-bellied Crested Flycatcher	*Elminia albiventris*	Uncomm	
		LF	Blue-headed Crested Flycatcher	*Trochocercus nitens*	Common	
			African Paradise Flycatcher	*Terpsiphone viridis*	Frequent	
		LF	Rufous-vented Paradise Flycatcher	*Terpsiphone rufocinerea*	Frequent	
		LF	Bates's Paradise Flycatcher	*Terpsiphone batesi*	Common	
		LF	Red-bellied Paradise Flycatcher	*Terpsiphone rufiventer*	Common	
		LF	Shrike-Flycatcher	*Megabyas flammulatus*	Uncomm	
		LF	Chestnut Wattle-eye	*Dyaphorophyia castanea*	Common	
		LF	White-spotted Wattle-eye	*Dyaphorophyia tonsa*	Uncomm	
		LF	Red-cheeked Wattle-eye	*Dyaphorophyia blisseti*	Rare	
		LF	Black-necked Wattle-eye	*Dyaphorophyia chalybea*	Uncomm	
			Yellow-bellied Wattle-eye	*Dyaphorophyia concreta*	Uncomm	
			Scarlet-spectacled Wattle-eye	*Platysteira cyanea*	Common	
			Black-headed Batis	*Batis minor*	Uncomm	
		MF	Grey-chested Illadopsis	*Kakamega poliothorax*	Common	
		LF	Brown Illadopsis	*Illadopsis fulvescens*	Common	
			Pale-breasted Illadopsis	*Illadopsis rufipennis*	Common	
		LF	Blackcap Illadopsis	*Illadopsis cleaveri*	Common	
EN	X	MF	White-throated Mountain Babbler	*Kupeornis gilberti*	Uncomm	
		LF	Capuchin Babbler	*Phyllanthus atripennis*	Uncomm	
VU	X	LF	Grey-necked Picathartes	*Picathartes oreas*	Rare	
		LF	Tit-hylia	*Pholidornis rushiae*	Uncomm	

Continued

Appendix 1 (cont.). Checklist of the birds of Takamanda Forest Reserve, Cameroon.

IUCN	RR	Biome	English name	Scientific name	Status	MGR, Status
		LF	Fraser's Sunbird	*Deleornis fraseri*	Common	
			Collared Sunbird	*Hedyptina collaris*	Common	
		LF	Bates's Sunbird	*Cinnyris batesi*	Rare	
			Olive Sunbird	*Cyanomitra olivacea*	Common	
	X	MF	Cameroon Blue-headed Sunbird	*Cyanomitra oritis*	Uncomm	
			Green-headed Sunbird	*Cyanomitra verticalis*	Uncomm	
		LF	Blue-throated Brown Sunbird	*Cyanomitra cyanolaema*	Common	
		LF	Green-throated Sunbird	*Chalcomitra rubescens*	Uncomm	
			Olive-bellied Sunbird	*Cinnyris chloropygia*	Common	
		MF	Northern Double-collared Sunbird	*Cinnyris reichenowi*	Uncomm	
			Orange-tufted Sunbird	*Cinnyris bouvieri*	Rare	
			Splendid Sunbird	*Cinnyris coccinigastra*	Uncomm	
		LF	Johanna's Sunbird	*Cinnyris johannae*	Uncomm	
		LF	Superb Sunbird	*Cinnyris superba*	Uncomm	
			Yellow White-eye	*Zosterops senegalensis*	Common	
		LF	Western Black-headed Oriole	*Oriolus brachyrhynchus*	Common	
		LF	Black-winged Oriole	*Oriolus nigripennis*	Uncomm	
			Mackinnon's Shrike	*Lanius mackinnoni*	Uncomm	
		LF	Black-shouldered Puffback	*Dryoscopus senegalensis*	Frequent	
			Pink-footed Puffback	*Dryoscopus angolensis*	Uncomm	
			Brown-crowned Tchagra	*Tchagra australis*	Uncomm	
			Tropical Boubou	*Laniarius aethiopicus*	Uncomm	
	X	MF	Yellow-breasted Boubou	*Laniarius atroflavus*	Rare	
		MF	Fülleborn's Black Boubou	*Laniarius fuelleborni*	Frequent	
		LF	Sooty Boubou	*Laniarius leucorhynchus*	Uncomm	
			Many-coloured Bush Shrike	*Malaconotus multicolor*	Uncomm	
		LF	Western Nicator	*Nicator chloris*	Common	
			Red-billed Helmet Shrike	*Prionops caniceps*	Uncomm	
			Square-tailed Drongo	*Dicrurus ludwigii*	Common	
		LF	Shining Drongo	*Dicrurus atripennis*	Common	
			Velvet-mantled Drongo	*Dicrurus modestus*	Uncomm	
			Pied Crow	*Corvus albus*	Uncomm	
		MF	Waller's Chestnut-winged Starling	*Onychognathus walleri*	Uncomm	

Continued

Appendix 1 (cont.). Checklist of the birds of Takamanda Forest Reserve, Cameroon.

IUCN	RR	Biome	English name	Scientific name	Status	MGR, Status
		LF	Forest Chestnut-winged Starling	*Onychognathus fulgidus*	Uncomm	
			Splendid Glossy Starling	*Lamprotornis splendidus*	Common	
			Grey-headed Sparrow	*Passer griseus*	Uncomm	
		SV	Bush Petronia	*Petronia dentata*	Rare	
VU	X	MF	Bannerman's Weaver	*Ploceus bannermani*	Rare	
			Spectacled Weaver	*Ploceus ocularis*	Rare	
		MF	Black-billed Weaver	*Ploceus melanogaster*	Uncomm	
		LF	Vieillot's Black Weaver	*Ploceus nigerrimus*	Common	
			Village Weaver	*Ploceus cucullatus*	Common	
		LF	Yellow-mantled Weaver	*Ploceus tricolor*	Uncomm	
		LF	Maxwell's Black Weaver	*Ploceus albinucha*	Uncomm	
			Dark-backed Weaver	*Ploceus bicolor*	Frequent	
		LF	Blue-billed Malimbe	*Malimbus nitens*	Frequent	
		LF	Crested Malimbe	*Malimbus malimbicus*	Frequent	
		LF	Red-vented Malimbe	*Malimbus scutatus*	Common	
	X	LF	Rachel's Malimbe	*Malimbus racheliae*	Uncomm	
		LF	Red-headed Malimbe	*Malimbus rubricollis*	Uncomm	
			Yellow Bishop	*Euplectes capensis*	Uncomm	
			Grey-crowned Negrofinch	*Nigrita canicapilla*	Common	
		LF	Pale-fronted Negrofinch	*Nigrita luteifrons*	Uncomm	
		LF	Chestnut-breasted Negrofinch	*Nigrita bicolor*	Uncomm	
		LF	White-breasted Negrofinch	*Nigrita fusconota*	Uncomm	
		MF	Red-faced Crimsonwing	*Crytospiza reichenovii*	Rare	
		LF	Western Bluebill	*Spermophaga haematina*	Uncomm	
			Green Twinspot	*Mandingoa nitidula*	Uncomm	
			Common Waxbill	*Estrilda astrild*	Common	
			Black-crowned Waxbill	*Estrilda nonnula*	Common	
			Bronze Mannikin	*Lonchura cucullata*	Common	
			Black-and-white Mannikin	*Lonchura bicolor*	Uncomm	
		MF	Oriole Finch	*Linurgus olivaceus*	Rare	
				TOTAL NUMBER OF SPECIES:	**313**	

Large Mammals of Takamanda Forest Reserve, Cameroon

Jacqueline L. Sunderland-Groves and Fiona Maisels

1 Introduction

Until recently, information regarding the fauna of Takamanda Forest Reserve (TFR) was, at best, fragmentary (Allen 1930, Sanderson 1940, Struhsaker 1967, Critchley 1968). No survey had been carried out in the Takamanda area since 1987 (Thomas 1988). Due to the lack of available information, Sanderson's specimen collections from areas surrounding Takamanda, housed in the British Museum of Natural History, provided the basis for a faunal checklist (Appendix 1). Fifty years later, Thomas (1988) confirmed the continued existence of 11 species of large mammals in the area reported by Sanderson. Before the start of the 1998 survey, the Sanderson 1934 collection, consisting of all dry skin specimens except ungulates and bats, was examined and verified (Dowsett 1997).

The major objectives of the 1998 study were to assess the current status of and threats to the population of the Critically Endangered (IUCN 2002) Cross River Gorilla *Gorilla gorilla diehli*. In addition, status of and threats to other large mammals in the Reserve were investigated: several large mammal species or subspecies were known to be endemic to the region, including chimpanzee *Pan troglodytes vellerosus*, drill *Mandrillus leucophaeus*, Preuss's guenon *Cercopithecus preussi*, and red eared guenon *Cercopithecus erythrotis*.

In the forests of Central and West Africa, hunting for meat is of increasing concern and is the major cause of ape decline (Walsh *et al.* 2003) and of other large mammal decline in general (Fa *et al.* 2002). Hunting is facilitated by increased access made possible by the construction of logging roads (Minnemeyer *et al.* 2002, Wilkie *et al.* 2000). In the Bamenda Highlands just east of the Takamanda area, most species of large mammals have been locally extirpated within the last century (Maisels *et al.* 2001).

A commercial road is currently being built in the Takamanda area between the towns of Mamfe and Akwaya (Sunderland-Groves *et al.* this volume). When complete, the road will cut directly between the Takamanda forest and the Mone and Mbulu forests, allowing ready access to the forests and, subsequently, increased export of agricultural and forest products, including bushmeat.

Although development projects such as roads are important for the local human population, increased accessibility to the area will undoubtedly affect the future survival of wildlife populations unless strict measures are taken to protect the animals. Following the 1998 survey, emphasis was placed on working with local communities and the Cameroon Ministry of Environment and Forestry (MINEF) to protect wildlife populations. Education materials were disseminated to increase conservation awareness and promote Cameroon's laws concerning illegal hunting of protected species.

2 Methods

2.1 Field methods

In Takamanda Forest Reserve, two primary vegetation strata—lowland forest, including riverine forest, and sub-montane forest, encompassing ridge or "highland" forest—were identified and surveyed, using the stratified random sampling technique. Within these strata, two lowland sites were sampled: Oyi on the edge of the Reserve and Makone in the center of the Reserve. Variation in sites was meant to reflect predicted differences in hunting pressure, where we presumed areas on the edge of the reserve would be subject to more hunting. Three highland sites were also selected for survey: Matene in the northern section of the Reserve, Obonyi I in the eastern part of the Reserve along the border with the Okwangwo division of Cross River National Park in Nigeria, and Basho on the western edge of the Reserve (Figure 2 in Chapter 1).

The survey used standard line transect methods that are practiced widely in animal density censusing (Burnham *et al.* 1980, Buckland *et al.* 1993). General transect protocols followed White and Edwards (2000). Forest in the transects was cut just enough to allow one person to pass. All transects were marked at 25-m intervals with flagging tape and allowed to settle for a minimum of three days before they were walked and data collected. The reason was to ensure that the disturbance and noise caused by cutting the transects did not bias direct observations of mammals such as monkeys.

In the lowland forest, 40 transects—all 2 km in length, except for one that measured 3 km (81 km in total) were laid out perpendicular to the main rivers, the Makone and the Oyi (20 along each river, each transect 1 km apart from and parallel to the next). In this manner, the rivers were sampled along much of their lengths within the Reserve, and vegetation on each side of the rivers was sampled in the same proportion as it occurs in the environment (Buckland *et al.* 1993). Four sampling sections, Makone River East, Makone River West, Oyi East, and Oyi West, contained 10 transects each and were surveyed during both the dry and wet seasons. The other two lowland sites were sampled only in the wet season.

Sixteen transects were cut in submontane/ridge forest (8 km in total), five in the Matene and Obonyi 1 hills, and six in the Basho hills. An additional 6 km of baseline was used to calculate encounter rates in the submontane forest. Transect starting points were selected randomly from a map and located using GPS. The baseline was located parallel to the contour of the hill, and transects were cut perpendicular to it. Each transect was 500 m in length; longer transects would not have sampled the desired topographical areas. The three highland forest areas were surveyed only during the dry season as time constraints made it impossible to repeat sampling of the highland strata during the wet season. Using portions of the baseline as separate transects is statistically invalid because they are not independent.

The data collected included indirect mammal sign such as dung and tracks and direct observations (animals seen or heard). All evidence of human presence such as traps, snares, hunter paths, bush houses, spent cartridges, and gunshots was recorded to evaluate hunting pressures. Changes in topography and vegetation were also recorded along each transect.

To standardize the sampling effort, the number of observers, speed of travel, and time of day were kept constant for each transect. Transects were not walked during heavy or medium rainfall because such conditions affect mammal movements and observer reliability. Additional reconnaissance surveys in the other vegetation types of the Reserve were carried out, especially in the higher altitude areas, and all signs of large mammals were recorded.

2.2 Data analysis

Although the survey was designed to estimate densities of animals, there were too few observations to use the DISTANCE program (Thomas *et al.* 2002), which requires at least 60 observations per species per stratum. Thus, we used encounter rate (number of animals or their sign encountered per kilometer) as the standard unit to assess the relative abundance of animal (and human) sign. Analysis of differences between datasets were made using the Mann-Whitney U test; unless data was paired, where we used the Wilcoxon Paired Rank test (Siegel and Castellan 1988).

3 Results

3.1 Species presence

Fifteen species of large mammal were recorded within the TFR, including forest elephant *Loxodonta africana cyclotis* in both lowland strata (Table 1). Of the eight primate species recorded, several are endemic, and some are internationally endangered. The gorilla *Gorilla gorilla diehli* is classified by IUCN (2002) as Critically

Table 1. Large mammal species recorded through transect and additional survey observations, Takamanda Forest Reserve, Cameroon (S = Seen; H = Heard; T = Tracks seen; D = dung piles seen; P = path (where no fresh tracks were seen); F = feeding sign; N = nest; red duikers refers to all medium-sized duikers, as species could not be reliably separated)

			Lowland Sites				Highland Sites		
Order	**Species**	**English name**	**Makone River East**	**Makone River West**	**Oyi East**	**Oyi West**	**Obonyi 1 Hills**	**Basho Hills**	**Matene Hills**
Proboscidea									
	Loxodonta africana cyclotis	Forest elephant	D, T	D, T	D, T	P			
Artiodactyla									
	Potamochoerus porcus	Red river hog	T	T	T	T	T	T	
	Hyemoschus aquaticus	Giant forest hog	T	T	T	T			
	Syncerus caffer nanus	Forest buffalo	T	S, T	T	H			
	Cephalophus silvicultor	Yellow backed duiker	T	T	T	T			
		Red duikers	S, D, T	S, T	S, D, T	T	D, T	T	D, T
	Cephalophus monticola	Blue duiker	S, H, D, T	S, T	S, H, T	T	D, T	T	
Primates									
	Gorilla gorilla diehli	Cross River gorilla	N				N, F	D, N, F	
	Pan troglodytes vellerosus	Chimpanzee	H, T, N				H, D, N	H, N	N
	Mandrillus leucophaeus	Drill		D	S				
	Cercopithecus erythrotis	Red-eared guenon	S, H	S	S, H	S, H			H
	Cercopithecus mona	Mona monkey	S, H	S, H	S, H	S, H		S, H	
	Cercopithecus nictitans	Putty nosed guenon	S, H	S, H	S, H	S, H	H	H	H
	Cercopithecus pogonias	Crowned guenon	H						
	Cercopithecus preussi	Preuss's guenon	S, H, D	D	S, H		S	H, F	

Table 2. Encounter rates for large mammal species per kilometer of transect walked, Takamanda Forest Reserve, Cameroon .

Species	Common Name	N/L Individuals	N/L Groups
Cercopithecus mona	Mona monkey		0.110
Cercopithecus nictitans	Putty nosed monkey		0.103
Cercopithecus erythrotis	Red eared guenon		0.081
Cercopithecus preussi	Preuss's guenon		0.044
Mandrillus leucophaeus	Drill		0.007
Red duikers	Red duikers	0.037	
Cephalophus monticola	Blue duiker	0.022	
Syncerus caffer	Buffalo	0.007	

Endangered (Sunderland-Groves et. al. this volume), and three—chimpanzee *Pan troglodytes vellerosus*, drill *Mandrillus leucophaeus*, and Preuss's guenon *Cercopithecus preussi*—are classed as Endangered. The red eared guenon *Cercopithecus erythrotis* is classified Vulnerable. Other fauna encountered include duikers *Cephalophus* spp., forest buffalo *Syncerus caffer nanus*, and red river hog *Potamochoerus porcus*. All medium to large mammal species seen and heard or for which sign was recorded during the study are listed by site in Table 1. Some of the sites were previously surveyed by Thomas (1988), and the mammals recorded at that time are listed in Appendix 2 for comparison with the results of this study.

3.2 Sightings

During the transect surveys, encounter rates were very low (Table 2). No apes were seen at any site in any season, no ungulates were seen in the highlands, and red duikers and *Cephalophus monticola* were seen only twice during the 12-month survey period. There were no sightings of any large mammals in the Matene hills. Only one large mammal sighting was recorded in Obonyi I hills (a troop of *C. mona* monkeys), and only one sighting was recorded in the Basho hills (a troop of *C. preussi* monkeys). *C. preussi* was seen only on the east banks of the Makone and Oyi Rivers. Drills were seen only once, on the east side of the Oyi River. Sighting data may be few in the highlands for two reasons, apart from that of few animals. First, the total length of transect surveyed was much shorter in the three hill strata than in the lowlands. Second, the hill sites were only surveyed in the dry season when noise is created by walking on leaf litter.

3.3 Vocalizations

Vocalizations were recorded mostly from primates, although an occasional ungulate alarm call was heard. *Cercopithecus nictitans* was the most commonly heard monkey species. There were no significant differences between the frequency of vocalizations at the highland and the lowland sites for *C. mona* ($P= 0.62$) or *C. nictitans* ($P=0.59$). However, monkeys called more frequently on the east side of the Makone River than on the west side (all monkeys pooled: $P=0.0001$; *C. nictitans*: $P=0.0019$) and more frequently on the east side of the Oyi River than on the west side (all monkeys pooled: $P= 0.0013$; *C. nictitans*: $P= 0.0313$). In addition, *C. mona* and *C. nictitans* called more during the wet than the dry season ($P=0.0501$; $P=0.021$). The encounter rate of all monkey vocalizations combined was highest in the

Figure 1. Encounter rate of monkey vocalizations at each site (95% confidence limits), Takamanda Forest Reserve, Cameroon.

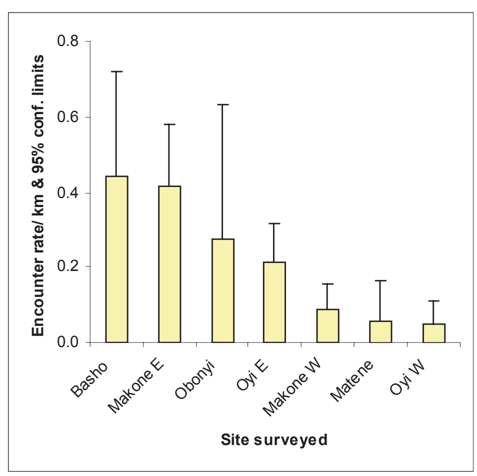

Table 3. Encounter rates for primates heard per kilometer of transect walked, Takamanda Forest Reserve, Cameroon

Species	Lowland Sites				Highland Sites		
	Makone River East	Makone River West	Oyi East	Oyi West	Obonyi 1 Hills	Basho Hills	Matene Hills
Cercopithecus nictitans	0.452	0.250	0.175	0.050	1.111	0.400	0.222
Cercopithecus	0.143	0.100	0.175	0.050		0.800	
Cercopithecus preussi	0.119		0.025			0.400	
Cercopithecus erythrotis	0.095		0.050	0.050			

Basho hills (Figure 2) and, for *C. nictitans*, the Obonyi 1 hills (Table 3). In the Matene hills, only *C. nictitans* was heard along the transects, although *C. erythrotis* was heard during a 'site selection' walk.*C. erythrotis* was not seen at all along transects in the highlands and rarely seen or heard in the lowland areas (a total of 10 sightings and 7 vocalization records in 12 months). *Cercopithecus preussi* was heard just 8 times on transect walks in 12 months, twice in the hills of the Basho area.

3.4 Tracks, dung, and other signs

Track data were recorded at the hill sites during the dry season when leaf litter covered the ground, making it difficult to see tracks. In addition, the hill strata were mostly rocky, and tracks did not show up well. In the lowland sites, frequent heavy rainstorms during the wet season washed away tracks. Because of these conditions, the results in this section are somewhat subjective.

Encounter rates for tracks were low throughout. The different animal tracks recorded along the transects were mostly made by ungulates, and most of those were

Table 4. Encounter rates for large mammal species tracks per kilometer of transect walked, Takamanda Forest Reserve, Cameroon.

Species	Lowland Sites				Highland Sites		
	Makone River East	Makone River West	Oyi East	Oyi West	Obonyi 1 Hills	Basho Hills	Matene Hills
Red duikers	1.74	2.15	2.68	1.05	4.22	0.20	0.22
Loxodonta	1.12	2.20	0.25	0.20			
Cephalophus monticola	0.55	0.95	0.50	0.15	0.22	0.20	
Potamochoerus porcus	0.29	1.10	0.85	1.25	0.89		
Syncerus caffer	0.12	0.20	0.10				
Hyemoschus aquaticus	0.10	0.05	0.18	0.10			
Cephalophus silvicultor	0.02	0.10	0.15	0.05			

Table 5. Summary of the indices of human pressure, Takamanda Forest Reserve, Cameroon (data are encounter rates/km surveyed; numerical data stem from transects, "present" stems from reconnaissance surveys).

Site	Traps	Hunter paths	Other paths	Other signs (e.g., cartridges, huts, gunshots)
Makone River East	0.76	1.62	0.24	0.04
Makone River West	0.30	2.97	1.00	0.02
Oyi East	0.23	1.50	0.38	0.18
Oyi West	1.10	1.55	0.55	0.04
Obonyi 1	Present	1.33	-	-
Basho	0.80	1.00	-	-
Matene	0.22	2.00	-	0.04

assigned to medium-sized red duikers (Table 4.). The majority of the other tracks were from *Cephalophus monticola* and *P. porcus*. There were more *C. monticola* tracks in the Makone area than in the Oyi area (P=0.004), but no significant differences between the two lowland sites for *P. porcus* (P=0.09) or “red” duikers (P=0.88). There were very few tracks in the highland forest areas, perhaps due to expanses of rocky outcrops and large quantities of leaf litter. The Matene site was particularly poor in tracks; only one red duiker track was recorded. No significant difference (P=0.125; P=0.21) in the frequencies of elephant paths or tracks on the two sides of the Makone River was noted. A few elephant tracks and paths were recorded on the west side of the Oyi, but the frequency was not different from the east side (P=0.69). There were no seasonal differences (P=0.11; P=0.29) for elephant paths at either Makone or Oyi, both of which were surveyed in the wet and dry seasons. No elephant signs were seen in the hill areas along transects, but elephant dung was seen on the steep part of the Makone East site.

So little dung was seen during the study period, it was impossible to analyze. Only 15 dung piles of eight different mammal species were observed. The maximum nunber of dung piles for any one species was four. These records were not sufficient for analysis.

3.5 Human pressure

Overall, more human signs (3.3 signs/km) were recorded at the lowland sites than in the highlands (1.9 signs/km). The only types of sign seen in the highlands were traps, hunter paths, and bent sticks, while in the lowlands, 11 different types were recorded. The highest encounter rate for hunter’s paths was in the Makone River West area (Table 5). The number of hunter’s paths was significantly higher in this area than on the east side during the wet season (P=0.01). There was no significant difference between the two sides of the river for cartridge cases or non-hunting paths (P=0.58; P=0.061). There was no difference between the east and west sides of the Oyi river during the wet season for any human sign (traps: P=0.11; hunting paths: P=0.24; cartridges: P= 0.19; other paths: P=0.78). Therefore the two sides of the Oyi River form a single stratum in terms of measurable human pressure. There was no significant difference between any of the three highland sites for hunting paths for pairs of sites compared (P=0.32 to 0.85). Basho and Matene were compared for trap encounter rate: there was no significant difference between them (P=0.32).

When all the data from the lowlands are compared with all data from the highlands (dry season only), there were significantly more traps and hunter’s paths in the lowlands than in the highlands (P=0.005; P=0.019), reflecting the higher hunting pressure in the lowlands.

4 Discussion

Because this was the first long-term survey of large mammals in Takamanda Forest Reserve, no data exist to compare changes in encounter rates over time, except for gorillas in the 1950s (see Sunderland-Groves *et al.* this volume). However, we did examine previous work in the area to determine whether species that were once in Takamanda no longer occur.

The surveys revealed that the Matene forest had both the lowest diversity and abundance of large mammals. Local hunters at Matene village reported that they now have to hunt in the Makone River area because there are so few large mammals remaining in their own forests. The Makone area was found to have the greatest hunting pressure, which may be indicative of the recent migration of Matene (and other) hunters to Makone.

Species that are currently very scarce in the area include elephant, buffalo, water chevrotain, and yellow-backed duiker. Elephants and buffalo were reported by Thomas to be "common" in the center of the Reserve during the 1987 survey, but elephants were neither seen nor heard in 1998 and 1999. Local hunters claimed that elephants entered Takamanda forest during the wet season to feed on fruits such as bush mango *Irvingia gabonensis*, and that they returned to Nigeria where they were not subjected to the same hunting pressure as in Takamanda.

Buffalo tracks and a single sighting were recorded in the lowlands. Water chevrotain and yellow-backed duiker sign was very rare throughout the surveys and was recorded only in the lowlands. Drill and crowned guenon were also rare. However, a more recent study (Groves 2002) observed drills in the Basho hills, Mone Forest Reserve, and parts of Mbulu forest, finding these animals to be more widespread than reported here.

Comparing our findings with those of Sanderson (1940) and Struhsaker (1967), it appears that at least one species of large mammal has gone extinct during the last 30 years; we did not record grey-cheeked mangabey *Cercocebus albigena*, although they were noted by Struhsaker. Local Takamanda hunters accurately described the color, size, and vocalization of this species and reported that a group remained in the Obonyi III area. The vernacular name for this species in Takamanda is *gebilika*. The vernacular name of *kebilika* in the adjacent forest area of Okwangwo in Nigeria is similar (Oates *et al.* 1990). However, *C. albigena* has not been recorded since 1967, and it is probably now locally extinct in both Okwangwo (Oates pers. comm) and in Takamanda.

The red-capped mangabey *Cercocebus torquatus* was recorded by Thomas (1988) near Makone West, and a specimen was collected just outside the Reserve (near the village of Atolo) in 1933 (Sanderson 1940). But these are the only two reports of this primate species having existed in the area, and during this study, local hunters could not identify the species from a description of the animal, vocalizations, or a photograph. It appears that *C. torquatus* previously existed in the area, but was hunted out or that *C. albigena* was mistakenly identified as *C. torquatus* in earlier studies.

The Sanderson collection includes two tantalus monkeys (*Cercopithecus aethiops*) sampled from around Mamfe. *C. aethiops* is mostly a grassland species, and it is possible that a few still remain in grassland sites north and east of Takamanda. Certainly, it still occurs in the grasslands of the Kilum-Ijim area, some 100 km due east of Takamanda (Maisels *et al.* 2001). During our 1998-1999 survey, local people said that this primate did not occur within the Reserve.

Leopard (*Panthera pardus*) and the giant pangolin (*Smutsia gigantea*) were reported by local hunters in Takamanda during this study. Neither species was collected by Sanderson (1940), recorded by Thomas (1988), or observed during this study. Occasional reports of leopard sightings were received, along with stories of leopard skins traded across the border with Nigeria in previous years. Pangolins are a very popular bushmeat in Africa, and although smaller sized pangolins were observed several times in villages, it was widely reported that giant pangolins had been extirpated from the area.

Bushmeat is still a prominent source of income and protein for villagers in TFR. Although traditional hunting rights were granted to the local communities during establishment of the Reserve, the use of firearms has been prohibited since 1934. Still, firearm hunting is widespread throughout the area. Until recently, access was limited mostly to footpaths, but hunting has been relatively intensive and will only increase with the new road if normal tropical forest trends (Bennett and Robinson 2000a) apply. In 1988, Thomas reported that the Takamanda Forest Reserve probably contained the most significant populations of large mammals in Cameroon west of the Sanaga River. This is no longer the case. We found that the perceptions of local people were paradoxical: on the one hand, hunters claimed that their forest resources such as bushmeat would never disappear. On the other hand, most people admitted that bushmeat was easily found ten years before our study, but had become very hard to find by 1999. This is a familiar story throughout forested Africa, where the forest itself "hides" the fact that the fauna is vanishing (Redford 1992, Bennett and Robinson 2000b, Redford and Feinsinger 2000, Robinson and Bennett 2000c). Although Takamanda still hosts a wide diversity of fauna, unsustainable hunting rates are having a rapid negative effect on wildlife populations. If such hunting practices continue at the current rate, more of the large mammal species found today will vanish.

In most humid tropical forests, protein requirements of local communities are either partly or almost entirely provided by wild animals, including mammals, birds, fish, and insects (Wilkie and Curran *et al.* 1998, Wilkie and Sidle *et al.* 1998, Bowen-Jones and Pendry 1999, Robinson *et al.* 1999, Robinson and Bennett 2000c). In tropical forests, the carrying capacity for people who depend exclusively on wild meat cannot greatly exceed one person /km² (Bennett and Robinson 2000a, b). No commercial hunting (that is, hunting for income rather than protein) of wild animals in tropical forests has, to date, been proved sustainable over the long term (Robinson and Bodmer 1999, Bennett and Robinson 2000c). In 1999, the human population density in the area within and around Takamanda Forest Reserve was estimated at about 3.6 people/km² (Groves and Maisels 1999) and has more recently been estimated at more than 4.6 people/km² (Schmidt-Soltau et. al. 2001.) Clearly, use of wildlife as the sole source of protein by the populations of the Takamanda area is unsustainable, particularly when coupled with commercial hunting.

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Appendix 1. Checklist of all British Museum of Natural History specimens excluding ungulates and bats, collected by Sanderson in the areas surrounding the Takamanda Forest Reserve, Cameroon.

Species	Common Name	Year collected	# Specimens	Dry skins examined by	Area of Collection
Gorilla gorilla	Cross River gorilla		4	JG	
Pan troglodytes	Chimpanzee	1933	2	RD	Kendem (Mamfe Division)
Mandrillus leucophaeus	Drill	1932/1993	5	RD	Mamfe, Atolo, Bali (Mamfe div.), Ikom Division
Cercocebus torquatus	Red capped mangabey	1933	1	RD	Atolo
Cercopithecus aethiops	Tantalus monkey	1932/1933	2	RD	Mamfe
Cercopithecus mona	Mona monkey	1932/1933	21	RD	Mamfe, Bashor II (=Basho II?), Tinta, Atlo (=Atolo), Assumb (= Assumbo), Mainyu bridge (=Manuy bridge)
Cercopithecus pogonias	Crowned guenon	1933	2	RD	Basho II, Atolo
Cercopithecus preussi	Preuss's guenon	1933	2	RD	Tinta
Cercopithecus erythrotis	Red-eared guenon	1932/1933	4	RD	Tinta, Mamfe, Ishobi (=Eshobi?), Bashor?
Cercopithecus nictitans	Puttynose monkey	193?	5	RD	Mamfe, Mainyu bridge (=Manyu bridge)
Galago elegantulus (Euoticus elegantulus)	Elegant needle-clawed galago	1932/1933	18	RD	Mamfe, Mafe, Bagi (Mamfe div.), Eschobi "bush" (=Eshobi)
Galago alleni	Allen's squirrel galago	1932/1933	7	RD	Nchang, Mamfe, Mfatok
Galago demidovii (Galagoides demidoff)	Demidoff's galago	1933	1	RD	Eshobi
Arctocebus (calabrensis) aureus	Calabar angwantibo	1932/1933	5	RD	Mamfe
Peridicticus potto	Potto	1932/1933	4	RD	Mamfe
Crocidura olivieri	White-toothed shrew	1932/1933	16	RD	Mamfe, Eshobi, Eschobi-Mamfe bush,
Civettictis civetta	African civet cat	1932/1933	9	RD	Mamfe, Atolo, Manyu bridge
Genetta servalina	Servaline genet	1932/1933	10	RD	Mamfe, Bakebe, Okogong, Basso, Olulu (Assumbo)

Continued

Appendix 1 (cont.). Mammal checklist of Takamanda Forest Reserve, Cameroon.

Species	Common Name	Year collected	# Specimens	Dry skins examined by	Area of Collection
Genetta tigrina	Blotched genet	1932/1933	6	RD	Mamfe, Kembong, N'dekwa, Victoria
Nandinia binotata	African palm civet	1932/1933	21	RD	Mamfe, Eshobi, Victoria, Mbilishi (=Mblishe), Mkani (Obrubra div.)
Herpestes naso	Long-snouted mongoose	1932/1933	3	RD	Mamfe, Okoyong, Mainyu bridge (= Manyu bridge)
Atilax paludinosus	Marsh mongoose	1932	2	RD	Mamfe
Crossarchus obscurus	Cusimanse	1932/1933	6	RD	Mamfe, Bachua etia, Nko (Abrubra div.?), Mainyu bridge (=Manyu bridge), Bakebe
Bdeogale nigripes	Black-legged mongoose	1932/1933	3	RD	Mamfe, Bashauo
Anomalurus derbianus	Lord Derby's anomalure	1932/1933	9	RD	Bassor, Bashor II, Bashaou, Bashor, Eshobi, Mamfe div.
Anomalurus beecrofti	Beecroft's anomalure	1932/1933	5	RD	Eshobi, Mamfe
Idiurus macrotis	Long-eared flying mouse	1932/1933	7	RD	Eshobi, Besong Abang, Tinta,
Idiurus zenkeri	Zenker's flying mouse	1933	1	RD	Eshobi
Protoxerus stangeri	African giant squirrel	1932/1933	12	RD	Okoyong, Mainyu-Bali Mamfe, Eshobi, Tinta
Heliosciurus rufobrachium	Red-legged sun squirrel	1933	12	RD	Tinta, Mkpani (Obrubra div.) Nko
Funisciurus auriculatus (oliviae)	Rope squirrel	1933	2	RD	Mamfe Eshobi
Funisciurus auriculatus (boydi)	Rope squirrel	1933	1	RD	Tinta
Funisciurus leucostigma (talboti)	Rope squirrel	1932/1933	11	RD	Mamfe, Ekuri (Obrubra), Nko
Aethosciurus poensis		1933	2	RD	Mamfe, Bashor Mamfe
Myosciurus pumilio	African pygmy squirrel	-	-	RD	SPECIMEN NOT FOUND AT BM
Oenomys hypoxanthus	Rusty-nosed rat	1932/1933	10	RD	Mamfe, Assumbo, Bashor Mamfe

Continued

Appendix 1 (cont.). Mammal checklist of Takamanda Forest Reserve, Cameroon.

Species	Common Name	Year collected	# Specimens	Dry skins examined by	Area of Collection
Lophuromys sikapusi	Brush-furred mouse	1932	5	RD	Mamfe
Hylomyscus alleni (canus)	African wood mouse	1932/1933	8	RD	Mamfe, Besong Abang, Eshobi, Eschobi-Mamfe bush
Stochomys	Target rat	-	-	RD	SPECIMEN NOT FOUND AT BM
Thamnomys rutilans	Broad-footed thicket rat	1933	1	RD	Mamfe-Eshobi
Malacomys longipes	Long-footed rat	1932/1933	12	RD	Mamfe-Eshobi bush, Mamfe, Eshobi
Hybomys univittatus	Hump-nosed mouse	1932/1933	4	RD	Mamfe, Assumbo
Mastomys coucha	Multimammate rat	1932/1933	18	RD	Mamfe, Assumbo, Tinta,
Cricetomys gambianus	Giant-pouched rat	1933	1	RD	Bachania Assumbo area
Cricetomys emini	Giant-pouched rat	1932/1933	9	RD	Mamfe, Bashauo, Bashor II, Assumbo, Tinta, Atolo
Lemniscomys striatus	Zebra mouse	1932/1933	11	RD	Mamfe, Mamfe-Eshobi
Praomys tullbergi	Soft-furred rat	1932/1933	31	RD	Tinta, Mamfe, Eshobi, Assumbo, Bakebe
Atherurus africanus	Brush-tailed porcupine	1932	4	RD	Mamfe

Appendix 2. Large mammals observed in 1987 and 1998-99 in the Takamanda Forest Reserve. Data from Thomas et al. (1988) and the current study. Some of the sites surveyed in 1998 were not surveyed in by Thomas et al. The observational data are from the current study (1998).

Site (1987)	Stratum (1998)	Site Name (1998)	Species in 1987	Species in 1998	Observed	Heard	Dung	Nests
Camp 5	Stratum	Makone River East	Not mentioned in text	*Loxodonta africana*			Y	
				Procavia ruficeps	Y			
				'Wild cat'			Y	
				Red duikers	Y		Y	
				Cephalophus monticola	Y		Y	
				Gorilla gorilla				Y
				Pan troglodytes		Y		Y
				Cercopithecus erythrotis	Y	Y		
				Cercopithecus mona	Y	Y		
				Cercopithecus nictitans	Y	Y		
				Cercopithecus preussi	Y	Y	Y	
				"Squirrels"	Y			
				Crossarchus obscurus	Y			
Opposite Camp 5 & 6	Stratum 2	Makone River West	*Loxodonta africana*	*Loxodonta africana*			Y	
			Syncerus caffer	*Syncerus caffer*	Y			
			Potamochoerus porcus					
				Red duikers	Y			
				Cephalophus monticola	Y			
			Gorilla gorilla					
				Mandrillus leucophaeus			Y	
			Cercopithecus erythrotis	*Cercopithecus erythrotis*	Y	Y		
			Cercopithecus mona	*Cercopithecus mona*	Y	Y		
			Cercopithecus nictitans	*Cercopithecus nictitans*	Y	Y		
			Cercopithecus pogonias					
			Cercopithecus preussi	*Cercopithecus preussi*			Y	

Continued

Appendix 2 (cont.). Large mammal observational data from Takamanda Forest Reserve, Cameroon.

Site (1987)	Stratum (1998)	Site Name (1998)	Species in 1987	Species in 1998	Observed	Heard	Dung	Nests
			Cercocebus torquatus					
-	Stratum	Oyi/Magbe East	Not mentioned in text	*Loxodonta africana*			Y	
				Red duikers	Y		Y	
				Cephalophus monticola	Y			
				Mandrillus leucophaeus	Y			
				Cercopithecus erythrotis	Y	Y		
				Cercopithecus mona	Y	Y		
				Cercopithecus nictitans	Y	Y		
				Cercopithecus preussi	Y	Y		
-	Stratum 4	Oyi/Magbe West	Not mentioned in text	*Cercopithecus erythrotis*	Y	Y		
				Cercopithecus mona	Y			
				Cercopithecus nictitans	Y			
-	Stratum 5	Obonyi 1 Hills	Not mentioned in text	Red duikers			Y	
				Cephalophus monticola			Y	
				Gorilla gorilla				Y
				Pan troglodytes		Y	Y	Y
				Cercopithecus nictitans		Y		
-	Stratum 6	Basho Hills	Not mentioned in text	*Procavia ruficeps*			Y	
				Gorilla gorilla			Y	Y
				Pan troglodytes		Y		Y
				Cercopithecus mona	Y	Y		
				Cercopithecus nictitans		Y		
				Cercopithecus preussi		Y		
				Atherurus africanus			Y	

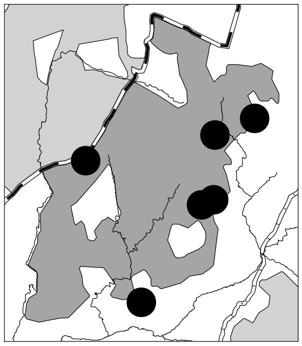
Continued

Appendix 2 (cont.). Large mammal observational data from Takamanda Forest Reserve, Cameroon.

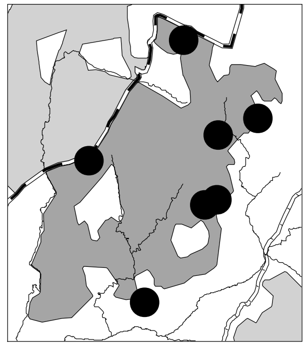
Site (1987)	Stratum (1998)	Site Name (1998)	Species in 1987	Species in 1998	Observed	Heard	Dung	Nests
Footpath between Mbilishe-Matene	Stratum 7	Matene Hills		Red duikers			Y	
				Pan troglodytes				Y
			Cercopithecus erythrotis	*Cercopithecus erythrotis*		Y		
			Cercopithecus mona	*Cercopithecus mona*		Y		
			Cercopithecus nictitans	*Cercopithecus nictitans*		Y		
			Cercopithecus pogonias					
			Mandrillus leucophaeus					

Appendix 3. Distribution of large mammal sightings in Takamanda Forest Reserve, Cameroon.

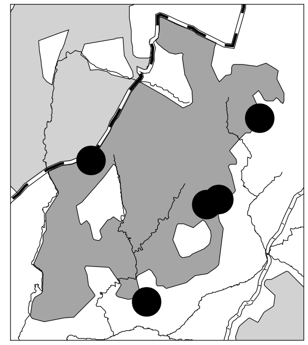
Cercopithecus erythrotis
(Red-eared monkey)



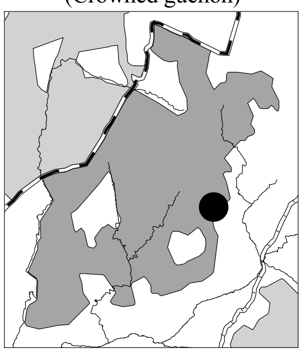
Cercopithecus nictitans
(Putty-nose monkey)



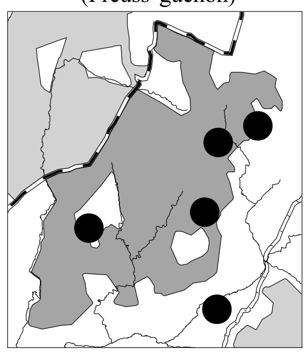
Cercopithecus mona
(Mona monkey)



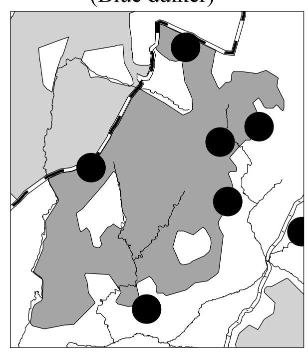
Cercopithecus pogonias
(Crowned guenon)



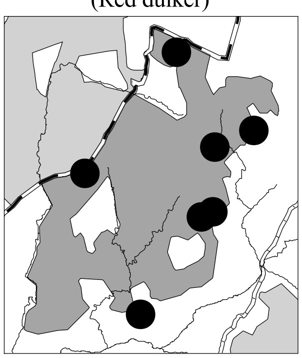
Cercopithecus preussi
(Preuss' guenon)



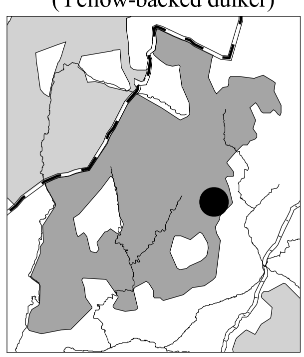
Cephalophus monticola
(Blue duiker)



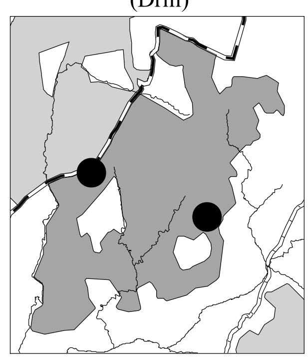
Cephalophus rufilatus
(Red duiker)



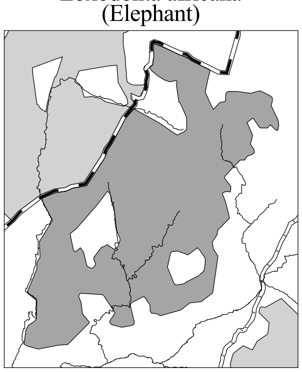
Cephalophus silvicultor
(Yellow-backed duiker)



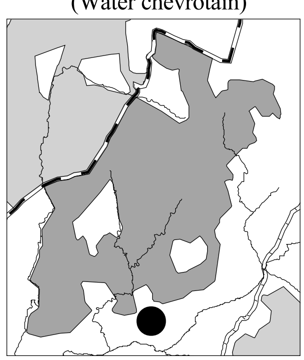
Mandrillus leucophaeus
(Drill)



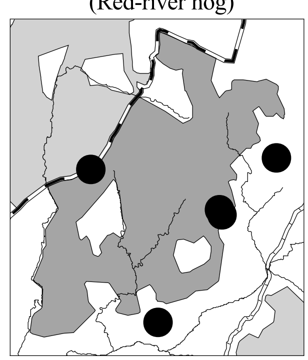
Loxodonta africana
(Elephant)



Myemoschus aquaticus
(Water chevrotain)



Potamochoerus porcus
(Red-river hog)



Surveys of the Cross River Gorilla and Chimpanzee Populations in Takamanda Forest Reserve, Cameroon

Jacqueline L. Sunderland-Groves, Fiona Maisels and Albert Ekinde

1 Introduction

Takamanda and Mone rorest reserves and the Mbulu forest are located on the Cameroon side of the Nigerian-Cameroon border. Together with the adjoining area in Nigeria—the Okwangwo division of the Cross River National Park—they form part of the last stronghold of the Cross River gorillas *Gorilla gorilla diehli*. These gorillas are classified as Critically Endangered (IUCN 2000) and now occur only in four isolated sub-populations (Afi, Mbe, Obudu, and Okwangwo/Takamanda/Mone/Mbulu) within an area of about 5,000 km².

Cross River gorillas were originally described as a new species (*Gorilla diehli*) by the German taxonomist Paul Matschie in 1904. Later taxonomic research reduced this species rank to that of a sub-species, leading to their eventual amalgamation with other lowland gorillas (*Gorilla gorilla gorilla*; Rothschild 1904, 1906, Elliot 1912, Coolidge 1929, Groves 1970). However, craniometric research by Stumpf *et al.* (1998) reopened the question as to whether the Cross River gorilla is a sub-species. Additional study by Sarmiento and Oates (2000), including the re-measurement of Nigerian and Cameroonian gorilla skulls, concluded that these gorillas are indeed more taxonomically distinct than previously described, and they are now recognized as the fourth sub-species of gorilla.

Information on gorilla abundance and distribution within this region has been documented for more than 70 years (Allen 1930, Sanderson 1940, March 1957, Struhsaker 1967, Critchley 1968, Harris *et al.* 1987, Thomas 1988, Harcourt *et al.* 1988, 1989, Oates *et al.* 1990, Groves 1996, Obot *et al.* 1997, Oates 1998). A call for surveys of the Mamfe-Obudu region (Oates 1996) mentioned that hunting was a major environmental problem and recommended that biological surveys of Takamanda should be undertaken, then followed by conservation management. Field surveys were subsequently conducted by Sunderland-Groves in 1998 and 1999 in Cameroon, which led to additional research in 2000 and 2001 that continues today.

The objectives of the initial 1998-1999 surveys were to collect baseline data on the large mammals of the reserves, focusing on the gorilla population, and assess conservation threats and potential. In relation to the gorilla population, the aim was to obtain an estimate of size and of habitat types most used by the animals. Results on apes from the 1998-1999 surveys are reported in detail in Sunderland-Groves and Maisels (in prep). To compare the results obtained in 2000 and 2001, the 1998-1999 data are summarized in this paper.

Although there is still much to learn about this sub-species of gorilla, considerable progress has been made over a relatively short period of time, elicting a more comprehensive overview of their range, distribution, and abundance within Cameroon.

2 Ape Conservation Status

According to local tradition in this region, the meat of great apes may not be sold, but gorilla hunting occurred before this survey started and still occasionally takes place in areas outside of Takamanda. Ape populations are more vulnerable to hunting than smaller primates; they recover very slowly from population reduction because of their inter-birth interval of about four years, late date of maturity, and complex social system (see Walsh *et al.* 2003 for an overview of present gorilla status in the region as a whole).

In more recent years, gorilla groups in Cameroon-Nigeria border region the study area have become more fragmented and isolated as their habitat has succumbed to agricultural and other land development activities. Construction of the new road between the towns of Mamfe and Akwaya, when completed, will cut directly between Takamanda and the Mone and Mbulu forests, preventing gorilla movement between the areas.

Hunting and agricultural activities will have a similar effect on the chimpanzee populations of the area that, like the gorillas, are fragmented and confined to highland areas. In 1997, the chimpanzees of eastern Nigeria and Takamanda were described as a distinct sub-species *Pan troglodytes vellerosus* (Gonder *et al.* 1997), and although their numbers in the wild have not been thoroughly investigated, it is thought that the populations are declining.

The Cross River Gorilla Research Project (Cameroon) has initiated conservation efforts to eliminate hunting of these two species in the region. The focus is on working with local communities and dissemination of educational materials in collaboration with the joint Ministry of Environment and Forests (MINEF)/GTZ project—Protection of the Forests Around Akwaya (PROFA).

3 Study area

The 675-km² Takamanda Forest Reserve is mostly covered by Atlantic evergreen forest, ranging from 100 m to 1500 m above sea level (Figure 2 in Chapter 1). Much of the lowland forest in the southern and central parts of the Reserve is between 100 m and –400 m in elevation. The terrain is rolling in the lowlands, but rises sharply to 1500 m in the northern part of the Reserve where slopes are extremely steep and areas of semi-deciduous forest, woody savannah (often degraded), and montane woody savannah with grasslands prevail between 1200 m and 2200 m (Letouzey 1985). Around villages, the vegetation has been modified and is degraded evergreen lowland forest and farmbush (a mosaic of cultivation and fallow). The lowland forest is particularly diverse; it is thought to be part of a Pleistocene refugium. The forest formation is distinct as there is a relative paucity of the Caesalpinioides, which are normally common in the Atlantic coastal forest (see Sunderland *et al.* this volume for a more detailed discussion of the vegetation in the area).

In 1985, the human population density in the Takamanda area was estimated at between 6 and 12 people/km² (Letouzey 1985). In 1999 the approximate total human population, based on a complete census of nine villages, was estimated at 2,490 (Groves and Maisels 1999). A more recent socio-economic survey conducted by PROFA that covered 43 villages within and surrounding the Takamanda Forest Reserve, including 12 villages on the Nigerian side of the border, estimated total human population at 15,707 (Schmidt-Soltau et al. 2001). Socio-economic activities in the region revolve strongly around the forest and its resources, especially for the villages that are far from markets (Ifeka 1999, Sunderland *et al.* this volume), and people who live in the most remote villages depend almost entirely on bushmeat for their protein requirements. They also rely on the harvest and sale of non-timber forest products as their main source of cash, particularly *Irvingia gabonensis*, or “bush mango,” rather than on cultivated crops or livestock.

The area has been historically partially protected by lack of access, but this is changing. Accessibility to the Takamanda Reserve from the Nigerian side is by foot only, but a new road from Mamfe (Figure 2 in Chapter 1) now allows access to within 5 km of its limits from the Cameroonian side. The Mone Forest Reserve is separated from the Takamanda reserve by a corridor of ungazetted forest, which, at its narrowest, is about 7 km wide.

During the 1998-1999 surveys, two main vegetation types were sampled: lowland forest and sub-montane forest. The study area comprised two lowland sites along the Makone and Oyi/Magbe rivers and three hill, or highland, areas—Matene, Obonyi, and Basho Hills—within Takamanda Forest Reserve (Figure 2 in Chapter 1). The Makone flows through the middle of the Reserve, and the Oyi forms part of the Reserve’s southwestern boundary. The 2000-2001 surveys concentrated solely on highland sites within the area.

4 Methods

4.1 Sampling design: 1998-1999

A sampling design established prior to commencement of the surveys, based on 1:50 000 maps of the area. The design comprised a series of standard line transects, which are widely used in animal density studies (Buckland *et al.* 1993). Transects were straight lines oriented at right angles to the Makone and Oyi rivers in the lowlands and at right angles to the slope in the hill country. These orientations enabled sampling of the different vegetation types in the proportions in which they occur in the environment. The objective of the design was to estimate the density of apes and other large mammals in terms of numbers per km².

Data analysis would normally be carried out using the computer program DISTANCE (Laake *et al.* 1993), which requires at least 10 transects per stratum (where "stratum" can be vegetation type, hunting pressure, or a combination of the two) and at least 60 observations per species per stratum to obtain a reliable density estimate. Sightings of large mammals were too rare to use DISTANCE. But the transect design allowed subsequent comparisons between zones (and seasons), using the encounter rate of observations per km (usually expressed as number of observations/km walked) and considering the transects as replicates.

In 1998-1999, 40 transects, totaling 81km in length, were cut at the lowland sites and 8 km of transects were established at the highland sites. An additional 6km baseline was used to calculate encounter rates in the sub-montane forest. All lowland transects were sampled during the wet season. The transects on the east sides of the Makone River and the Oyi/ Magbe East were also sampled in the dry season. The three highland forest areas were sampled only in the dry season. See Sunderland-Groves and Maisels (this volume) for additional information on 1998-1999 methodology.

4.2 Sampling design: 2000-2001

Since practically no ape data were recorded in the lowlands during the earlier surveys, the 2000-2001 surveys concentrated on highland sites within Takamanda. Five highland areas were selected for survey, using line transects within and bordering the area. Obonyi I hills and Basho hills were revisited, but the Matene hills were not because so few animal signs were recorded in 1998-1999. Three additional highland sites were surveyed in 2000-2001: Takpe hill, Mblishe hill, and Atolo hill. Strictly speaking, the areas of Mblishe and Atolo fall in the Mbulu forest outside the Takamanda boundary. However, the original Takamanda boundary reached close to the village of Atolo (Order 1937), and hence the sites were included in the Takamanda data set. Four 500-m transects were surveyed at each hill site, for a total of 20 transects.

Obonyi I, Basho, and Takpe were surveyed in both the dry and wet seasons. The hills at Mblishe and Atolo were sampled only in the wet season. Highland transects were not pre-cut because it was reported that sections of the transects cut at the lowland sites in 1998 were being used by local people as hunter paths. Instead, transects were simply measured using a hip-chain (measuring thread). Random nest searches (walking through the forest looking for gorilla nest sites off the transects) were also carried out in each area, and we attempted to locate as many fresh nest sites as possible. These data supplemented information recorded on transects to obtain a more accurate estimate of group size and population per area. General reconnaissance nest searches were carried out in an additional six highland sites (Takpe east hills, Makile hills, Obonyi 3 hills, Takamanda hills, Mende hills and Umbuli hills) to confirm the presence or absence of apes.

4.3 Data collection

Data collected on transects included indirect signs of apes (dung and tracks), ape nests, direct observations (animals seen or heard), and rough age of sign (fresh, recent, old). We also recorded the perpendicular distance from the center line of the transect for DISTANCE, although this proved unnecessary. All evidence of human activity (traps, snares, hunter paths, bush houses, spent cartridges, gunshots heard, etc.) was recorded to evaluate hunting pressures. We also recorded changes in topography and vegetation along each transect. The sampling effort between transects was standardized by keeping the number of observers, speed of travel, and time of day consistent. Transects were not walked during heavy or medium rainfall as this affects mammal movements and observer reliability (see Sunderland-Groves and Maisels this volume).

For ape nests, care was taken to distinguish "definite gorilla nest" (nest on the ground or tree nest with gorilla dung underneath) from "definite chimp nest" (tree nests with chimp dung underneath). If a nest site had both tree and ground nests, it was a definite gorilla nest site because chimps never build ground nests. Ape dung is easily distinguished by smell and form, but old tree nests without dung cannot be assigned to gorillas or chimps with confidence. Therefore, nest sites where all nests were in trees were recorded as "tree-only nest sites." Upon locating a nest site each area was thoroughly searched to ensure that all nests within the group were identified and recorded. These data were then used to calculate mean nest group size.

Random nest searches were conducted in highland areas either after data collection on transects had been completed or to confirm presence or absence of apes at sites where time was not sufficient to conduct transect surveys. The additional data recorded during nest searches were used to calculate overall mean group size. Nest data collection during random nest searches followed the same protocols as those undertaken during transect surveys.

4.4 Data analysis

4.4.1 Distribution of apes and of human pressure

Distribution of gorillas and chimps within the Takamanda Reserve and adjoining forests was inferred from the geographic location of sign that could be definitely assigned to one of the two species.

4.4.2 Group size

Each nest site is the sleeping site for one group of apes for one night. All weaned individuals make one nest per night, so the size of each nest group is an indicator of group size. There are variations as occasionally apes may make a second nest during the night or sleep on the ground without making a nest. However, mean group size can be roughly calculated for gorillas using all nest groups that can definitely be assigned to gorillas. Mean nest group size and standard deviation for nest groups that could only be assigned to "apes" were calculated from the tree-only nest sites.

4.4.3 Abundance of apes and of human sign

The encounter rate (number of observations per km of transect) was used to estimate relative abundance of humans and apes throughout the survey and also to compare between sites and seasons.

Because DISTANCE could not be used, gorilla and chimpanzee densities were roughly calculated under the formula proposed by Tutin and Fernandez (1984):

$$[(N/A)/V][M]=D,$$

where N=number of sleeping sites, A=area sampled in km^2, V=mean number of days the nest remains visible, M=median nest group size, and D=number of weaned individuals/km^2.

Encounter rates were calculated (number of nests or nest sites per km walked, per stratum, and/or per season) and compared between strata and seasons between this study and previous work by March (1957) in the same region, and gorilla surveys carried out elsewhere in Africa (Williamson and Usongo 1995, Maisels and Cruickshank 1996, Hall *et al.* 1998).

In the lowland forest at Lopé, Gabon, gorilla nests remained visible for an average of 78 days (Tutin *et al.* 1995). Mean chimp nest duration in Gabon was 113.6 days (Tutin and Fernandez 1984). Since no data are available on the deterioration rate of nest sites in

Cameroon, this survey used the same figures recorded in Lopé. It is possible that by using average nest duration for Gabon in this study, errors may have occurred. Due to the faster decay rate and disappearance of ground nests, it is possible that some of the tree-only nests sites were actually made by gorillas. Subsequent work in Gabon by Tutin *et al.* (1995) showed that about 26% of gorilla nest groups "convert" to chimpanzee nests as they age. If a gorilla group made nests in trees and on the ground, which is common (Tutin *et al.* 1995), only the tree nests will be visible after a given time, and the nest group may be erroneously assigned to chimps. Therefore, when the densities of chimps and gorillas at a site have been calculated from formula 1, the missing 26% of the gorilla nest groups must be calculated from the chimp density and reassigned to gorillas.

It is not known whether the ratio of gorilla ground nests to tree nests is the same at all sites. Until evidence proves otherwise, we use the same conversion factor as the Lopé team.

5 Results

5.1 Sampling Effort

We walked 122 km of transects in the lowlands in 1998-1999 (some transects were walked twice in different seasons) and 8 km of transects and 6 km of baseline in the highlands. An additional 28 km of transects and baseline were walked (some transects were walked during two different seasons) in the highlands in 2000-2001, and additional nest searches were conducted at each site.

5.2 Ape Distribution

During the course of surveys between 1998 and 2001,we investigated 12 highland areas and two lowland sites (Makone east/west and Oyi east/west). Gorillas were found to exist at six of the highland sites, and chimpanzee or tree-only nests were located at nine of the highland sites. There was ape sign at two of the highland sites (Takamanda and Mende).

Table 1. Summary of gorilla and chimpanzee distribution from transect surveys and nest searches, Takamanda Forest Reserve, Cameroon, 1998 - 2001 (+ indicates that the species was present; T=transect; NS=nest search)

Site	Approximate altitude (m)	Gorilla	Tree-only sites	Transect/nest search
Makone east and west (lowland)	0-720	+	+	T, NS
Oyi east and west (lowland)	0-700			T, NS
Takpe Hill	560	+	+	T
East Takpe Hills	400	+	+	NS
Basho Hill	640	+	+	T, NS
Obonyi 1 Hills	725	+	+	T, NS
Obonyi 3 Hills	260		+	NS
Mblishe Hills	740+		+	T, NS
Atolo Hills	1250	+		T, NS
Takamanda Hill	570			NS
Mende Hills	1530			NS
Umbuli Hills (nr Matene)	240-1500		+	NS
Matene Hills	420-875		+	T, NS

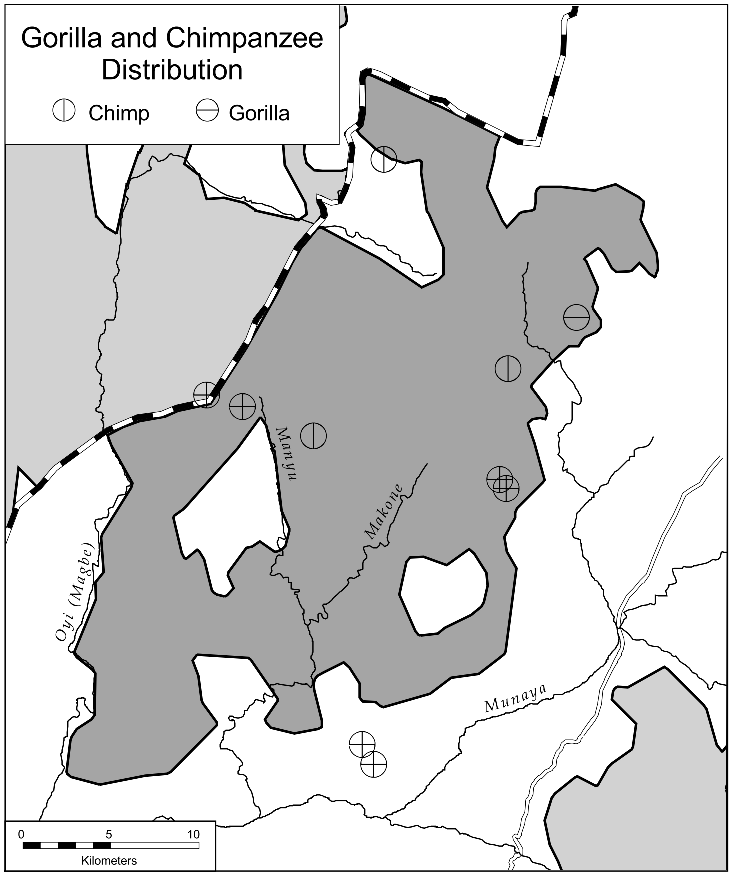


Figure 1. Gorilla and Chimpanzee sampling sites in the Takamanda Forest Reserve, Cameroon.

In the lowlands, gorilla and chimpanzee signs were found at one site—Makone River east. Although this was classified as a lowland site (<500 m), nests were found only where the slopes were steep and above 400 m. It appears that the gorilla population is very fragmented, as their sign is almost completely absent from the matrix of lowland areas within which the highlands are embedded (Table 1; Figure 1).

5.3 Ape Density Estimates 1998-1999

During the 1998-1999 survey, just 12 gorilla nest sites and 49 tree-only nest sites were found, of which 9 and 30, respectively, were recorded along the transects. The majority of ape nest data was recorded in the areas of the Obonyi 1 hills and Basho hills. One tree nest was found in the hills near the village of Matene (Matene hill), but not while surveying transects, and tree nests were also located between the villages of Assam and Takpe. During transect surveys, ape nests were also recorded on the east side of the Makone River in an area where slopes were very steep. Along a total of 122 km of transect (adding dry and wet season surveys), only one gorilla nest group was found in the lowlands (Makone east). Using all available data, mean gorilla group size and standard deviation was 3.0 ± 1.5 (median=2.5), and mean tree-only nest group size was 2.73 ± 2.25 (median=2; Table 2).

Nest data for tree-only sites were more frequent in the lowlands than for gorillas, but again their nests were found only at Makone east. Tree-only nests were found on five transects at this site in the dry season and on five in the wet season (six nest groups in each). The encounter

Table 2. Ape nests: Summary of all data both off and on transects, Takamanda Forest Reserve, Cameroon, 1999 and 2001 (1999: L=136 km; 2001: L=28 km)

Year	Species	Total # nest groups	Mean group size	Median group size	# of nest groups seen from transects, all strata combined	Encounter rate of nest groups seen on transects (#/L)
1999	*Gorilla gorilla deihli*	12	3.00	2.5	9	0.066
	Pan troglodytes vellerosus	49	2.73	2.0	30	0.221
2001	*Gorilla gorilla deihli*	58	3.45	2.5	18	0.642
	Pan troglodytes vellerosus	76	2.86	2.5	15	0.536

rate for tree-only nest groups was found to be higher in both the Obonyi 1 hills and the Basho hills than in the lowland forests of Makone east, once more indicating that apes were found more frequently in the higher altitude areas. We assigned about 74% of these tree-only nests to chimpanzees.

Although the sample size was small, a very rough estimate of ape density was made for the highlands and the lowlands following the Tutin and Fernandez (1984) formula and their suggested correction factor (Tutin *et al.* 1995). In the highland areas, gorilla density was calculated between 1.2 and 1.8 individuals/km², while chimpanzee density was 0.93 to 1.40 individuals/km². For the lowlands, gorilla density was 0.03 to 0.05/km², and chimpanzee density was 0.10 to 0.12/km². These are estimates with unknown precision because the sample size was so small. We therefore suggest that there was about one gorilla/km² and perhaps one chimpanzee/km² in the highlands, and almost no gorillas and fewer than 0.1 chimpanzees/km² in the lowlands.

5.4 Ape Density Estimates 2000-2001

Fifty-eight gorilla nest sites and 76 chimpanzee or tree-only nest sites were recorded during transect surveys and nest searches from September 2000 to August 2001. Eighteen gorilla nest sites and 15 chimpanzee or tree-only nest sites were recorded along 17 km of transect. Three of the areas surveyed were sampled twice, once in the dry season and once in the wet season, for a total of 28 observer-kms. When all nest data are considered, including nests that appeared to be from single individuals, mean group size and standard deviation for gorillas was 3.45 ± 3.52 (median 2.5), and mean chimpanzee (tree-only nests) was 2.86 ± 1.76 (median 2.5) (Table 2).

Along transects, the encounter rate for gorilla nest groups and individual nests was higher at Obonyi 1 hills and Basho hills than at Takpe (Table 3). No gorilla nests were encountered in either Mblishe or Atolo during transect surveys, although gorilla nest sites were located in Atolo during nest searches. Additional gorilla nest sites were recorded on the east side of the Makile hill (Makone east).

There were more chimpanzee (tree-only) nest sites recorded in the Obonyi I hills than at any other highland site (Table 4). Only one tree-only nest was observed in the Takpe hills along transects, but six additional chimpanzee nest sites were recorded during nest searches. Chimp (tree-only) nests were not recorded in the highland area close to Atolo. One chimp nest site was observed in the hills of Obonyi 3 and one close to the village of Umbuli, located on the Nigerian border. More tree-only nest sites were recorded on the east side of the Makile hill (Makone east).

Table 3. Encounter rate for gorillas along transects, Takamanda Forest Reserve, Cameroon, 2001

Site	Nest groups	Individual nests	Survey distance (km)	Groups/km	Individuals/km
Takpe Hill	4	6	7.0	0.57	0.86
Basho Hill	7	14	7.0	1.00	2.00
Obonyi I Hill	7	24	7.0	2.00	2.00
Mblishe Hill	-	-	3.5	-	-
Atolo Hill	-	-	3.5	-	-
Total	**18**	**44**	**28**		

In all, 84% of the gorilla nests detected were within 5 m of the transects (roughly 275,000m²), and 33% of the chimpanzee nests were within 10 m of the transects (280,000 to 555,400m²). Following the formula of Tutin and Fernandez (1984), a rough estimate of ape density was made (again based on small sample sizes). In applying this formula, we estimate that there were approximately 2.06 gorillas/km² and 0.59 chimpanzees/km².

To summarize, the Takamanda Forest Reserve covers 676 km²; 19% of this area is above 500 m, which during these surveys was classified as highland. Using the gorilla density figures calculated during the 2000-2001 surveys results in an estimate of about 286 gorillas. This seems highly unlikely given the estimate from the 1998-1999 surveys and because gorilla sign was not recorded at all highland sites. We therefore maintain that the estimate is about 100 gorillas.

5.5 Human Sign

When all data from the lowlands were compared with all data from the highlands (dry season only), there were significantly more traps and hunters' paths in the lowlands than in the highlands, reflecting more hunting pressure in the lowlands (Figure 2).

The 2000-2001 surveys were only conducted in highland areas, so we only compared hunting pressure among the highland sites (Figure 3). During transect

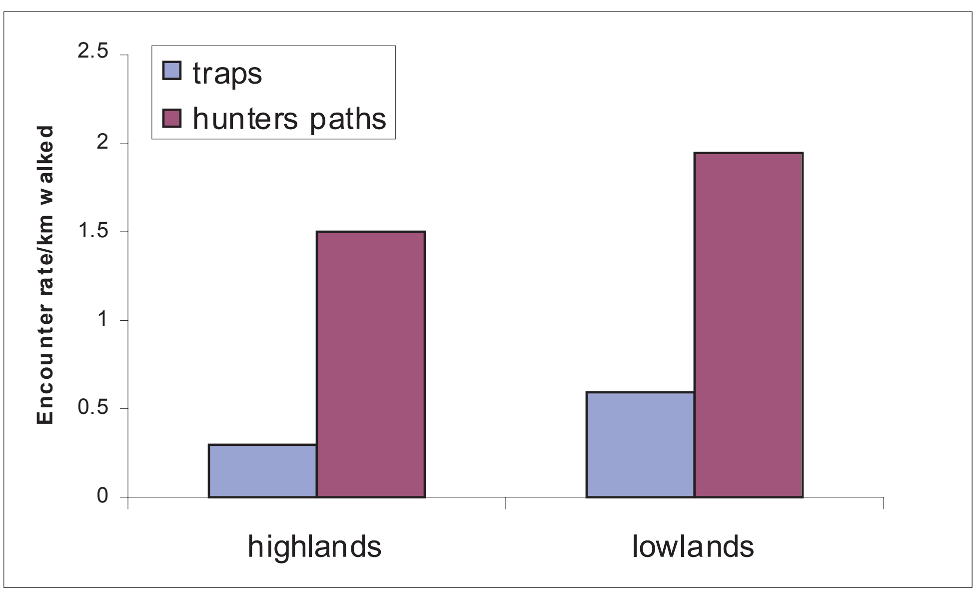


Figure 2. Encounter rates of hunters paths and traps in the highlands and lowlands, Takamanda Forest Reserve, Cameroon, 1998-1999

Table 4. Encounter rate for chimpanzees along transects, Takamanda Forest Reserve, Cameroon, 2001

Site	Nest groups	Individual nests	Survey distance (km)	Groups/km	Individuals/km
Takpe Hill	1	1	7.0	0.14	0.14
Basho Hill	4	5	7.0	0.57	0.71
Obonyi I Hill	8	26	7.0	1.14	3.71
Mblishe Hill	2	5	3.5	0.57	1.43
Atolo Hill	-	-	3.5	-	-
Total	**15**	**37**	**28**		

surveys, no bush huts were encountered in the highland areas. As was the case in 1999, no traps were seen on transects in the Obonyi I hills or on the hill at Mblishe. All human sign (paths, traps, cartridges) combined indicated that Mblishe had the lowest encounter rate in relation to human pressure, suggesting that it is the least hunted of all sites

6 Discussion

The most recent estimate of the Cross River gorilla population in Cameroon is approximately 100 in Takamanda Forest Reserve with perhaps an additional 75 to 80 individuals in the adjacent Mone and Mbulu forests (Groves 2002b), for an overall population in Cameroon and Nigeria of 250 to 270 gorillas. March (1957), surveying the Nigerian side of the border, reported an encounter rate of 12 to 13 gorilla nests per km walked. The highest encounter rate for gorillas during the 1998-2001 surveys was two nests/km, which is significantly lower than March's observations.

Cross River gorilla and Nigerian chimpanzee populations face a tenuous future. In particular, Cross River gorillas have been recorded in Cameroon only in Takamanda Forest Reserve and adjacent forest areas of Mone Forest Reserve and Mbulu forest. These small sub-groups and populations are now restricted to hill areas because of increased hunting and other human activities in the lowlands. Thus, the overall population is fragmented, with little chance of the sub-populations meeting. Such fragmentation may not be recent. Studies

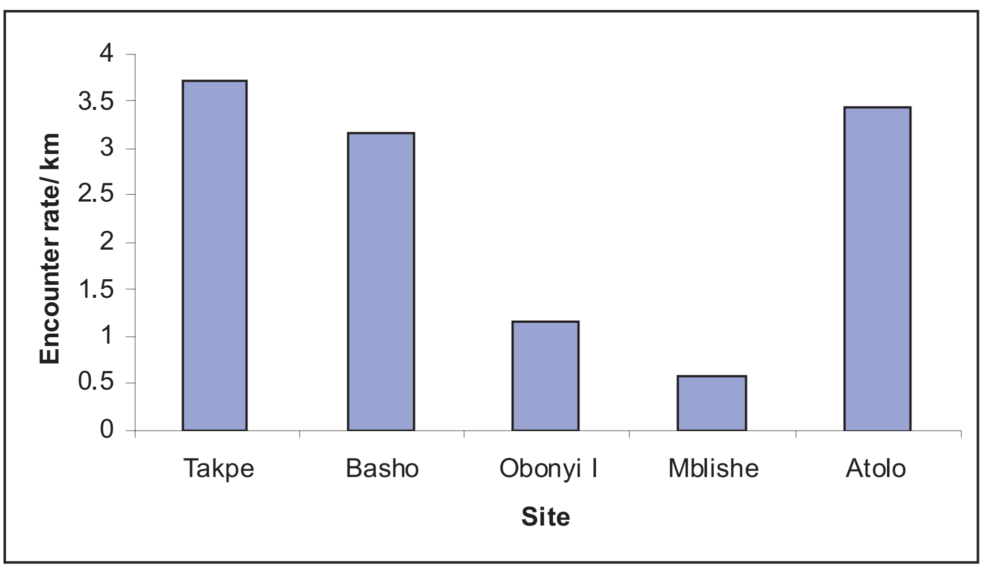


Figure 3. Encounter rate of human sign at all sites, Takamanda Forest Reserve, Cameroon, 2001

from more than 70 years ago (Allen 1932) reported that gorillas existed on steep, inaccessible slopes in highland areas. Presumably hunters using guns were not as common then as now, so the question of why the gorillas appear to prefer these higher altitude (less hunted) sites and are unwilling or unable to cross large tracts of lowland forest awaits resolution.

In Takamanda Forest Reserve, vegetation surveys (Sunderland *et al.* this volume) have not revealed a dramatic difference of known preferred gorilla foods in the higher altitude sites. One possible determining factor of fragmentation of at least some of the gorilla groups in Takamanda could be the existence of major rivers. It would be nearly impossible for gorillas of the Obonyi I hills to cross the Makone, Makwere, and Manyu rivers to reach gorillas in either Takpe or Basho hills. This factor, coupled with high hunting pressure in the lowland areas, may have caused the widespread fragmentation of the gorilla population.

Construction of the road from Mamfe to Akwaya will cause more fragmentation. To date, the road has reached the village of Bandolo in Mbulu forest and has already created an ecological divide between Takamanda and Mone. If the road is completed, which seems likely, it will cut directly between Takamanda and Mbulu, and ape movement between the two forested areas will certainly cease.

The main threats to gorilla and chimp populations in most areas of Central Africa are commercial hunting, followed by ebola haemorrhagic fever in some localities (Walsh *et al.* 2003). The primary immediate threats to gorillas in the Takamanda area appears to be hunting connected to human activities, especially road construction. On the more positive side, villagers in Takamanda Forest Reserve implemented a local ban in 1998 on the shooting of gorillas and chimpanzees, and no credible reports of gorilla killings have been registered since the ban went into effect. In 2002, the Cross River Gorilla Research Project launched an education program that focuses on conservation of Cross River gorillas. These initiatives, along with recent anti-poaching projects of the Cameroon and GTZ/PROFA partnership, are having an effect with regard to conservation of endangered species in Takamanda. A total ban on hunting of all endangered species must be instigated and monitored to ensure survival of the gorilla population into the future—especially in light of inevitable further fragmentation of the population as people move into the area of the growing road network.

Acknowledgments

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Fisheries in the Southern Border Zone of Takamanda Forest Reserve, Cameroon

Marina Mdaihli, Tim du Feu, and Julius S. O. Ayeni

1 Introduction

The Cameroonian–German (GTZ) Project for the Protection of Forests Around Akwaya (PROFA) collaborates with local communities and authorities to achieve community-based conservation[1]. This approach aims to maintain the biological diversity of Takamanda Forest Reserve (TFR) and improve the forest-based living conditions of local peoples.

In the course of collecting baseline data for planning sustainable resource use in TFR, fishing was found to contribute as much as game hunting to consumption and the trading economy of villages within and around the Reserve (du Feu 2002). Yet, forest managers concentrate on the generation of revenue from timber and wildlife harvests. Within the context of formulating a sustainable management plan for TFR, it therefore was necessary to provide baseline scientific information on fish biology and on the economic benefits of fisheries in the TFR area.

This paper reports on fisheries of the southern border zone of the Reserve, based on a fisheries baseline study undertaken from 23 October-3 December, 2000, under commission by PROFA. Information from the study and baseline socio-ecological data (Ayeni and Mdaihli 2001, Schmidt-Soltau 2001) are being used to draft a participatory plan for sustainable management of TFR forests.

1.1 PROFA

PROFA is administered by the Divisional Delegation for Environment and Forests (Manyu Division at Mamfe), an agency of the Ministry of Environment and Forestry in Yaoundé. The overall goal during the first phase of the PROFA (March 2000 to February 2003) was to develop a management plan that ensures the maintenance of biodiversity in TFR and contributes to improvement of living conditions for people within the Reserve's border zones. A positive outcome of the first phase will enable expansion of the project to cover the nearby Mone Forest Reserve and extension of the timeframe to 12 years (three-year orientation, eight-year implementation phase, and a "handing over" phase of one year).

The following are the anticipated project outputs:

- Draft forest management plan for TFR, partially tested.
- Participatory forest management capacity of local populations and the Divisional Delegation is strengthened through cooperation among all involved parties.
- Traditional income-generating activities and self-help initiatives are identified, and a gender-sensitive strategy for sustainable resource management is developed and tested.

2 Site description

The Reserve is situated at the northern most corner of Southwest Province, Cameroon, north of the Cross River

[1] Community-based conservation attempts to move the responsibility for natural resource management from the elite to the rural poor and from the urban to the village hamlets. This approach is focused on the people who live with and directly bear the costs of natural resource conservation. It enables local people to define their own priorities and develop at their own pace and in their own way—gaining knowledge and skills as they go (Uphoff 1985). In an ideal situation, community-based conservation arises within a community rather than being imposed through a top-down external force.

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Basin and is separated from the southeastern section of the Cross River National Park in Nigeria by the Cameroon-Nigeria international border. Covering an area of 67, 599 ha, TFR contains an additional 6,500 ha of village enclaves. Matene settlements in Cameroon are sandwiched between the Cross River National Park and the TFR. The introductory chapter by Sunderland-Groves *et al.* (this volume) provides full details of the project area including a map of the village locations.

The most prominent water body in the region, the Cross River, and its many tributaries drain southwestern Cameroon and southeastern Nigeria. The Oyi River, a tributary of the Cross River, forms the greater part of it's the Reserve's western border, while the eastern and southern borders of the Reserve follow small rivulets and footpaths. Several small rivers flow south into the Munaya and the Cross River. In the northern part of the Reserve, the hilly terrain rises to more than 1,000 m with mountains reaching up to 1,600 m.

Two seasons, dry and wet, characterize rainfall in the study area. Typically, heavy rains start in mid-March and last to mid-November, with the dry season extending from the latter half of November to mid-March. Average yearly rainfall ranges from 2,500 to 3,500 mm. Average monthly relative humidity at Besong-Abang south of the study area ranges between 76% and 89%. The mean annual temperature is 23º C with an average maximum of 30º C and minimum of 21º C. The hottest months are December to February. Temperatures decrease with altitude, and Mamfe at an elevation of 152 m records a maximum of 34º C in March compared to a minimum of 18º C in January. Akwaya at an altitude of 1,500 m in the northern extremity of the study area is much cooler than Mamfe in the south, and receives more rainfall because of the effect of the highlands.

3 Materials and methods

The data that form the basis for this paper were collected in two surveys—a fisheries baseline study and a fisheries framework survey of TFR's border zone areas.

3.1 Fisheries Baseline Study

The fisheries baseline survey (du Feu 2001) provided:

- A checklist of fish species and literature on the fishery in the study area.
- A description of the composition and the approximate distribution of fish species and of fisherfolk, fishing methods, and seasonality of the fishery.
- A summary of fish processing and fish marketing in the area.

Information on the fishery was obtained from discussions with fisherfolk and through two questionnaires, one for the whole fishing village and the other for individual fisherfolk. Resident literate persons, identified by the village chief and trained by the project team, administered the individual questionnaires to 474 people in the study area.

To establish preliminary yields, a total of 72 catches were measured over five consecutive days. Using that information, it was difficult to estimate catch per unit effort (CpUE) for different gear types because a variety of fishing gear was used over the measurement period. In addition, fishing activity was not estimated from fisherfolk who had their catches weighed because they were fishing at the time of questioning and therefore would have an unrepresentative high level of activity. Instead, activity questions were included on the individual questionnaire, specifically: Had the individual gone fishing over the past three days. This question alone produced a total of 1,440 activity records or an average of 3.04 activities per person (474 individuals) over the three-day period.

To establish preliminary yield estimates for the survey area and the whole of TFR, the total number of fisherfolk was obtained from the questionnaires in the south and from interviews with village chiefs in the northern areas. The mean catches and activity levels were derived from CpUE calculations for two villages and activity data from the fisheries baseline survey. CpUE is based on the general assumption that the number of

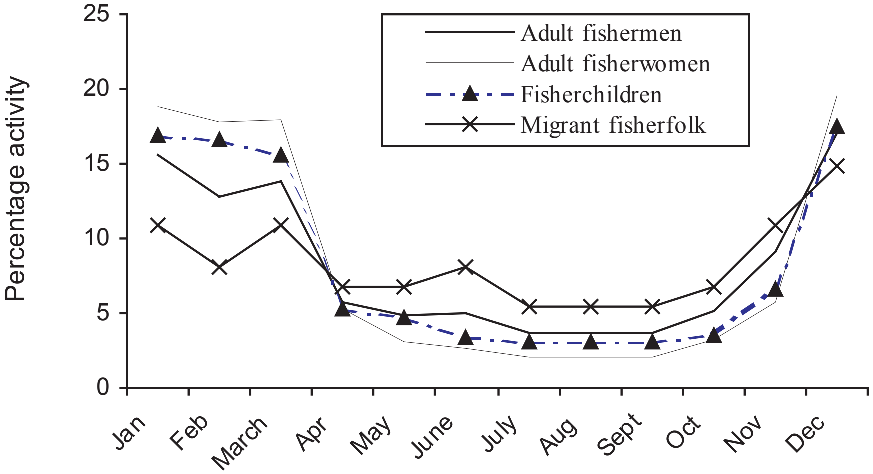

Figure 1. Seasonality of fishing by fisherfolk in the border zone south of Takamanda Forest Reserve, Cameroon

individual fish removed from a population will be proportional to the effort expended in taking the sample.

Total population data, obtained from estimates of Grooves and Maisels (1999) and Ayeni and Mdaihli (2001), were used to estimate per capita consumption of fish. Because published literature on fisheries in the study area is scanty, reliance was placed on the collection of unpublished reports of field expeditions on fisheries surveys (King 1996, Roberts 1975, Simon 1998) in nearby Cross River National Park.

Nomenclature and taxonomy used in the current paper follows that of Lévêque *et al.* (1990, 1992) and Froese and Pauly (2003).

3.2 Fisheries Framework Survey

The fisheries framework survey was designed on the basis of the findings of the baseline study above. In 18 fishing villages in the TFR border zone area, all people who fish were counted, their names were recorded, and they were grouped as follows:

- Resident adult fishermen
- Resident adult fisherwomen
- Fisher children
- Fishermen from other Cameroonian villages
- Nigerian fishermen

In addition, the number and types of fishing gear, boats, and engines they own were recorded.

4 Results and discussion

4.1 Seasonality of Fishing

Fishing is an activity conducted in all sorts of waters with peak activity extending from the end of the rainy season (December) into the short, dry season in March (Figure 1). At this time, the water currents are slow and the river/stream levels less variable than during the wet season. Fish also become more concentrated as the river level drops, making them easier to catch.

There is a rapid rise in fishing activity from October to December after the wet season when streams and rivers are emptying. During this period, a large number of juvenile fish that hatched during the rains and used flooded areas and streams as nursery grounds are caught—primarily through the use of fish fences, traps, cast nets, and cross-over nets. However, fishing for juveniles that have not had a chance to reproduce reduces the overall annual fish production of the water bodies.

4.2 The Fisherfolk

The 2001 fisheries framework survey identified approximately 2,400 part- and full-time fisherfolk in the

Table 1. Type and number of fisherfolk in TFR, Cameroon.

Type of Fisherfolk	Number
Resident fishermen	911
Resident fisherwomen	625
Fishing children	722
Migrant fishermen from Nigeria	31
Migrant fishermen from Cameroon	110

study area, of which 38% were resident adult males, 30% were children, 26% were resident adult females, 5% were migrants from within Cameroon, and 1% were migrants from Nigeria (Table 1).

4.3 Fishing Equipment

Dugout canoes or canoes made of sawn timber (planked canoes) are commonly used for fishing, propelled by paddling since there are virtually no outboard engines in the study area (Table 2). Fishing gear includes gill nets, cast nets, drift nets, beach seines, hand nets, hooks of all kinds, poles and lines, traps, fish fences, cutlasses, and bare hands.

Typical gill nets have a mesh size of 3 inches. When set parallel to the shore, these nets have no harmful effect on the fishery. If set across the river, however, they can block upstream breeding movement and migration and capture large numbers of juvenile fish.

Cast nets have a small mesh size of 1.5 – 2 inches that can damage fish stocks through premature harvesting of juvenile fish.

Drift nets usually target breeding adults as they migrate upstream to spawn. The number of nets is not sufficient to warrant concern, but should be monitored.

Beach seines, or "keli-keli," are extremely destructive because as they are hauled along, they dredge the riverbed and thus destroy breeding and nursery sites. This is a particular problem for continuous spawners such as cichlids.

Scoop/hand net, commonly called "nylon trap" nets, have a mean mesh size of just one inch. Large catches of juveniles can be expected. Cichlids, the main species caught, are not highly fecund and therefore prone to decline in yield if juveniles are over-fished. . Also of concern is disturbance of breeding nests as people wade through the streams with their nets.

Large Hook, or the "number 1 hook," represents the least damaging of all fishing methods, apart from the associated fishery required for bait fishes. Large hooks target predator fishes; through decreases in the number of predators, increased yields of prey species lower in the food chain can be expected.

Poles and lines, known as "day hooks," probably account for a large mortality of juveniles, judging from the number of children fishing and the small size of the hooks that they use.

Wire traps are made of chicken wire with a single opening; they are up to one meter in length. Traps are notorious for catching juvenile fish, particularly of cichlids. Traps probably cause the highest mortality of these species.

Fish fences catch all species of fish during the juvenile's migration from the streams where they were spawned to the main river from November to January. Care must be taken to accurately determine the number of fish fence sites and composition of the catch to make an accurate assessment of impacts.

Table 2. Fishing equipment used by fisherfolk in Takamanda Forest Reserve, Cameroon

Equipment	#	Equipment	#
Canoes	438	Hand nets	1,457
Engines	1	Hooks	20,917
Gill nets	6,793	Poles and lines	2,328
Cast nets	1,029	Traps	5,833
Drift nets	422	Fish fences	84
Beach seines	21	Baskets	1,199

4.4 Fish Poisons

Two types of fish poison exist. The most dangerous is the organo-chlorine insecticide Gammalin 20 (Reid 1989), which are applied during low water (November-March).

Poisons from local plants are more widely used, especially by women, and have been recorded as far back as 1905 (Teugels *et al.* 1992). Traditional poisons include *Trephosia*, a leaf tree (local name Tachinkot, Kachi), the bark of the *Piptadeniastrum africanum* (a tree; Groves and Maisels 1999), and two types of fruit—one of *Randia* sp. (local names Ejibi, Kembu, Epum, and Otchuwatumwa) and the other of *Omphalocarpum procerum*.

Cameroon law now bans chemical poisons. There is no prohibition on use of traditional poisons from local plants, but herbal poisons are banned if classified under a provision of Cameroon law that covers “all other methods deemed to be destructive against fauna or balance of the aquatic ecosystem.”

4.5 Fish Processing and Marketing

The only form of fish processing is hot smoking, commonly referred to as “drying.” All excess fish are smoked either for storage in the home or for sale to other households or markets. The most common fish eaten by village folk are fresh *Clarias, Labeo*, and tilapia. They sell larger, higher-priced fish and retain smaller ones for home consumption.

Every fishing household performs its own smoking. This may appear to be a waste of firewood and effort, especially given periodic, small catches. However, the fish smoker is a simple structure made of a slatted shelf (usually bamboo) placed above the kitchen fire. Because the kitchen fire is always lit, there is adequate smoke for curing.

Prior to smoking, the fish are de-scaled, and the intestines and gills are removed. The fish is then washed and, if smaller than 15 cm, placed flat on the smoking shelf. If larger, a wood skewer is inserted through the mouth to the tail so that the fish is bent circular. The person who caught the fish is usually responsible for preparing it, although this activity is sometimes shared with other members of the household. Fish are smoked for up to three days, then placed in covered rattan baskets on a shelf about 2 m above the fire to remain dry.

There are few fish markets in the study area. Fish are either consumed by the household (23% of surveyed catches) or taken to other houses for sale (77%). Thus, fish are an important source of protein and income.

The main market for fish is in the study area is Mamfe; it is held every Saturday. A roadside market exists along the Mamfe-Nyang road. Its stops include Nyang (Wednesday), Mukonyong (Thursday), and Eshobi (Friday). Only two fish stalls were seen in the road market, and both sold smoked crayfish of very poor quality. There are no fish markets west of the Mamfe-Nyang road.

During the rainy season when this survey was conducted, sea fish were sold mainly at Mamfe market, which had 12 stalls selling salt-water fish compared to 8 selling freshwater fish. Fish sellers offered either freshwater or salt-water fish, never a mix. There was no price difference between the two. Salt-water fish came from Limbe on the coast and included small stone heads, mullets, barracuda, and shrimp. Women take most freshwater fish to the Mamfe market and use the proceeds from selling the fish to purchase household items, although sometimes fish traders go to villages to buy fish for market. Fish sold at Mamfe are used for local consumption and not exported elsewhere.

4.6 Fish Breeding and Migration

From October to December, fish breeding and migration occur in the small streams draining the project area. This period marks the time when hatchlings produced in the preceding rainy season use the flooded streams as breeding grounds before returning to the main rivers. It is during the same period, fish fencing, traps, cast nets and cross-over nets that cause high mortality to juvenile fish are frequently operated.

Migrating *Labeo* spp. make up 10% of all recorded catches. This level is probably much higher when one includes catches during annual migrations. The commercial importance of these fish presents a case for controlling the fishing effort during their migration in November.

Within the forest streams, large breeding migrations of four species were recorded between October and December. The most common was migration of *Labeo batesii*, *Hemigrammopetersius brevidorsalis*, and *Barbus* sp. Similar migration of *L. batesii* have been reported in streams of nearby Okwangwo Division of Cross River National Park at the villages of Bemi, Okwa I, Okwa II, and Kanyang (King 1997). Large-scale fish migrations of *Labeo coubie* were also reported by Simon (1998) for the same area of the national park.

4.7 Fish Species Caught

About 40% of the adult populations (above 15 years in age) in the villages fish, mostly for home consumption. Fish that are sold are either fresh (50%) or smoked (50%). Figure 2 shows the main fish groups harvested using various fishing gear. Fishermen stated that cichlids dominate in their catch followed by predatory *Hydrocynus* sp. and *Hepsetus* sp. The Clariidae—for example, Clarias, Mochokidae, and Bagridae—are also abundant. Popular fish for consumption in the area are Tilapia, Crow–crow nose, Mbanga, Mudfish, Dog fish, and Snake fish (see Appendix 1 for common and specific names).

It is interesting that predators such as *Hydrocynus vittatus*, *Hydrocynus brevis*, and *Hepsetus odoe* figure behind prey fish such as cichlids in the catch. This may indicate an abundance of prey species and perhaps a healthy fishery. The presence of flooded forest banks undoubtedly assists predators, providing "lay in wait and stealth" habitat for effective predation.

Snake fish (Mastacembelidae) are also high on the list of species captured, possibly because they are easy to catch and therefore frequently mentioned. Not surprisingly, the Siluriformes (*Clarias* sp. and *Barbus* sp.), ideally suited to the riverine/stream environment and able to withstand low levels of oxygen in flooded areas, were also on the list, in fourth and fifth places. Bagridae and Mochokidae were also represented.

4.8 Estimate of Fish Production

Extrapolating the sample to the total number of fisherfolk in the survey area and multiplying by the CpUE recorded from Bache and Kajifu villages and activity data from the individual questionnaire survey resulted in a yield estimate of 106.3 tons for November (Table 3). The methodology used here is a standard practice for determination of fish yields in African rivers (Welcome 1976). It is likely that annual yields may differ from that obtained through simple multiplication by 12 months, given the varying levels of activity and CpUE expected during the dry season. Levels of monthly activity obtained from the questionnaire survey were multiplied by the November CpUE (assumed constant) to more accurately project the annual yield and to give an idea of the expected monthly variation (Figure 3). The result was an estimated annual yield of 1,056 ton, worth approximately FCFA 400 million, or about $700,000.

4.9 Fish Biodiversity

In the southern sector of TFR along the Munaya River, some 54 fish species belonging to 22 families have been recorded to date (Appendix 1). While not exhaustive, this list compares favorably with that of the Okwangwo Division of the Cross River National Park, whose tributaries also partly drain the greater portion of the study area. For the Okwangwo Division, King (1997) recorded 31 species representing 6 orders and 9 families. Several of the 90 species from the upper Cross River (Reid 1989) were confirmed as endemics, including *Tetraodon pustulatus*, *Gobiocichla trewavasae*, *Afromastacembelus sexdecimspinus*, and a new species of *Leptocypris*.

Literature on the fishery in the region is almost solely centered on checklists and descriptions of fish species, with little emphasis on the overall fishery (Moses 1981, 1987; Reid 1989; Schliewen 1996; King 1997; Simon 1998). Teugels *et al.* (1992) provides the most

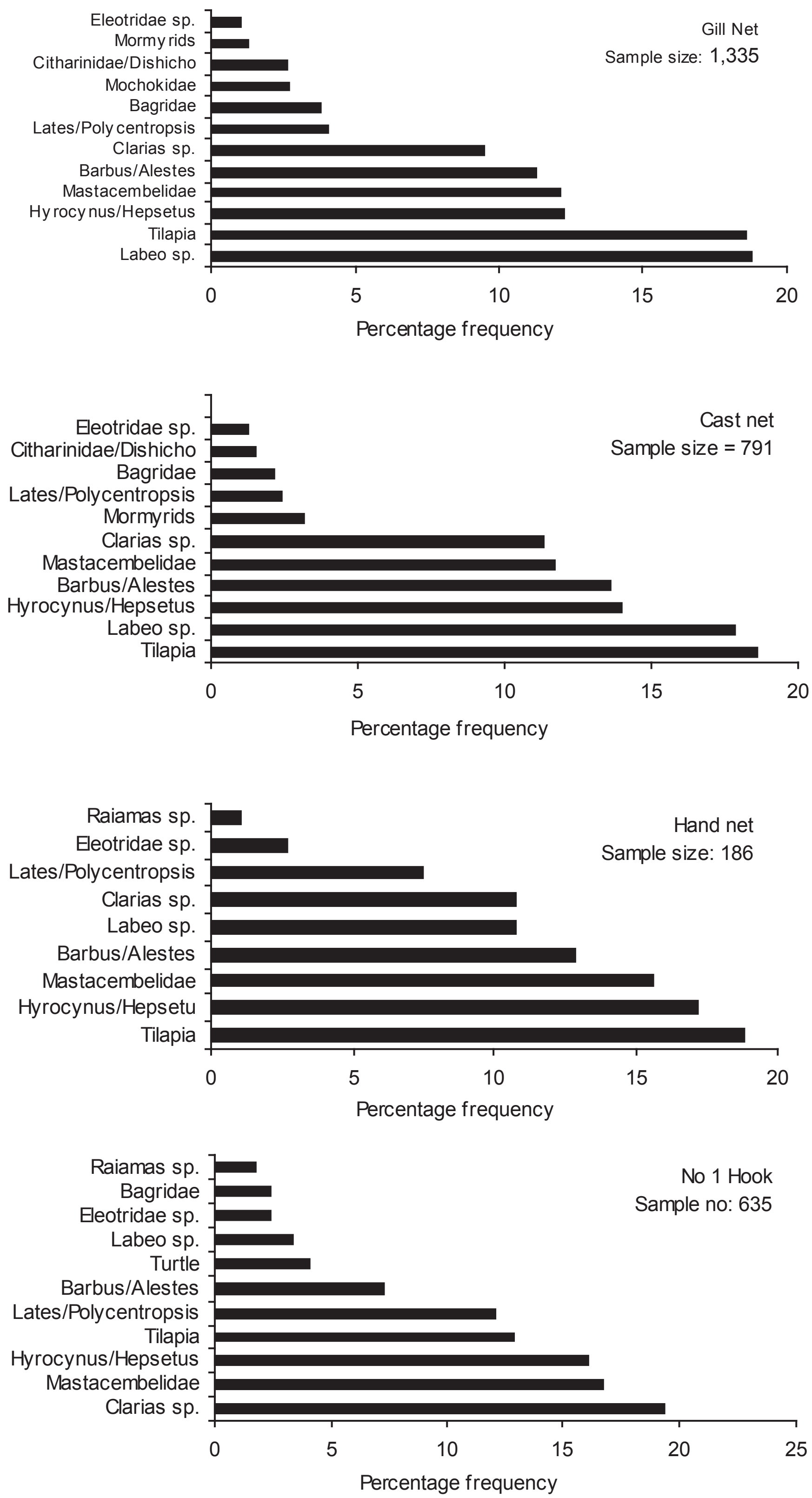

Figure 2. Frequency of species groups caught in the border zones south of Takamanda Forest Reserve, Cameroon.

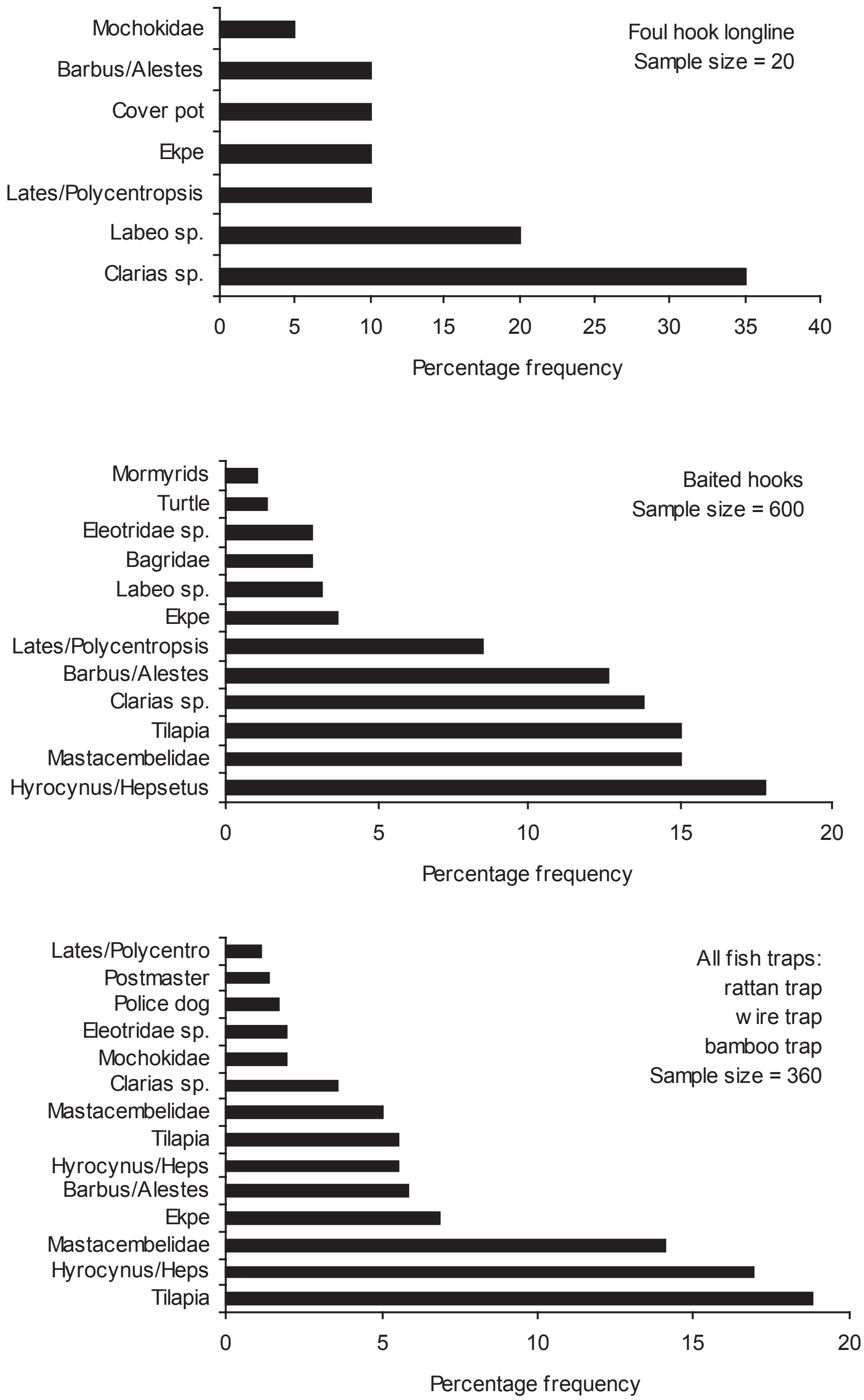

Figure 2 (cont.). Frequency of species groups caught in the border zones south of Takamanda Forest Reserve, Cameroon.

comprehensive list of fish species available and recognizes 166 species from 15 orders. Species include those from the lower Guinean ichthyo-faunal province and the upper Guinean, Nilo-Sudanian, and Zairian provinces. The Cross River has more fish species than any other comparable West African river basin and presents a rich Ichthyofauna (Teugels *et al.* 1992). At the present moderate levels of fishing intensity in the study area, no species can be classified as endangered, although the threats caused by specific fishing methods are of concern.

4.10 Other Aquatic Animals

This study also included questions asking fisherfolk how often they observed other animals while fishing. The objective was to provide additional information on the abundance of aquatic wildlife. The monitor lizard was the most common creature seen, followed by the otter (Table 4). As expected, manatees and hippos, once common, are now less so. Some shellfish such as prawns *Macrobrachium* sp. are harvested inside hollow Indian bamboo traps. Crabs, frogs, and toads receive little attention.

5 Recommendations

To obtain a good understanding of fisheries, especially to enable PROFA to recommend measures that will prevent the valuable stocks of the Upper Cross River from being over-fished, it is recommended that the fisheries monitoring system that was initiated in March 2001 be carried on throughout the project's lifespan. In particular, monitoring should focus on beach seines, cast nets, and the catch by fish fences and small hooks. Whenever the catch exceeds the maximum sustainable fish yield, management measures to regulate the particular fishery will be needed.

Table 3. Estimates of fishing effort, catch per unit effort, and yields for the border zones south of Takamanda FR, Cameroon

	Total	Adult fishermen	Adult fisherwomen	Fisherchildren	Cameroon Fisherfolk	Nigerian fisherfolk
Total number (frame)		399	286	1,114	3	2
Mean ügear types used day^{-1} $fisher^{-1}$		3.7	1.7	1.6		
Percent activity		46	33	57	-	-
Effort (total ïfisher days $month^{-1}$) †		5,560	2,860	18,973	-	-
CpUE (Kg $fisher^{-1}$ day^{-1})		8.96	5.62	2.13	-	-
Total yield (t) south of TFR ††	106.3	49.8	16.1	40.4	0	0
Total yield TFR	239.2	132.6	48	58.6	0	0
Total yield (t) extrapolated to entire TFR area	345.5	182.4	64.1	99	0	0

† Fishing effort = Activity x total number x 30 days per month,

†† Where south of TFR = survey area, Entire area = survey area +TFR

TFR= Reserve enclaves and support zones

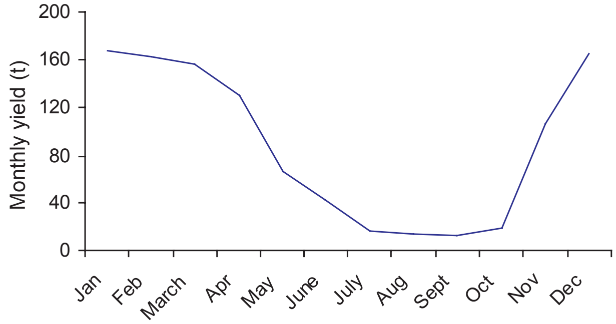

Figure 3. Predicted monthly yield estimates of Takamanda Forest Reserve, Cameroon.

It is further recommended that the campaign against the use of Gammalin and traditional herbal fish poisons be continued. Awareness already exists in the villages, and almost all fisherfolk are against this practice.

To further protect fish stocks, it is recommended that collection of fish eggs from migrating *Labeo* sp. be prohibited before the November migration.

In addition, PROFA should open a small research center to store preserved fish specimens to assist in compilation of fish species checklists and provide a useful fish identification training tool for data recorders.

More research is required to determine any declining patterns in mean sizes of fish caught by hand nets. The cichlids of importance in the fishery must be examined to determine when precise remedial management measures should be implemented. In the meantime, it is safe to recommend that the minimum gear mesh size of 3 inches recommended for most African lakes and rivers is appropriate for the study region.

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Table 4. Reported frequency of sightings of aquatic wildlife while fishing in support zones south of Takamanda FR, Cameroon.

Frequency	**Monitor lizard** *Varanus niloticus*	**Otter** *Aonyx capensis*	**Crocodile** *Crocodylus niloticus*	**Manatee** *Trichechus senegalensis*	**Hippo** *Hippopotamus amphibius*
Every week	59	31	21	16	18
Once a month	23	29	41	20	20
Once a year	18	39	38	65	63
Sample size (ü fisher interviewed)	255	347	226	192	91

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Appendix 1. List of fish species with "Pidgin" English and local dialect names of Takamanda Forest Reserve, Cameroon.

Family	Species	English Name	Pidgin Name
Bagridae	*Auchenoglanis bisculatus* (Geoffrey Saint-Hillaire, 1808)	Catfish	
Bagridae	*Bagrus docmak* (Forskall, 1775)	Silver catfish	Male belly up
Bagridae	*Bagrus flamentosus* (Pellegrin, 1924)	Silver catfish	Male belly up
Bagridae	*Chrysichthys nigrodigitatus* (La Cép"de, 1803)	Catfish	Belly up (female)
Centropomidae	*Late niloticus (Linnaeus, 1762)*	Nile perch	Goper
Characidae	*Brycinus brevis* (Boulenger, 1903)	African tetras	Mbanga
Characidae	*Brycinus longipennis* (Gunther, 1864)	African tetras	Mbanga
Characidae	*Hydrocynus brevis* (Gunther, 1864)	Tiger fish	Dog fish
Characidae	*Micralestes elongates* (Draget, 1957)		Mbanga
Characidae	*Micralestes humilis* (Boulenger, 1899)		Mbanga
Cichlidae	*Pelvicachromis pulcher* (Boulenger, 1901)	Tilapia	Bone back
Cichlidae	*Pelvicachromis taeniatus* (Boulenger, 1901)	Tilapia	Bone back
Cichlidae	*Sarotherodon galilaeus* (Linnaeus, 1758)	Tilapia	Bone back
Cichlidae	*Tilapia mariae* (Boulenger, 1899)	Tilapia	Bone back
Citharinidae	*Citharinus citharus* (Geoffrey Saint-Hillaire, 1808)	Moon fish	Sand leaf fish
Citharinidae	*Citharinus latus* (Muller & Troschel, 1845)	Moon fish	Sand leaf fish
Clariidae	*Clarias agboyiensis* (Sydenham, 1980)	Catfish	Mudfish
Clariidae	*Clarias anguillaris* (Linnaeus, 1758)	Catfish	Mudfish
Clariidae	*Heterobranchus bidorsalis* (Geoffrey Saint-Hillaire, 1809)	Catfish	Mudfish
Cyprinidae	*Barbus bynni occidentalis* (Boulenger, 1911)	Barbs	Mbanga
Cyprinidae	*Barbus lagoensis* (Gunther, 1868)	Barbs	Mbanga
Cyprinidae	*Labeo parvus* (Boulenger, 1902)	African carps	Craw-craw nose
Cyprinidae	*Labeo senegalensis* (Valenciennes, 1942)	African carps	Craw-craw nose
Cyprinidae	*Raiamas nigeriensis* (Daget, 1959)		Aeroplane fish
Dasyatidae	*Dasyatis garouaensis* (Stauch & Blanc, 1962)	Ray	Cover pot
Denticiptidae	*Denticeps clupeoides* (Clausen, 1959)		Mbanga fish
Distichodontidae	*Distichodus engycephalus* (Gunther, 1864)	Grass-eaters	
Distichodontidae	*Ichthyborus monodi* (Pellegrin, 1929)	Grass-eaters	
Hepsetidae	*Hepsetus odoe* (Bl0ch, 1794)	African pike	Dog fish
Malapteruidae	*Malapterurus electricus* (Gmelin, 1789)	Electric fish	Electric fish
Mastacembelidae	*Aethiomastacembelus nigromarginatus* (Boulenger, 1898)	Spiny-eel	Snake fish
Mastacembelidae	*Caecomastacembelus decorsei* (Pellegrin, 1919)	Spiny-eel	Snake fish

Appendix 1 (cont). List of fish species with "Pidgin" English and local dialect names of Takamanda Forest Reserve, Cameroon.

Family	Species	English Name	Pidgin Name
Mochokidae	*Brachysynodontis batensoda* (Ruppell, 1832)	Catfish	Knock-a-knock Postmaster
Mormyridae	*Campylomormyrus tamandua* (Gunther, 1864)	Trunkfish	Elephant fish
Mormyridae	*Gnathonemus petersii* (Gunther, 1862)	Elephant fish	Elephant fish
Mormyridae	*Hippopotamyrus pictus* (Marcusen, 1864)	Trunkfish	Elephant fish
Mormyridae	*Hippopotamyrus psittacus* (Boulenger, 1897)	Trunkfish	Elephant fish
Mormyridae	*Marcusenius cyprinoides* (Linnaeus, 1758)	Trunkfish	Elephant fish
Mormyridae	*Mormyrops oudoti* (Daget, 1954)	Trunkfish	Elephant fish
Mormyridae	*Mormyrus macrophthalmus* (Gunther, 1866)	Trunkfish	Elephant fish
Mormyridae	*Mormyrus rume* (Valenciennes, 1846)	Trunkfish	Elephant fish
Mormyridae	*Mormyrus* spp.	Trunkfish	Elephant fish
Mormyridae	*Mormyrus tapirus* (Pappenheim, 1905)	Trunkfish	Elephant fish
Nandidae	*Polycentropsis abbreviata* (Boulenger, 1901)		Grouper
Notopteridae	*Papyrocranus afer* (Gunther, 1868)	Feather back	Canda planty
Notopteridae	*Notopterus nigri* (Gunther, 1868)	African knife- fish	Canda planty
Osteoglossidae	*Heterotis niloticus* (Cuvier, 1829)	Bony tongue	
Phractolaemidae	*Phractolaemus ansorgii* (Boulenger, 1901)	Blood fish	Mudskip
Polypteridae	*Polypterus ansorgii* (Boulenger, 1910)	Bichir / Thorny-eel	Snake fish
Schilbeidae	*Schilbe brevianalis* (Pellegrin, 1929)	Butterfish	Female belly up
Schilbeidae	*Schilbe intermedius* (Ruppel, 1832)	Butterfish	Female belly up
Tetraodontidae	*Tetradon lineatus* (Linnaeus, 1758)	Puffer fish	Football fish
Tetraodontidae	*Tetradon pustulatus* (Murray, 1857)	Puffer fish	Football fish

Distribution, Utilization, and Sustainability of Non-Timber Forest Products from Takamanda Forest Reserve, Cameroon

Terry C.H. Sunderland, Simon Besong, and Julius S.O. Ayeni

1 Introduction

Non-timber forest products (NTFPs) are materials derived from forests—excluding timber but including "bark, roots, tubers, corms, leaves, flowers, seeds, fruits, sap, resins, honey, fungi, and animal products" (Clark and Sunderland in press). NTFPs are collected from a wide range of ecotypes such as high forest, farm fallow, otherwise disturbed forest, and farmland (Peters 1996) for use as food, medicine, and barter. In some cases, they are the only means for residents of remote forests to participate in the cash economy (Arnold and Ruiz-Perez 1996). People throughout the tropics rely on the harvest and sale of NTFPs for their economic well being.

It is only relatively recently that non-timber forest products have become the focus of research and development initiatives (Neumann and Hirsch 2000), primarily to ensure sustainable use of forest resources to meet human needs while conserving the natural systems that produce the goods (Wilkie 1999). This paradigm shift reflects the important role of NTFPs in conservation and community development initiatives through both product promotion and coherent strategies for sustainable use (Wollenberg and Ingles 1999, Neumann and Hirsch 2000).

The framework for sustainable use of NTFPs must include adequate baseline knowledge of the species concerned, an understanding of the marketing systems in which these products are traded, and appropriate legislation (Cunningham 1999). Such a framework can serve as the mechanism for equitable distribution of benefits, community participation in resource management, and generation of revenues from non-timber forest products (Neumann and Hirsch 2000).

2 Importance of NTFPs in Takamanda Forest Reserve

In common with many areas in the tropics and elsewhere in West and Central Africa, the inhabitants of Takamanda Forest Reserve (TFR) and its environs depend heavily on exploitation of forest resources (Groves and Maisels 1999, Ayeni and Mdaihli 2001, Schmidt-Soltau 2001, Zapfack *et al.* 2001). In particular, NTFPs help to stabilize incomes because they can be harvested when demand for farm labor is low but when NTFP production is at its peak (Schmidt-Soltau 2001). It is estimated that 70% of the total population in the larger study area collects forest products for consumption and sale, representing an estimated income of 500 million CFA (about $850,000) a year (Ayeni and Mdaihli 2001), or a mean of 190,000 CFA (about $320) per household—39% of total household income (Schmidt-Soltau 2001). Recent findings also estimate that the majority (68%) of harvested NTFPs are sold in home communities, 19% are transported for sale in Nigeria, and 13% are traded in local Cameroon markets (Schmidt-Soltau 2001, Sunderland 2001).

In Takamanda, bush mango and eru combined contribute to 82.2% of household income (Table 1) and are by far the most valuable products to the communities within the Reserve. The retail value per unit of other products such as the *Carpolobia* cattle stick and *Randia* chewing stick is relatively high, but most local communities realize very little from the harvest and sale of these products, an inequity that is a key component in the management of NTFPs in TFR as discussed in more detail below.

Table 1. Major plant NTFPs from Takamanda Forest Reserve, Cameroon, and their contribution to household income (from Schmidt-Soltau 2001, Sunderland 2001)

Common name	Scientific name	Plant part used	Use	% contribution to cash income	Main market(s)
Bush mango	*Irvingia gabonensis* and *I. wombolu*	Seed	Condiment, soup thickener	58.9	Ikom, Amana (Nigeria) Mamfe
Eru	*Gnetum africanum* and *G. buccholzianum*	Leaves	Edible vegetable	23.3	Ikom, Amana (Nigeria) Mamfe
Njansang	*Ricinodendron heudelotii*	Seed	Condiment	6.6	Mbu, Nyang, Mamfe
Bush pepper	*Piper guineensis*	Seed, leaf	Condiment, leafy vegetable	2.9	Ikom, Amana (Nigeria) Mamfe
Chewing stick	*Garcinia mannii*	Wood	Dental hygiene	1.9	Agbokim, Ikom (Nigeria) Mamfe
Bush onion	*Afrostyrax kamerunensis*	Seed	Condiment	1.5	Ikom, Amana (Nigeria) Mamfe
Bitter kola	*Garcinia kola*	Seed	Stimulant, medicinal	1.0	Mbu, Nyang, Mamfe
Raffia	*Raphia hookeri*	Leaves	Thatching	0.7	Local sale within TFR
Hausa stick	*Carpolobia lutea* and *C. alba*	Stems	Cattle stick	0.4	Ikom (Nigeria)
Cola nut	*Cola nitida*	Seed	Stimulant, cultural	0.4	Ikom, Amana (Nigeria) Mamfe
Alligator pepper	*Aframomum spp.*	Seed	Medicinal	0.3	Mbu, Nyang, Mamfe
Akpa	*Tetrapleura tetraptera*	Seed pod	Condiment	0.1	Mamfe
Njabe	*Baillonella toxisperma*	Seed	Oil	0.1	Local sale, Mamfe
Essok		Mushroom	Edible	0.1	unknown
Screw pine	*Pandanus candelabrum*	Leaves	Thatching for mats	0.07	Local sale within TFR
Rattan	*Laccosperma secundiflorum L. robustum and Eremospatha macrocarpa*	Stems	Weaving	0.07	Local sale within TFR
Ngongo	*Marantaceae*	Leaves	Weaving, wrapping	0.06	Local sale within TFR
Bush plum	*Dacryodes edulis*	Fruits	Edible	0.06	Local sale within TFR
Poga	*Poga oleosa*	Seed	Edible	0.06	Local sale within TFR

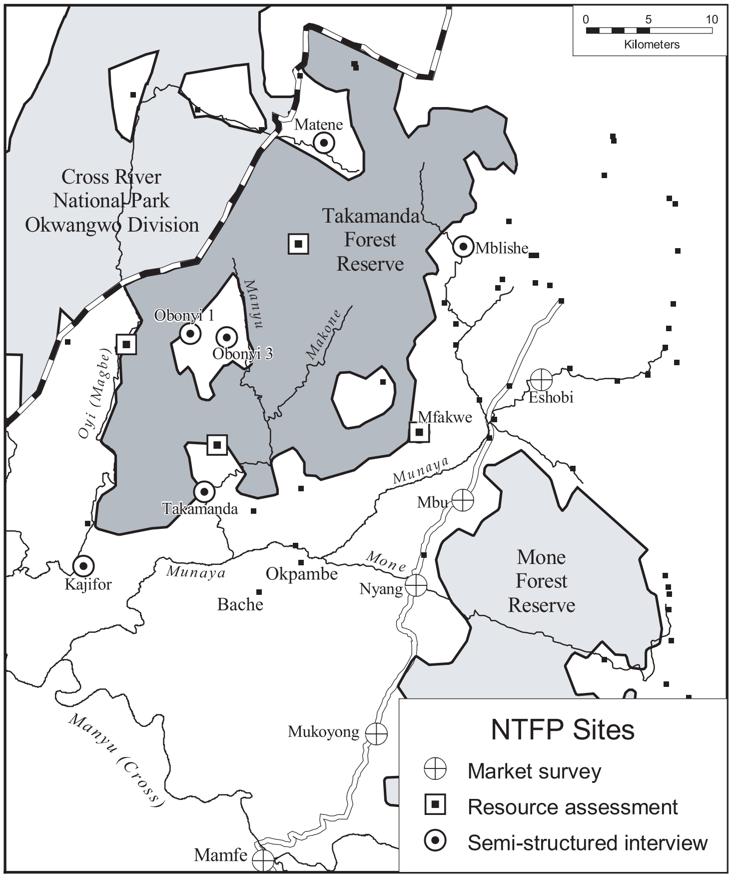


Figure 1. Location of NTFP surveys in the Takamanda Forest Reserve, Cameroon.

2.1 Recent trends in NTFP trade in TFR

Until the 1980s, most of TFR and its environs were relatively inaccessible, except through pedestrian access. The majority of NTFPs were traded locally or were carried on the heads of residents across the Cameroon-Nigeria border. Logging in the late 1980's logging activities, particularly to the south of the Reserve, led to the construction of access roads that reached as far as Bache and Okpambe (Figure 1) These roads facilitated greater access to TFR and its resources, with a corresponding increase in the harvest and trade of many NTFPs by both indigenous peoples and Nigerian traders. By early 1994, many Nigerians began "invading the forest" (Ebot 2001) to harvest *Gnetum*, *Carpolobia*, bush mango, and *Garcinia* chewing stick, with the complicity of the local population. More recently, construction of the Akwaya road, albeit sporadic, has led to the opening of rural markets from Mamfe to Mbu (the latter operates only in the dry season), providing additional means of selling forest products. These changes in infrastructure and marketing conditions, coupled with the absence of any formal controls, have led to the "significant over-exploitation of NTFPs" within the study area (Ebot 2001).

This paper is based on the findings of a study of NTFPs in Takamanda Forest Reserve as part of the GTZ-funded Protection of the Forests around Akwaya (PROFA) project. It reviews the NTFP sector with emphasis on the few forest resources that contribute significantly to household incomes. Each of these resources and the conditions under which they are harvested and utilized or sold are discussed, along with the traditional, legislative, and institutional constraints pertaining to their sustainable and equitable exploitation. Recommendations linked to the paper's conclusions are provided to assist in creation of a framework for strategies that promote the NTFP sector.

3 Methods

The study was conducted from 19 November 2001 to18 February 2002. It consisted of a series of semi-structured and informal interviews with resource users and staff of the Ministry of Environment and Forestry in Yaoundé (MINEF), an inventory-based resource assessment, and market surveys. A comprehensive literature review preceded the fieldwork.

3.1 Semi-structured interviews

A series of semi-structured interviews—employing an open format that allowed conversational, two-way communication—was undertaken in the communities of Kajifu, Takamanda, Obonyi I, Obonyi III, Matene, Mblishi, and Mfakwe (Figure 1). In each community, the interviews were conducted primarily with village council members and with resource users of key non-timber forest products. The users often included women and members of youth organisations, which led to a more representative assessment of the NTFP sector. To determine the institutional and legislative constraints related to NTFPs, informal interviews commenced with MINEF staff in Mamfe.

3.2 NTFP resource inventory

A randomly stratified, transect-based inventory was completed during January 2002 at four key community-managed forest areas in TFR: Takamanda, Obonyi I, Matene, and Mfakwe (Figure 1) These sites represent ecological and socio-economic variables prevalent in the Reserve, as identified by a number of researchers (Groves and Maisels 1999, Sunderland 2000, Schmidt-Soltau 2001) and provide a useful overview of the NTFP sector from both perspectives. The inventory methodology included the following:

3.2.1 Layout

In common with a tested methodology for NTFPs in the Mokoko River Forest Reserve (Sunderland and Tchouto 1999), the inventory for this study consisted of a series of temporary, parallel, 10m-wide transects established along a baseline at predetermined intervals of 100m (10% sampling). Each transect was 1km in length along a predefined compass bearing. Maintaining a constant and correct bearing along the transect is critical to ensure that all transects are parallel. The goal is to include the full range of forest types along the length of each transect.

3.2.2 Enumeration

Once the transects were established, the enumeration team moved slowly along the transect and carefully searched within 5 m either side of the central line for individuals of all species selected for this inventory (Table 2). The 5-m distance was checked with a tape measure for individuals considered borderline. All trees at least 4 cm in diameter at breast height (1.3 m above the ground) were included, as were all rattans, treelets, and shrubs at least 50 cm in height.

Villagers proved to be the best spotters of the desired taxa. A field botanist reviewed all individuals before they were measured for dbh and/or height. The information was recorded on field worksheets along with the location of the individuals along the transects. Additional information included life form, phenology, and evidence of harvest.

3.2.3 Regeneration

At 100-m intervals along each transect, nested 5-m x 5-m regeneration plots were established. All seedlings of the desired species below 50cm in height in the plots were counted and recorded. The recording sheets for the regeneration plots were separate from the recording sheets for the transect data.

Table 2. NTFPs sampled in Takamanda Forest Reserve, Cameroon

Resource	Species name	Common name
Bush mango	*Irvingia gabonensis* and *I. wombolu*	bush mango (vern.); ogbono (Igbo); bojep (Boki); eloweh (Ovande); kelua (Basho); gluea (Anyang)
Eru	*Gnetum africanum* and *Gnetum buchholzianum*	eru (Efik); eru (Ibibio); ukasi (Igbo); ikokoh (Ovande); gelu (Anyang); ecole (Boki)
Carpolobia cattle sticks	*Carpolobia alba* and *C. lutea*	cattle stick (vern.); sanda (Hausa); nyerem-mbe (Ovande); okah (Boki); essa (Anyang); fesha (Basho)
Randia chewing sticks	*Massularia* (syn. *Randia*) *acuminata*	Randia chewing stick (vern.); pako (Yoruba); odeng (Boki); egili (Ovande); egili (Anyang); feyili (Basho)
Njansang	*Ricinodendron heudelotii*	njansang (vern.); ngoku (Basho); itche (Becheve); ngoge (Boki); ngongeh (Anyang)
Bush pepper	*Piper guineensis*	kakwale (Ovande); iyeyeh (Becheve); ashoesie (Boki); taquale (Basho); acachat (Anyang)
Garcinia chewing sticks	*Garcinia mannii*	Igbo chewing stick (vern.); osun ojie (Boki); okok (Efik); aku ilu (Igbo)
Bush onion	*Afrostyrax kamerunensis*	felou (Basho); elonge (Becheve); eloweh (Ovande); elu (Anyang)
Njabe oil	*Baillonella toxisperma*	moabi (Trade); bojie = stump, edjie = fruits (Boki); mpoh (Basho)
Rattan canes	*Laccosperma secundiflorum, L. robustum* (large diameter); *Eremospatha macrocarpa* (small diameter)	gekwiya (Anyang) = large rattan; echie (Anyang) = cane ropes
Fever bark	*Annickia (syn. Enantia) chlorantha*	kakerim (Boki); foukou (Basho); ekwoh (Anyang); ofaechi (Becheve)

3.3 Market surveys

A series of informal surveys were undertaken in January 2002 at markets in Mbu, Nyang, Mukonyong, Eshobi and Mamfe. While these surveys do not comprise a wholly representative assessment of the conditions under which most NTFPs are traded (particularly with the influence of seasonality), they do provide a useful overview of the products being traded, by whom, and how. Assessments of markets at Ikom and Amana during a recent study of NTFPs of Cross River State, Nigeria, elicited additional useful information about the nature and scale of the cross-border trade (Sunderland 2001).

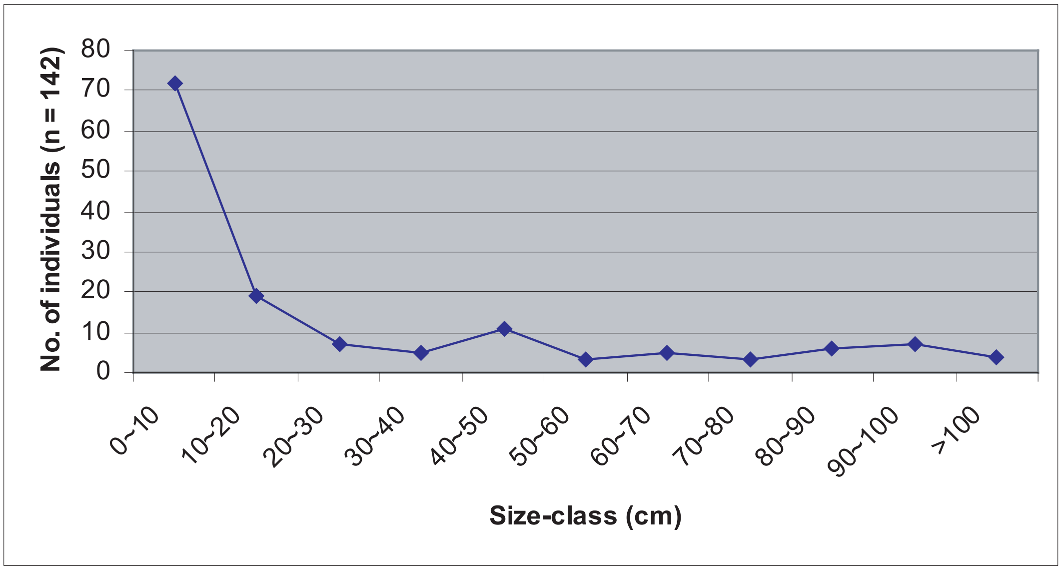


Figure 2. Number of individuals sampled and size-classes for bush mango, Takamanda Forest Reserve, Cameroon.

4 Results and Discussion

4.1 Bush mango (*Irvingia gabonesis*[1])

Table 3 summarizes the transect data for *Irvinga gabonensis*). The Takamanda and Matene sites have a greater abundance of bush mango than Obonyi I and Mfakwe. Takamanda and Obonyi I have relatively few large-diameter individuals (>10 cm dbh), indicating that there are less productive trees in these areas. In the case of Takamanda, this is because of poor recruitment and survival to maturity, most likely stemming from over-harvesting of fruit. Matene is by far the most productive area for bush mango, with high numbers of individual trees >10 cm dbh.

The cumulative size-class distribution for bush mango shows irregularities in recruitment (Figure 2). This may be caused by the tendency of bush mango to mast, but is more likely due to long-term harvesting of fruits and seeds.

[1] *Irvingia wombolu* is not common in the TFR and was not encountered during the inventory.

Table 3. Summary of data collected from transects for bush mango in Takamanda Forest Reserve, Cameroon

Site	Total no. of individuals	Mean no. of individuals/ha	Mean no. of individuals/ha >10cm dbh	Mean dbh (cm)
Takamanda	51	12.75	2.5	10.07
Obonyi I	23	5.75	3	43.7
Matene	46	11.5	8.25	38.02
Mfakwe	22	5.5	3.75	23.5
Mean (all sites)	35.5	8.88	4.38	28.82

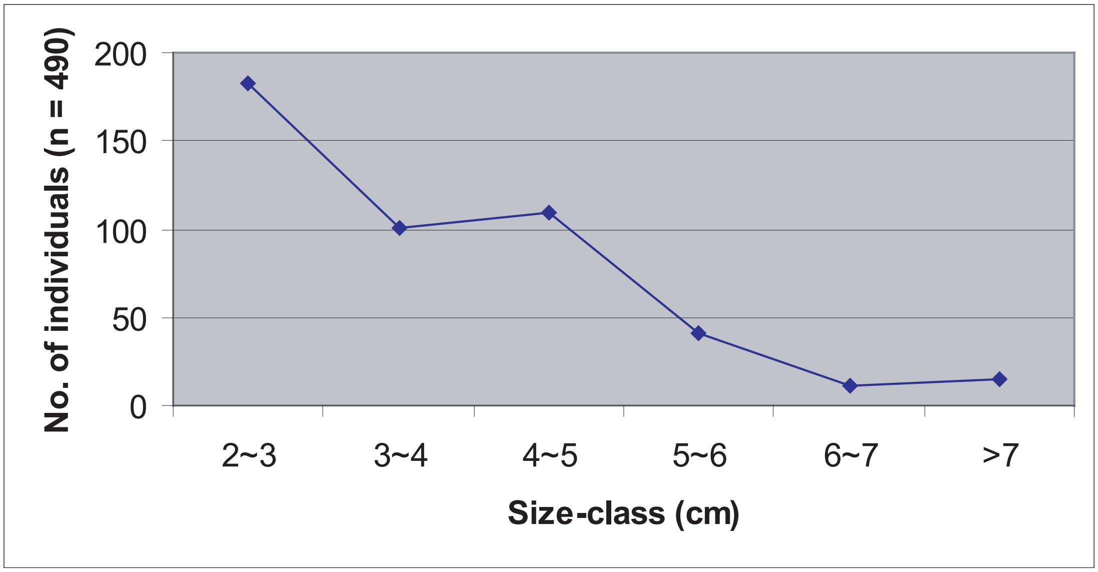


Figure 3. Number of individuals sampled and size-classes for Randia, Takamanda Forest Reserve, Cameroon.

4.2 Randia chewing stick *(Massularia acuminata)*

Table 4 summarizes the transect data for *Massularia acuminata*. Distribution of *Randia* is relatively constant throughout the Reserve, with correspondingly constant numbers of productive stems / ha. The low mean dbh is a result of over-exploitation of larger individuals.

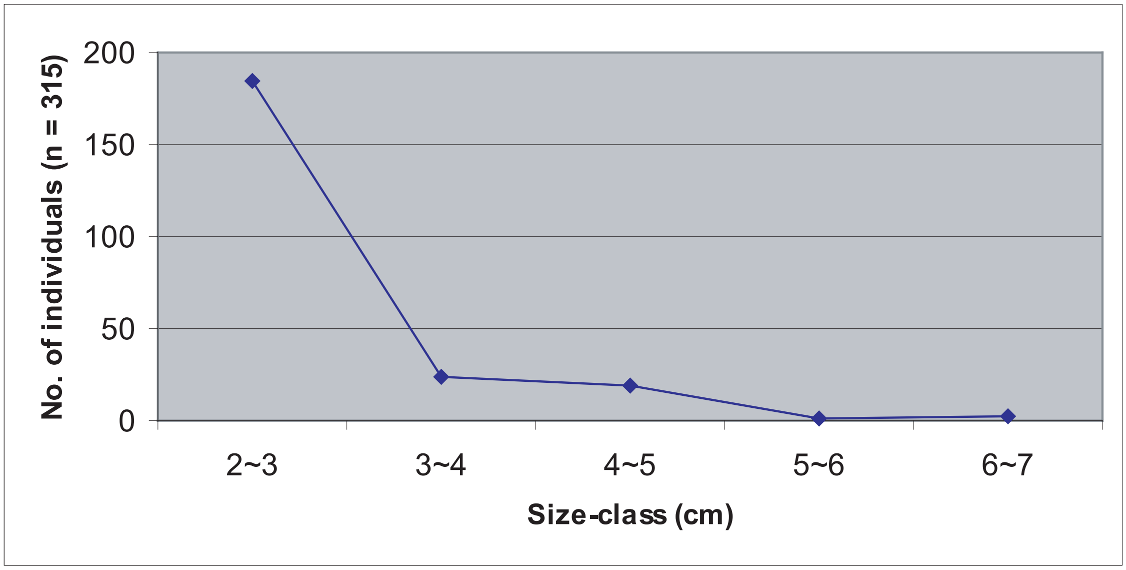
The erratic cumulative size-class distribution shows irregular regeneration and recruitment, corresponding to the removal of mature individuals (Figure 3). Hence, exploitation is having a long-term effect on the population.

4.3 Hausa cattle stick (*Carpolobia* spp.)

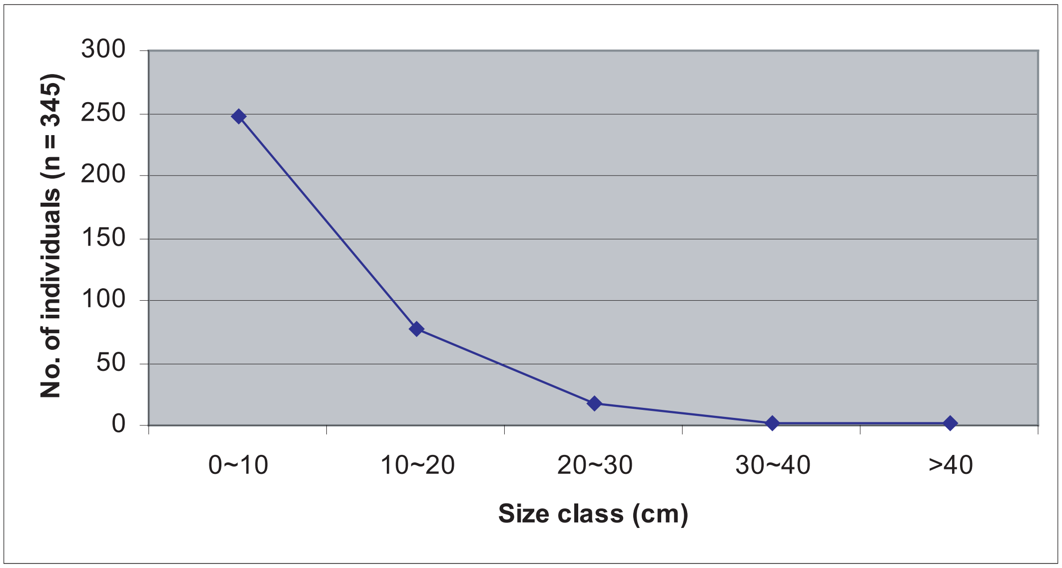
Table 5 summarizes the transect data for *Carpolobia* spp. These are predominantly lowland species and hence are not present in any significant numbers in higher-elevation Matene. Over-exploitation in Obonyi I and Mfakwe resulted in low numbers of mature individuals,

Table 4. Summary of data collected for Randia from transects in Takamanda Forest Reserve, Cameroon

Site	Total no. of individuals	Mean no. of individuals/ha	Mean no. of individuals/ha >10cm dbh	Mean dbh (cm)
Takamanda	157	39.25	13.75	3.23
Obonyi I	143	35.75	8.75	3.19
Matene	91	22.75	11	4.23
Mfakwe	99	24.75	10.5	4.05
Mean (all sites)	122.5	30.6	11	3.68



No. of individuals (n = 315)
200
150
100
50
0
2~3
3~4
4~5
5~6
6~7
Size-class (cm)



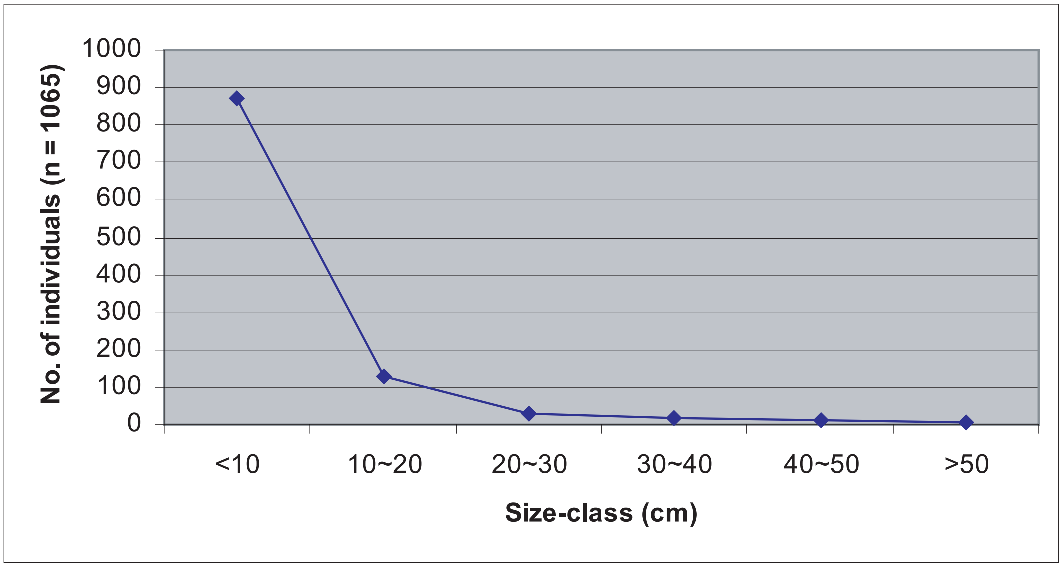
4.4 Chewing stick (*Garcinia mannii*)

Table 6 summarizes the transect data for *Garcinia mannii*. Obonyi I has by far the greatest populations of *G. mannii*, followed by the other lowland sites at Takamanda and Mfakwe. This species is poorly represented in higher-elevation Matene, as expected. In general, the mean dbh for *G. mannii* is high for this species at Takamanda, when compared with the Mokoko area where the mean dbh is 4.28, and indicates minimum impacts from exploitation.

G. mannii shows a healthy cumulative size-class distribution, evidence of healthy regeneration and recruitment and few immediate impacts from exploitation (Figure 5). However, this population should be monitored, particularly with the recent increase in harvesting of mature individuals.

4.5 Bush onion (*Afrostyrax kamerunensis*)

Table 7 summarizes the transect data for the bush onion. Bush onion is abundant at Takamanda and Matene,



where there are greater proportions of secondary forest, and common in Obonyi I and Mfakwe. The cumulative size-class distribution indicates good regeneration and recruitment and no immediate impacts of utilization (Figure 6).

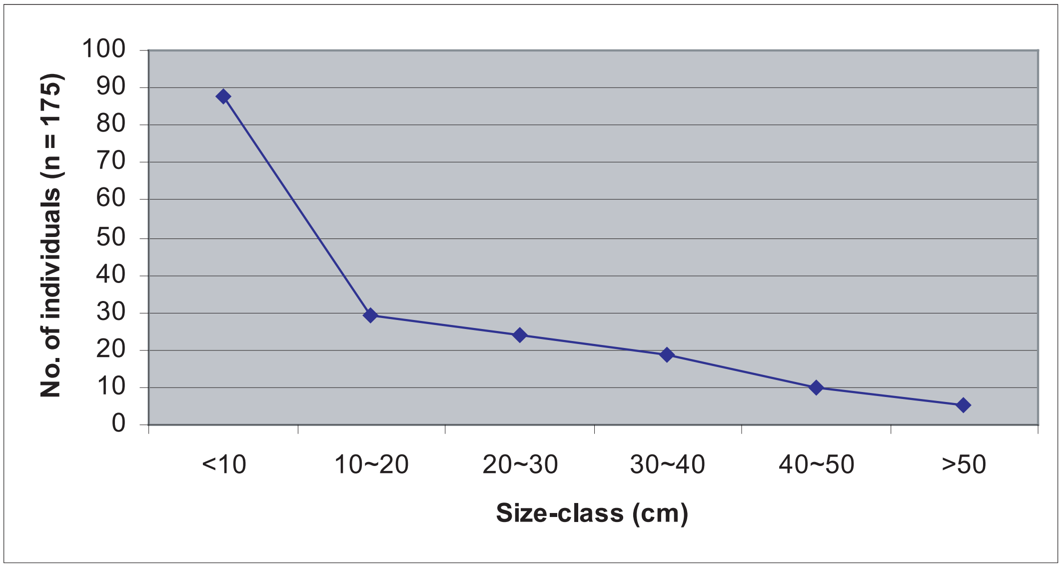
4.6 Fever bark (*Annickia chlorantha*)

Table 8 summarizes the transect data for Fever bark. Compared to the other three sites, Takamanda is characterized by fewer individuals of *A. chlorantha*. Matene and Mfakwe in particular have high concentrations of individuals with a high proportion of productive stems.

The cumulative size-class distribution for this species exhibits good regeneration and recruitment and no immediate impacts of utilization (Figure 7).

4.7 Lianas: Eru (*Gnetum* spp.) and bush pepper *(Piper guineensis*)

Piper guineensis shows a greater abundance in Takamanda Forest Reserve at 6.45 individuals/ha (Table 9) than in Mokoko Forest Reserve as 4 stems/ha. Although there are no comparative figures for *Gnetum*



spp. and these data do not show the species as uncommon, there are many reports of local scarcity in areas of high exploitation.

4.8 Rattan palms

As Table 10 indicates, both commercial species of rattan (*L. secundiflorum* and *E. macrocarpa*) can be considered abundant. Regeneration and recruitment for these species are significant, and rattan is not at risk of over-harvesting in Takamanda Forest Reserve.

4.9 Results from interviews and surveys

The remainder of this paper is based primarily on the results of our literature review, interviews, and market surveys.

4.9.1 Sustainability issues

In general, NTFP exploitation that is not destructive (for example, the removal of the fruits of bush mango) can be described as relatively sustainable as long as there is evidence that the population is not declining over time through the constant removal of reproductive material (Cunningham 1999). Destructive harvesting practices that are undertaken at low levels of exploitation such as

Site	*Gnetum spp.*		*Piper guineensis*	
	Total no. of individuals	**Mean no. of individuals/ha**	**Total no. of individuals**	**Mean no. of individuals/ha**
Takamanda	86	21.5	42	10.5
Obonyi 1	181	45.25	33	8.25
Matene	0	0	16	3
Mfakwe	220	55	25.75	4
Mean (all sites)	121.75	30.4	103	6.45

the removal of bark strips (for example, *Annickia chlorantha*) may pose a threat to the individual, but likely not to the population or species as a whole (Table 11). In general, many NTFPs such as bush mango, njansang, bush onion, and bush pepper, where the impacts of harvesting are minimal, are not at immediate risk of being over-exploited, and there are few reports of increasing scarcity of these products.

Destructive harvesting such as felling and removal of the individual is wholly unsustainable. In terms of conservation, over-exploitation is exacerbated when a species occurs in low densities or has a restricted natural distribution (for example, *Garcinia mannii*). As important, the removal of all mature individuals from an area poses a threat to local populations (for example, *Carpolobia, Garcinia*, and *Randia*). In such cases, the removal of reproductively mature individuals significantly impacts the regenerative potential of the population, which has considerable long-term effects on the capacity of the species to replace itself.

Recent increases in the harvest of many NTFPs at TFR for export to Nigeria is evidence of significant local

Resource	Life form	Part harvested	Impact of harvesting	Level of Sustainability
Bush mango	Canopy-emergent tree	Fruits	Low	**Relatively sustainable**, good regeneration and community-level cultivation
Eru	Woody liana	Leaves	Low to medium to high (depending on technique)	**Relatively sustainable** if leaves are plucked and the stem is not cut, but destructive **unsustainable** harvesting is often undertaken
Njansang	Canopy-emergent tree	Fruits	Low	**Relatively sustainable**, good regeneration and community-level "encouragement"
Carpolobia cattle sticks	Small to medium tree	Stems	High	**Highly unsustainable** because of removal of whole stem, including root collar
Garcinia chewing stick	Medium to large tree	Bole	High	**Highly unsustainable**; species has limited geographical range and is in danger of extinction over the long term
Randia chewing stick	Small to medium tree	Stems	High	**Highly unsustainable**; population beginning a significant decline
Njabe	Canopy-emergent tree	Fruits (more commonly timber)	Low to high	**Relatively sustainable** if harvested for fruits, but unsustainable is harvested for timber
Bush pepper	Climbing	Leaves and fruits	Moderate	**Relatively sustainable** if leaves and fruits are plucked and the stem is not cut
Rattan canes	Climbing palms	Mature stems	Low to medium	**Relatively sustainable** at current levels of harvest

scarcity of these resources in that country (Sunderland 2001), a situation that is largely determining, and exacerbating, the current unsustainable harvest of many NTFPs discussed in this paper.

For example, harvest of *Carpolobia* stems is wholly unsustainable. These stems are cut below the swollen root collar to capture natural "handles" for the cattle sticks. The damage is so great that there is little or no prospect of regeneration through re-shooting, or coppicing. Coupled with this, the individuals preferred for harvest are adolescents (dbh of 4-6cm); hence, many *Carpolobia* stems are removed before reaching reproductive maturity. The loss of these immature individuals seriously affects the population's long-term potential for recruitment through seed production. In the Kajifu area, *Carpolobia* no longer exists because of this practice.

In addition, both harvesters and traders report that *Randia* is becoming increasingly scarce in the Reserve. Harvesters must travel farther and farther into the bush to find mature stems. While the species is still relatively common, destructive harvesting is leading to a serious population decline.

4.9.2 The effects of seasonality on NTFP activities

While many non-timber forest products are available for harvest and sale all year, some are somewhat seasonal, and the economic cycle for many communities relies heavily on the timing of these resources (Table 12). The effects of seasonality are particularly pronounced for bush mango and other fruit-producing species and have significant implications for household budgets.

Resource	Impacts of seasonality	Availability
Bush mango	High	Rainy season type (*I. gabonensis*) available June to September; dry season type (*I. wombolu*) available February to April
Eru	Moderate	All year, although there is less plucking and reduction of supply during early rains as people are occupied with farming
Carpolobia cattle sticks	Low	All year, although transportation problems in rainy season restrict supply to markets
Randia chewing sticks	Low	All year, although transportation problems in rainy season restrict supply to markets
Njansang	Moderate	Fruits produced during rainy season, but after processing, they can be stored indefinitely
Bush pepper	Moderate	Fruits produced in dry season; leaves can be harvested all year
Garcinia chewing sticks	Moderate	All year, although increased availability in rainy season because of better boat access to remote creeks in forest
Bush onion	Moderate	Fruits produced during rainy season, but after drying, they can be stored for some time
Njabe oil	Moderate	Fruits produced in early rains; oil can be stored indefinitely

4.9.3 Traditional resource management systems

For some key resources, the majority of communities in the Reserve have clear regulations concerning the harvest of NTFPs from their forestlands. For example, regulatory controls on access to eru and bush mango are particularly well developed—for the most part, they exclude "outsiders" from harvest—and generally throughout the study area, communities benefit substantially from the harvest and sale of these resources.

However, the harvest of other forest products such as *Randia* or *Carpolobia* that are not traditionally valued in TFR contributes little to either household incomes or the community purse. Dealers who purchase such NTFPs directly from community collectors pay only a token fee to register with the community. This nominal fee is an encouraging sign of an institutional structure in place that is able to regulate access to the harvesting of key NTFPs. Nevertheless, the proportion of benefits that accrue to the communities of origin is but a small fraction of the final sales price of many nontimber forest products. Community members who are often involved at the collector level generally do not move the products along the marketing chain, and hence the majority of the benefits from the final point-of-sale for many NTFPs accrue mostly to non-indigenous wholesalers and traders. This is true even for traditionally valued products such as eru and bush mango.

A primary reason for the lack of indigenous involvement along the marketing chain is that most communities do not have a realistic notion of the true market value of some forest products. This is particularly the case for products that are not used locally to any great extent (for example, *Randia* and *Carpolobia*). In this regard, access to the resource base, or the resource itself, is often unknowingly undersold to outside harvesters or dealers, with many communities, at best, benefiting only from the provision of labor. In addition, an inability to process and store raw materials at the community level means that only the price of raw material production accrues to the communities. For bush mango, this is further exacerbated by the fact that the markets are flooded during times of production, and prices are correspondingly low. If the material could be dried and stored effectively and released when prices are higher a greater level of income would result at the community level.

Many of the people who participated in this study's interviews expressed a desire to enter the formal wholesale trade for some products, which would enable them to sell directly in Nigeria. Lack of credit facilities was cited as a main barrier to success.

4.9.4 Formal legislation

Generally, people who harvest and sell NTFPs are from the "informal sector;" that is, they are essentially self-employed, not recognized in official statistics, have little access to capital, and earn money from labor-intensive enterprises. From harvest to final consumption, the domestic trade in NTFPs is thus part of the "hidden" economy. As a result, "informal" taxation practices abound, by both forestry officials and customs officers, particularly given the extent of the cross-border trade.

It is clear that the NTFP sector is a significant income generating activity for communities in TFR. Capturing the benefits of this trade on a more formal basis would significantly change the manner in which these resources are perceived and managed. Ensuring that NTFP harvest and trade contributes to both rural and urban incomes, as well as to forest conservation, is the focus of the discussion surrounding the entire sector. In Cameroon, a fundamental institutional change is needed to ensure that NTFPs can enter the formal trading, revenue, and taxation systems that apply to the timber resource, for example. Such change must occur at both the community level, where communities receive a fair price for access to the resource, and the level of MINEF.

A major constraint to the realization of formal revenues from the trade and sale of major NTFP resources at the community level is inadequate provision for NTFPs in existing forestry legislation. Aside from permits issued by MINEF for the transport and evacuation of eru (Ndoye pers. comm.), many products, no matter their market value, are not included in the current permit system, which focuses primarily on medicinal plants (see box).

MINEF recently created a directorate for NTFPs. Ideally this unit will be responsible for formalizing revenue collection for the NTFP sector. To date, no policy changes have been proposed.

Despite the lack of an adequate permit system, a key issue in the control of forest resources is the lack of capacity within MINEF, an agency suffering from shortfalls in staff expertise, inadequate basic infrastructure, and logistical support to implement much of the formal forestry legislation. This has undoubtedly fostered a culture of "private settlement" as accepted practice.

Historically, a number of bilateral aid projects and other conservation initiatives have essentially created parallel institutions to Cameroon's government services that function adequately while they receive funding and are serviced by ex-patriot technical staff. However, many have no hope of continuing once, predictably, aid and support are withdrawn at the end of the project cycle. This sidelining of MINEF has contributed to the current poor capacity of the Ministry, and in a twist of irony, poor capacity is cited as the reason why many aid agencies do not directly support MINEF. It might be argued that strengthening of MINEF staff, providing logistical and technical support, and establishing improved systems of accountability and transparency within MINEF would be a far better approach to management of forest resources. In this regard, some of the more innovative forest legislation currently under discussion would likely have more chance of success, particularly for the NTFP sector.

4.9.5 Cultivation

In certain instances, cultivation can provide a long-term solution to over-exploitation of certain forest resources if it is economically and biologically feasible. It is unlikely that cultivation is a viable option for many over-exploited NTFPs in the Reserve, particularly with the poor market access prevalent in the area. However, community-level

Box. Large-scale exploitation of non-timber forest products (mostly medicinal plants) is subject to obtaining a *permis d'exploitation*. This permit determines the quantities to be exploited or collected within a specified geographic area. The length of the exploitation permit usually does not exceed one year (National Forestry Law no. 94/01; *article 56*; October 1994), except by special arrangement.

The volume or amount of material allowed for exploitation depends on the desired material (fruits, bark, leaves, etc.). This quota is set by Cameroon's Department of Forestry. However, even the most rudimentary baseline and monitoring data for estimating potential sustainable yield is woefully incomplete for most, if not all, taxa.

Exploitation permits also apply to special products such as eru. Even if special products are found on lands belonging to private individuals, they remain the property of the state, except where they have been "acquired" by the individual concerned (although it is not specified how acquisition may take place).

initiatives at planting bush mango have proved relatively successful, and there is considerable opportunity to improve the varieties planted through early-yield cultivars of bush mango developed by Dr. Jonathon Okafor. This could alleviate an often-heard concern of many community members that they bush mango takes many years to begin to bear fruit.

In addition to bush mango, many residents of TFR showed enthusiasm for growing eru in home compounds. A number of Takamanda village Chiefs who visited Limbe Botanic Gardens in late 2000, where eru cultivation is well advanced, indicated considerable interest in this possibility.

4.9.6 Product diversification

The heavy reliance on just a few forest resources for income at TFR can pose considerable hardship for some communities. The Matene area, in particular, is primarily dependent on the bush mango resource for access to the cash economy, leaving villagers vulnerable during years of poor production. Product diversification would make a huge difference in this community and others that also rely on two or three key products. For example, the Matene people have historically gathered honey for sale to other TFR communities, and the current value of this product (1,000 CFA/liter or about $1.30) could make this a viable income-generating activity.

4.9.7 Gender issues

In contrast to the NTFP sector in other areas, there is considerable equity in the division of forest resource use and management at TFR. Women are active in the harvest and sale of NTFPs, particularly eru (harvesting only) and the harvest and local sale of njabe oil, njansang, and bush onion. Local development initiatives aimed at promoting and developing household strategies for improving incomes from NTFPs (for example, providing basic machinery for cracking njabe nuts and training in eru cultivation) would likely have a better chance of success if targeted to women's groups within the communities.

5 Conclusions

Forest resources such as *Carpolobia* and *Randia* that are harvested by non-indigenous peoples are removed with very few, if any, benefits accruing to TFR communities. Although harvest of these resources is unsustainable at current rates, MINEF has too few resources to protect these species. The rudimentary village systems for controlling forest resources (for example, Chiefs, village councils, and youth groups) are not fully capable of ensuring that an equitable share of the NTFP trade and benefits accrues to local communities. In addition, the highly porous Cameroon-Nigeria border and the lack of adequate guidelines for taxation of and revenue collection from the trade in NTFPs means that trade benefits are focused in the "informal" economy.

The current rate of harvest of most NTFPs exceeds the ability of many species to regenerate, and the harvest of a number of species can be regarded as unsustainable. This is obvious for species such as *Carpolobia* and *Randia*, but there may also be deleterious long-term effects on regeneration from seed removal (bush mango) and the plucking of leaves (*Gnetum* spp.) that may be unquantifiable in the short term. Long-term monitoring should be implemented both to determine the impacts of harvesting high-value NTFPs and to aid in devising guidelines for sustainable management of all NTFPs.

There is considerable potential to introduce cultivation for some high value NTFPs, especially early-yield cultivars of bush mango and eru for both household use and formal sale.

Product diversification could help reduce the current heavy reliance on a few high-value NTFPs at TFR. Additional forest products should be investigated for their potential to contribute to household incomes.

Acknowledgments

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Landcover change in the Takamanda Forest Reserve, Cameroon: 1986-2000

Dan Slayback

1 Introduction

As with many areas of conservation interest, the Takamanda Forest Reserve (TFR) is part of a dynamic, human-influenced landscape. Although located in a fairly remote region along the Nigerian border, the reserve is surrounded by numerous small villages on its eastern and southern sides, with three villages enclaved within the reserve itself (see figure 2 in Chapter 1). Figure 1 graphically indicates the relative proximity of much of the reserve to human settlements and movement. Additionally, numerous old village sites scattered throughout parts of the reserve indicate the extent and fluidity of previous human settlements.

Until recently, access to the reserve was relatively difficult, often requiring a day's journey on foot to reach either the southern boundary (from Mamfe) or the northern boundary (from the Obudu Cattle Ranch in Nigeria). Since the late 1980s, however, access to the area has been improved with the completion of a large-span bridge over the Manyu river at Mamfe. With this bridge in place, both logging companies and the government have constructed unpaved roads into the region. The government has also made significant progress on the long-awaited Mamfe-to-Akwaya road, which may be completed within the next few years at current rates of progress. A network of footpaths currently connects most villages in the region to one another.

Given the existing pattern of settlements and the recently improved access to the region, we wanted to examine recent landcover change in and around TFR. Fortunately, the archive of high-resolution satellite imagery for the region includes clear images from 1986 and 2000, allowing a study of landcover changes over that 14-year period.

2 Methods

2.1 Data

NASA's Landsat series of earth-observing satellites have been acquiring medium to high-resolution multispectral earth imagery since 1972. Starting with the launch of Landsat 4 in 1982, the satellites began carrying the 30-meter resolution Thematic Mapper (TM) instrument. The resulting TM data archive, from 1982 to present, is the most extensive global collection of high-resolution imagery.

However, the archive contains relatively few cloud-free images from the coastal areas of central Africa, including the scene covering the TFR (identified as WRS path 187 row 56). This is in part due to the extreme cloudiness of the region and the satellite's 16-day repeat coverage (any scene is observed only once every 16 days). Also, previous data acquisition policies and technical difficulties hindered the acquisition of imagery over central Africa until the launch of Landsat 7 in 1999. Fortunately, one relatively clear Landsat 5 image is available from December 12, 1986. This image and a clear Landsat 7 image from December 10, 2000 were acquired for this analysis.

To ensure the precise image-to-image registration required for detecting changes between an image pair, both scenes were orthorectified (by the EarthSat corporation). Orthorectification uses the known locations of many ground reference points to remove the artificial curvature of satellite-acquired imagery, which is an artifact of the satellite's viewing geometry. Further preprocessing of the imagery was unnecessary; due to the

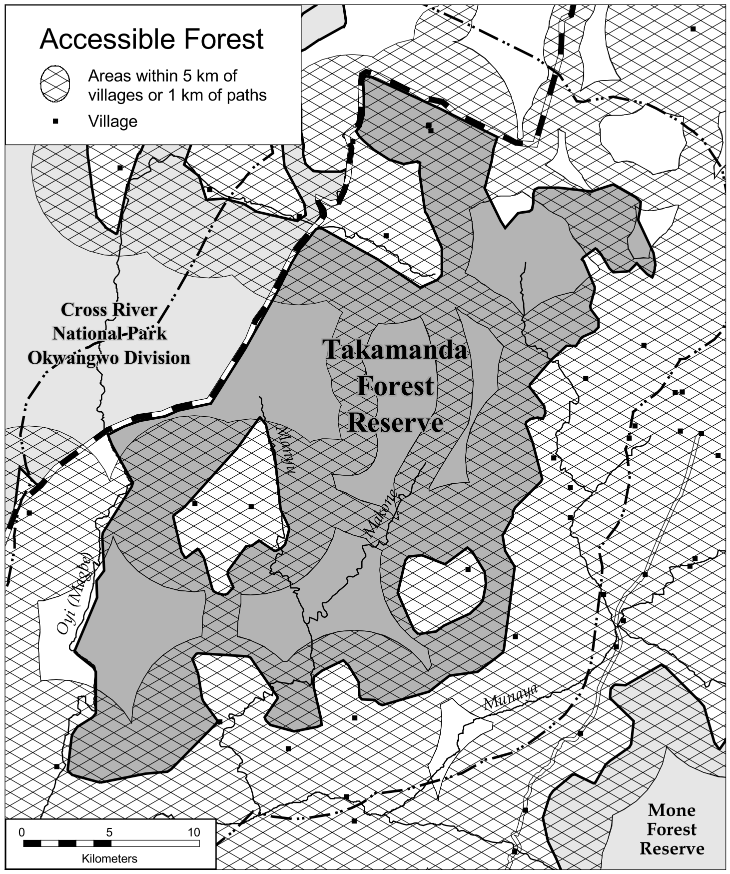

Figure 1. 5 km buffers around village sites and 1 km buffers around roads and footpaths; much of the reserve is within a few hours walk of human settlements.

type of automated change detection methods used (a composite multi-date classification; more below), atmospheric correction was not required (Song, Woodcock *et al.* 2001). The full Landsat scenes were subset to a 1600 x 1760 pixel (~46 x 50 km) window surrounding the TFR (Photo gallery).

The Landsat TM instrument records imagery at 30-meter resolution in 6 different spectral bands, including 3 bands in the visible and 3 in the infrared. Vegetation is known to respond strongly in the red and infrared bands; healthy green leaf matter absorbs red radiation and strongly reflects near-infrared. Additionally, Boyd and Duane (2001) found that the green (band 2) and middle infrared (bands 5 and 7) wavelengths are useful in discriminating tropical forest regeneration. In humid tropical environments, imagery in the blue wavelengths (band 1) is generally dominated by scattering off of water vapor particles, and so appears very hazy, and relatively little useful ground-reflected signal penetrates this haze. Thus, I used the green (band 2), red (band 3), near infrared (band 4) and middle infrared (bands 5 and 7) bands for this analysis.

2.2 Change classification

Changes in landcover between the two dates of imagery were estimated using standard supervised classification techniques. Specifically, the maximum likelihood algorithm method was used in PCI's Imageworks software package. This method assigns class membership based on the statistical properties (mean and standard deviation) of each defined class for all included image bands. The classes are defined manually; typically an operator with knowledge of the imagery manually delineates sites (groups of pixels) of each class on the imagery. Based on the spectral character of these training sites, the maximum likelihood algorithm then makes probability-based class assignments of all image pixels.

To generate landcover change classes using these classification methods, the training sites were selected to include both change classes (such as "forest to non-forest") and non-change classes ("unchanged lowland forest"), and the spectral bands from both dates of imagery were input to the classification procedure simultaneously. This is sometimes termed composite multi-date classification, since images from both dates are composited and used together, as if from a single date. The preliminary orthorectification step makes this approach possible as it ensures the precise overlay of images from different dates. After running the classification, some post-classification processing and manual editing were conducted to clean up and finalize the classification map.

Various statistics were calculated from this final classification map to quantify changes in landcover. To provide better insight into where changes might be occurring most rapidly, these measures were calculated for several regions: the entire 1600 x 1740 image subset; the area within the TFR boundaries (excluding enclave communities); the areas of the two enclave communities (Obonyi and Kekpane); and the area within a 5-km buffer zone surrounding the TFR.

3 Results

3.1 Change Classification

Training sites for nine different classes were initially defined (see Sunderland *et al*. this volume) to include eight static classes (lowland forest, ridge forest, mid-elevation forest, montane forest, grassland/bare, secondary forest/farms, water, shadow), and one change class indicating forest conversion (forest → secondary forest/farms). Note that in a static interpretation of the output classification (e.g. for a year 2000 landcover map), the forest conversion class would be added to the secondary forest/farms class. No distinction was made between secondary forest and farms because these two landcover types are fluid and difficult to distinguish; farms usually have a scattering, or more, of larger trees, and due to the agricultural practices in the region, areas of secondary forest will be farmed again after several years of forest regrowth. The four different types of undisturbed forest (lowland, ridge, mid-elevation, and montane) were included in the classification both because we wanted to map the extent of these forest types (see Sunderland *et al*. this volume), and because lumping them together produces an overly broad and poorly defined forest class, which becomes confused with secondary forest in the classification results. Several other types of change might have also been included, but were not, such as grassland → burned grassland, and forest regrowth (farms → secondary forest); these were either not of interest (the former) or too difficult to consistently differentiate (the latter). In either case, we verified that these areas were satisfactorily classified with the existing scheme. For example, the grassland → burned grassland areas were routinely classified as grassland, and the areas of possible regrowth (farms → secondary forest) were classified as secondary forest. A class for shadow was necessary because the poor and variable illumination on the shadowed sides of hills makes differentiation of different landcovers much more difficult.

The resulting classification was then visually inspected, and in an iterative process, minor adjustments were made to the training classes and certain classification parameters. Despite many such adjustments, it became apparent that an additional class would be useful to indicate areas of "possible" secondary forest. These areas can typically be classified as either lowland forest, secondary forest, or ridge forest, depending on the set of training sites and classification parameters. However, as these areas do not appear to be separable solely from image reflectances, it was decided to create a separate "possible secondary forest" (PSF) class. Generally, firsthand knowledge of the area is required to assign definitive labels to these regions, but many can be labeled based on a closer inspection of the imagery; for example, the areas on hillsides not in the vicinity of villages are most likely undisturbed forest (ridge or lowland). On the other hand, a PSF area just south of the Obonyi enclave's southernmost point is known to be "elephant bush" – an area where extensive elephant activity has significantly affected the forest strFucture (and thereby its reflectance). It is important to note that inclusion of this additional class did not significantly impact the change class of primary interest here (forest → secondary forest); the PSF is a static class and only significantly affected the areas of lowland, secondary, and ridge forests.

The classification output was then sieve-filtered to remove isolated individual or small groups of pixels. This filtering improves the appearance of the results by removing what often appears to be speckle and noise, and increases the accuracy of the results (see "Accuracy assessment" below), since most of the landcover types in this region naturally occur as fairly homogenous landscape features. The sieving was applied to isolated groups of pixels with 6 or fewer members (approximately 0.5 ha); these groups were changed to the most common surrounding class. The final landcover change classification can be found in the photo gallery.

3.2 Accuracy assessment

In this area, there is a fairly continuous gradation between farms, secondary forest, and undisturbed forest. Teasing out these at-times subtle differences can often push the limits of the information available in this imagery. For this classification, the principal difficulty was in finding a balance between a good classification of secondary forest around villages and a good classification of undisturbed forest between villages. This final result is felt to be the best compromise, although a conservative one; it may be underestimating to a small extent secondary forest around villages, in favor of lowland forest. However, the areas of change (forest conversion between 1986 and 2000) were quite stable in all versions of the classification due to the clear signature produced by a change, over time, from undisturbed to secondary forest. The accuracy of the classification was assessed both quantitatively, using testing sites, and qualitatively, relying upon personal familiarity with the region.

Along with the training sites, a separate set of testing sites was also selected for each class. As with the training sites, their selection was based largely on visible imagery characteristics and knowledge of the different landcover types, and not on ground-truth data. Since these testing sites are not input to the classification procedure, they can be used to independently evaluate the classification output via a confusion matrix; confusion matrices indicates how the pixels in each testing site were actually classified. Given the confusion matrix, the accuracy of each class' classification can be computed as a percentage.

For the final output classification (after sieving), the average accuracy (for example, the average of all accuracies) for the landcover classes, excluding water and shadow, was 87%, and the overall accuracy (weighted by the number of pixels in each testing site) was 94%. (The overall accuracy is higher because the undisturbed forest sites were relatively large and well classified). The confusion matrix shows that the main error is a tendency towards classification as lowland forest; 18% of ridge forest, 9% of forest conversion, and 6% of secondary forest test sites were classified as lowland forest. Also, 35% of PSF test sites were classified as lowland, but this is less surprising, since we expect the PSF to really be either lowland or secondary forest. Table 1 shows the classification accuracies for each class (for example, the percent of each testing site that was classified correctly).

Table 1. Accuracy (percent classified correctly) based on testing sites

Class	Accuracy
Lowland forest	100
Secondary forest	92
Possible secondary forest (PSF)	65
Forest conversion	91
Ridge forest	70
Mid-elevation forest	99
Montane forest	86
Grassland / bare	100

Note that the generality of these results are dependent on the quality and representativeness of the testing site pixels. For this study, only limited ground truth data was collected, and the testing sites were determined manually based on limited data and personal familiarity with the region. For example, it is possible that the 9% of the forest conversion testing site pixels that were classified as lowland forest actually *are* lowland forest; no site visits to those specific locations were made, and the testing site pixels for forest conversion may actually contain some lowland forest pixels. Nevertheless, these results do indicate that the classification tends to a conservative estimate of forest conversion areas; none of the lowland forest testing site pixels were misclassified.

The accuracy of the classification was also evaluated qualitatively, based on personal knowledge of the area and supplemented by a visit to the reserve in June 2002. During this visit, the locations of transitions between secondary forest or farms and primary forest were noted and recorded with GPS measurements. During preliminary classifications, these locations were used to help tune the training sites and classification parameters. With the final classification, they were also checked to evaluate the result. Qualitatively, the result appears to capture quite well the areas of forest conversion around villages. As indicated by the accuracy results above, there may be some underestimation of the amount of forest conversion, in favor of lowland or secondary forest. Lacking more extensive ground truth data, this conservative result is preferable.

The main areas of confusion surround the ridge forest class, and the results for certain areas of the image. The ridge forest class, although botanically distinct, has not been mapped to any extent previously, so selection of training and testing sites was based mostly on visual image characteristics and expected locations of this forest type. Geographically, the classification of ridge forest around Matene village (see figure 1 in chapter 1) is of particular concern; this area was visited, and much of what comes out in the classification as ridge forest is most likely secondary forest. However, the higher elevation here may contribute to secondary forest appearing as what elsewhere is ridge forest. Aside from this area around Matene, almost all ridge forest appears (in the classification, as we believe is true in the field) on the sides or ridges of hills. To some extent, this may simply reflect the different illumination conditions on hillsides, but lacking more extensive ground surveys of this forest type, we cannot be sure. The other area of concern is the northeastern corner of the image, in the vicinity of Akwaya. No visit was made to this region, which is at a significantly higher altitude than most of the image, and since the vegetation of the region is quite different structurally from the lowland areas, we simply cannot know if the secondary and forest conversion classes are correct here.

3.3 Change patterns

With the final classification output, total areas were computed for each class, for 5 different zones in the image: (1) the Takamanda Forest Reserve (excluding enclave communities), (2) the Kekpane enclave, (3) the Obonyi enclave, (4) a 5-km buffer zone around the outside of TFR, and (5) the entire 1600 x 1760 pixel image subset. Table 2 shows these totals, omitting the water and shadow classes.

As can be seen in the final classification image (Figure in photo gallery), most of the areas of forest conversion are located on the periphery of existing villages and areas of preexisting secondary forest/farms. This suggests that clearing for farming is expanding into previously undisturbed forest; if the areas of forest conversion were also located within these village centers and within patches of secondary forest, that would tend to indicate that those forest conversions were really from older secondary forest, not from undisturbed lowland forest. In a few cases, however, most of the farms around a village are from ‘recent’ forest conversion, such as Obonyi 1 (on the W side of the enclave) and Obonyi 2 (to the west of TFR); for those villages, farming may *not* be significantly expanding beyond previously farmed areas. From the general patterns visible in this classification, however, one would tend to conclude that the farm rotation cycle is probably too short for secondary forest

Table 2: Areas of output classes (hectares) (*totals include areas of the water and shadow classes)

Class	*Entire image*	*Takamanda*	*Kekpane*	*Obonyi*	*5-km buffer*
Lowland forest	144,425	40,750	1,540	2,550	42,240
Secondary forest	5,010	110	70	300	1,280
Possible sec. for. (PSF)	1,740	410	10	230	470
Forest conversion	4,120	140	40	110	1,430
Ridge forest	11,460	2,190	30	0	4,380
Mid-elevation forest	12,090	5,260	0	0	4,430
Montane forest	9,310	510	0	0	3,910
Grassland / bare	15,170	3,220	4	10	8,440
Total*	224,940	57,430	1,690	3,250	71,800

from abandoned farms to return to the appearance of undisturbed lowland forest.

Significantly, some of the areas of the most apparent farming expansion are those along the new Mamfe-Akwaya road, along the western side of the Mone Forest Reserve. Also, the villages on the southern side of the image (Kajifor and Bache) have only recently become accessible by road (due to recent logging operations) and show considerable farming expansion in their vicinity, perhaps as a direct result. The longer term impact of these roads on patterns of clearing in the region remains to be seen.

4 Conclusion

The Takamanda Forest Reserve is currently undergoing relatively little forest clearing activity, except in the vicinity of enclaved villages and some villages located just outside the reserve boundary (for example, Takamanda village). However, rates of forest clearing appear to be increasing, as the expanding patterns of forest conversion indicate. Potentially half of all secondary forest within TFR has been cleared in the past 14 years; if "possible secondary forest" is not included as secondary forest, then 110 ha of secondary forest were preexisting in 1986, and since 1986 an additional 140 ha have been created from previously undisturbed forest. Within the TFR, the PSF class appears generally *not* to be secondary forest, except for the elephant bush areas to the south of the Obonyi enclave. What is unclear is how much regrowth needs to occur before secondary forest in this region appears as primary forest in Landsat imagery. To some extent, such old secondary forest might be the source of some of the clearing near villages, rather than relatively undisturbed lowland forest.

To fully understand whether these clearing activities are significantly encroaching upon the reserve would require a more detailed study. Although the historical satellite imagery archive is sparse, additional imagery of the area could be examined to determine more precisely when patches of forest were converted to farms. Also, any historical population data for the area would help shed light on how population pressure might be affecting clearing activities.

Although rates of clearing may not be alarming at the present for the TFR itself, the current and likely future activities around the reserve are alarming. Presently, the reserve is ringed by villages on almost all sides, and these villages show active and expanding areas of farming activity. Furthermore, the expansion of roads into the areas to the south and east of the reserve may not bode well for the flora or fauna of the region; it is possible that the greatly improved access to markets and services provided by these roads may lead to a significant increase in clearing activity. This could be for both the planting of both cash crops (such as cocoa, coffee, and palm nuts), and for increased subsistence crop farming, if populations also increase; if improved access brings better schools and health services, out-migration from these villages may be somewhat discouraged, or even reversed. The roads also provide improved market access for bushmeat, leading to increased hunting pressures. Furthermore, all of the above pressures – increased clearing, farming, and hunting – will contribute to the increased fragmentation of the forest, with potentially negative impacts on wide-ranging species, such as the endangered Cross River gorilla or the forest elephant populations. Even now, the Cross River gorilla populations are thought to be largely cutoff from one another and critically endangered (Sunderland-Groves *et al*.this volume)

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Future Conservation and Management of the Takamanda Forest Reserve, Cameroon

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The studies presented in this volume reflect the overall biological importance of Takamanda Forest Reserve (TFR), the urgent need to protect the area to ensure its viability into the future, and, ideally, implementation of sustainable management practices. The studies also provide an important biological baseline for initiation of long-term monitoring that will aid evaluations of conservation and management interventions. Both flora and fauna in the area are extremely rich and diverse. The Reserve holds a wealth of biodiversity of national and regional importance.

Three primary challenges face conservation efforts in the Reserve, as described here.

1. Uncontrolled hunting and unsustainable harvest levels of non-timber forest resources such as the hunting of wildlife for bushmeat. If conservation measures are not undertaken in the near term, the Reserve may well become yet another "empty forest" (Redford 1992) in Cameroon.

2. Loss of forest cover to developments such as construction of the Mamfe-to-Akwaya road. This road will have several impacts: (a) the opening of natural forest in the Reserve to large-scale motorized travel for people who normally pass through the area on foot; (b) the proliferation of trade routes; (c) increased access for even more intensive exploitation of the Reserve's resources, notably timber and bushmeat. At the moment, a significant swath of forest is being cleared and converted to cocoa and coffee plantations in anticipation of the Mamfe-to-Akwaya road.

3. Current legal status of TFR. The Reserve is a "production forest," a designation that leaves open the potential for future commercial logging. Failure to ensure legal protection for the Reserve immediately augers ill for the area's outstanding biodiversity.

Conservation in an area where people rely on exploitation of forest resources for their livelihoods is a sensitive and complex challenge. Despite considerable investments related to resolving this issue in recent years, there are few successful examples or models of integrated conservation and development initiatives where improved quality of life and conservation objectives have proved to be mutually compatible (Oates 1999).

In Takamanda, an area that is still relatively isolated, local amenities are few and far between. There are no piped water facilities, no electricity, few schools, and only one health center that is seldom staffed and carries few supplies. Local peoples are desperate for such amenities and view construction of the Mamfe-to-Akwaya road as a huge step forward in connecting their villages to the rest of Cameroon. In conjunction with this enthusiasm for "progress," however, is the need to create an awareness of the grave environmental problems that roads and other alterations in forest cover create (Trombulak and Frissell 2000, Wilkie et al. 2000)—changes that may alter not only the environment but the very lifestyle of the villagers and which must be constantly monitored to ensure the minimum amount of environmental damage.

Despite such complex issues, a number of activities are underway to address future conservation and management of the area. Since 1998, researchers have been conducting surveys focusing on the Cross River gorilla and other large mammals in TFR and adjacent

Mone Forest Reserve and Mbulu forest. Funded by Wildlife Conservation Society's Africa Program, this program records baseline data, incorporates a conservation/education component, collaborates with the Cameroonian government through the Ministry of Environment and Forests (MINEF) and the GTZ collaborative project PROFA to support the enforcement of national wildlife laws. An immediate impact of these efforts has been implementation of a community-led local ban on hunting for gorillas, chimpanzees, and drills.

At the present time, this program is working with PROFA to assess the potential of upgrading the protective status—possibly to "wildlilfe sanctuary"—of TFR and Mone Forest Reserve and to provide a degree of future protection for the Mbulu forest, which currently enjoys no formal protected area status.

With regard to the future of the MINEF/GTZ project PROFA in Takamanda and Mone, the aims are as follows:

Takamanda Forest Reserve

- Undertake a review of the current protection area status of TFR according to available, and appropriate, levels of protection under Cameroon's 1994 forestry law.
- Complete the long-term management plan for TFR, with participation from stakeholders, for approval from the governments of Cameroon and Germany, to be followed by implementation of the plan.
- Initiate (beginning in 2004) a comprehensive "village development program" to encourage the inhabitants of the area to commence economic activities that do not cause over-exploitation of forest resources. A possible component of this program will be to compensate hunters for lost income if they forego earnings obtained from the sale of bushmeat.
- Continue the monitoring program for vegetation, large mammals—with special emphasis on gorillas—and monitoring of other priority taxonomic groups as appropriate given available resources.

Mone Forest Reserve

- Most immediate, demarcate the Reserve's boundary.
- Initiate baseline biological and socio-economic data collection.
- Complete a management plan, with participation from stakeholders, for approval from the governments of Cameroon and Germany to be followed by implementation of the plan.
- Initiate a monitoring program for vegetation and large mammals to provide comparative information to that for TFR.

The process followed by the various teams conducting assessments in TFR, as described in this volume, was highly successful in providing baseline biological information for conservation management. This model can easily be replicated at a relatively low cost spread over various conservation and funding organizations to conduct similar biodiversity assessments in other areas of Cameroon and Central and West Africa—particularly in areas that are known to be rich in biotic resources but for which limited information is available. Multi-stakeholder, multi-taxonomic assessments are an important first step in defining conservation priorities and potential management solutions.

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