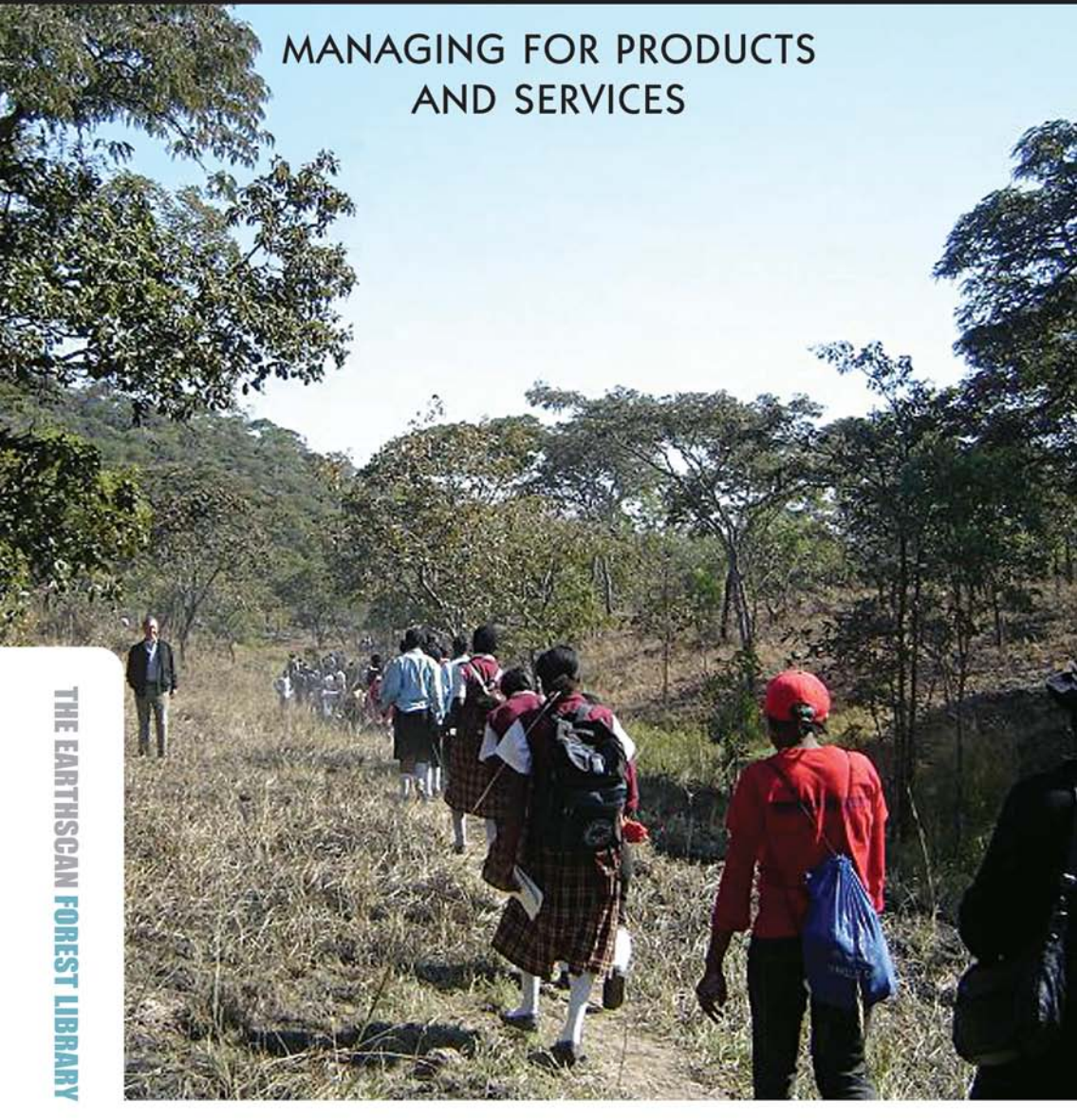
The Dry Forests and Woodlands of Africa

MANAGING FOR PRODUCTS AND SERVICES



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EDITED BY EMMANUEL N. CHIDUMAYO AND DAVISON J. GUMBO

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Managing for Products and Services

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Emmanuel N. Chidumayo and Davison J. Gumbo

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To Dr Mário Alberto and Dr Petros Nyathi
who passed away before the book could be published.
Their contributions to the book are invaluable.

Contents

Foreword

This book is a contribution by 30 African scientists associated with at least 16 institutions across Africa and a few outside the African Continent working towards solving African resource management problems in the dry forests and woodlands. It is one of the outputs of a CIFOR (Center for International Forestry Research) project, with support from Sida-Natur, on Achieving the Millennium Development Goals in African Dry Forests: From Local Action to National Policy Reforms. Dry forest vegetation (including woodland) is dominated by woody plants, mainly trees, with tree canopy cover over 10 per cent of the ground surface within climates with a dry season of 3 months or more (i.e. areas characterized by frequent droughts, occasional floods and general vulnerability to climate variability). It covers about 17.3 million km^2 in 31 countries in West Africa, East Africa and southern Africa. It is the home of 505 million people, most of whom depend on the dry forests and woodlands for their livelihoods, mainly through rain-fed crop agriculture, livestock farming and gathering of timber and non-timber forest products, which also support local industries. Earlier books on the dry forests and woodlands focused on the Miombo woodlands of southern Africa, but this book covers the entire area of the dry forests in sub-Saharan Africa.

The value of the book is the link it provides between the available resources of the dry forests and woodlands, and the use and management of their diverse products and services to contribute to poverty reduction and wealth creation. Chapters 2 to 4 cover the detailed description of the dry forest vegetation types in sub-Saharan Africa in terms of their characteristics, floristic diversity and their potential value to provide products and services. Chapters 5 to 10 address the management practices of the African dry forests and woodlands for specific products and services, and their links with policy, tenure, governance, gender and commercialization. These chapters specifically address non-wood forest products (Chapter 5), timber and other wood products (Chapter 6), firewood and charcoal (Chapter 7), livestock, wildlife and rangelands (Chapter 8), forest plantations and woodlots as a means to create alternative resources (Chapter 9), and, finally, environmental and ecosystem services such as carbon sequestration, soil and water conservation and socio-cultural–spiritual values (Chapter 10). Each individual chapter identifies a number of useful key issues and challenges, and Chapter 11 synthesizes the key issues in the management of the dry forests and woodlands, and suggests the way forward in terms of policy and

legislative reform, stakeholder participation, resource governance, managing for multiple products and services, and climate and land-use change scenarios.

This book provides a current baseline of knowledge on the current resources of the dry forests and woodlands, their use and value, and possible means to manage them towards sustainable development into the future. It poses a challenge to policy-makers and resource managers to make integrated and sustainable resource management a reality to resources users who depend on good governance and the dry forest resources for their livelihoods and prosperity under threats of environmental change.

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Extraordinary Professor in Forest Science
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Preface

Since time immemorial dry forests and woodlands of sub-Saharan Africa have provided diverse ecosystems goods and services to large populations of humans and livestock that depend on them. Dry forests and woodlands are profoundly important for local livelihoods, and yet, this role is hardly recognized by the respective sub-Saharan African governments – more so against the backdrop and importance accorded to tropical forests. Further, policy inadequacies are noted and dry forests are a low priority in sub-Saharan Africa. Lately, sub-Saharan Africa's dry forests and woodland have been rapidly declining due to harvesting of wood for commercial and domestic purposes and this has had major implications for the local people. Sub-Saharan Africa is a developing region where deforestation and desertification have remained as major issues of concern. With these changes, biodiversity, which is not only important for ecotourism but also a significant source of non-wood forest products is severely under threat. All the key attributes of the dry forests and woodlands are intricately linked and a change in one will affect the other. Thus, the threat posed by climate change on the forests will invariably affect livelihoods and therefore there is an urgent need to increase natural and human capacity to deal with the problems triggered by this development.

This unique book brings together scientific knowledge on and about dry forests and woodlands from eastern, western and southern Africa, and describes the relationships between forests, woodlands, people and their livelihoods. Dry forest is defined as vegetation dominated by woody plants, primarily trees, the canopy of which covers more than 10 per cent of the ground surface, occurring in climates with a dry season of three months or more. This broad definition – wider than those used by many authors – incorporates vegetation types commonly termed woodland, shrubland, thicket, savanna and wooded grassland, as well as dry forest in its strict sense.

The book provides a comparative analysis of management experiences from the different geographic regions of sub-Saharan Africa, emphasizing the need to balance the utilization of dry forests and woodlands between current and future human needs. Further, the book explores the techniques and strategies that can be deployed to improve the management of African dry forests and woodlands for the benefit of all, and especially the communities that live off this vegetation. This book aims to stoke local, regional, national and international discussion on these forests and woodlands that provide livelihoods to almost 60

per cent of sub-Saharan Africa's population. In this way the book is not only calling for a better understanding of the policy issues surrounding these forests but also the biophysical aspects of the same. Thus, the book lays a foundation for improving the management of dry forests and woodlands for the wide range of products and services they provide.

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July 2010

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We are particularly indebted to Bruce Campbell and Cris Marunda, then Director of CIFOR's Forests and Livelihoods Programme and Project Coordinator (Zambia Office), respectively, whose early work and vision made this book part of the Dry Forest Project. The editors also note the important contributions made by administrative staff in CIFOR HQ – Nani Djoko, Ratih Septivita, Henny Linawati and Hiasinta Lestari: they too through their hard work and support made this book a success. Last but not least we would like to thank Tim Hardwick of Earthscan for giving direction as well as encouragement. Finally, we would like, together with the publisher, to thank all those who provided materials for the book including illustrations. We are also grateful to all publishers and organizations for providing copyright permissions to reproduce material, which are acknowledged and cited in relevant captions and reference lists.

We hope that the insights paid in this book contribute towards a better management of sub-Saharan Africa's dry forests and woodlands.

List of Abbreviations

AAC	allowable annual cut
CAMPFIRE	Communal Areas Management Program for Indigenous Resources
CBD	Convention on Biological Diversity
CBNRM	community-based natural resource management
CDM	Clean Development Mechanism
CIFOR	Center for International Forestry Research
CITES	Convention in International Trade in Endangered Species
CO_2	carbon dioxide
dbh	diameter at breast height (1.3m high)
DRC	Democratic Republic of Congo
ES	ecosystem services
FAO	Food and Agriculture Organization of the UN
GDP	gross domestic product
ITTO	International Timber Trade Organization
IUCN	International Union for Conservation of Nature
JFM	joint forest management
NDVI	Normalized Difference Vegetation Index
NGO	non-governmental organization
NTFP	non-timber forest product
NWFP	non-wood forest product
PES	payments for environmental services
R&D	research and development
REDD	Reduced Emissions from Deforestation and forest Degradation
SFI	Sustainable Forestry Initiative (of AF&PA)
SOC	soil organic carbon
SFM	sustainable forest management
TFCA	trans-frontier conservation areas
UNFCCC	UN Framework Convention on Climate Change
WHO	World Health Organization
WWF	World Wide Fund for Nature

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Dry Forests and Woodlands in Sub-Saharan Africa: Context and Challenges

Emmanuel Chidumayo and Crispen Marunda

Defining Dry Forests and Woodlands of Sub-Saharan Africa

Dry forest and woodland are vegetation types dominated by woody plants, primarily trees, the canopy of which covers more than 10 per cent of the ground surface, occurring in climates with a dry season of three months or more. Dry forests in Africa occupy an area between rainforests in the Congo basin and open woodlands of western and southern Africa. Woodlands in Africa are diverse vegetation formations that include woodland proper, bushland, thicket and, in some cases, wooded grassland. The Center for International Forestry Research (CIFOR) in sub-Saharan Africa has implemented a dry forest programme since 1996 but with a narrower focus on southern Africa. The programme, although called dry forest, includes both dry forest proper and woodlands as defined above. Currently CIFOR's dry forest programme is coordinated by regional offices in Burkina Faso for the West African Region and Zambia for the Southern African Region, and includes all countries in sub-Saharan Africa that have dry forests and woodlands. These vegetation types in sub-Saharan Africa are found in 31 countries in western, eastern and southern Africa and are the dominant vegetation in 63 per cent of these countries. They cover approximately 17.3 million km^2 and are inhabited by nearly 505 million people (2003 estimate).

Table 1.1 *Some indices of human well-being in sub-Saharan African countries with a significant cover of dry forests*

Index of human well-being	*Average*	*Range*
Population living below poverty line (%)	53	35–80
Life expectancy from birth (years)	57	31–58
Budget revenue (US$ per capita)	126	21–1462
Health expenditure (US$ per capita)	22	4–127
Population with access to essential drugs (%)	57	25–87
Agricultural labour (% of total labour force)	69	32–92
Traditional energy use (% of total energy use)	79	25–98

Source: Based on NationMaster.com (2004)

Socio-economic Context of Dry Forests and Woodlands in Sub-Saharan Africa

Africa entered the 21st century as the poorest, most indebted, marginalized and technologically backward continent in the world. Life expectancies, per capita revenues and expenditures on health are the lowest in the world, while the proportion of the population dependent on traditional energy sources (firewood, charcoal and organic wastes) is among the highest. Various other indices of human well-being (Table 1.1) testify to this predicament that sub-Saharan Africa faces in the new century.

In many countries of sub-Saharan Africa the majority of the people live in rural areas where the main livelihood source is subsistence crop and/or livestock production. The major zone of crop agriculture in sub-Saharan Africa is in the dry forests and woodlands; much of which is rain-fed and is therefore vulnerable to climate variability. The climate of the dry forest and woodland regions is characterized by frequent droughts and occasional floods that frequently cause crop failure. During such times the coping strategies of local people invariably involve gathering of wild foods in the forest. But the reliance on dry forests and woodlands is not only a safety net, important as this may be; these vegetation formations also play a significant role in supporting local industries. Most important, is the diverse range of forest products, including fruits, fish and bush meat, edible insects, beeswax and honey, and traditional medicines, that are indispensible to the lives of communities living in dry forest and woodland zones. Most of these non-wood forest products are produced, traded and consumed outside the formal cash economy and therefore are not adequately captured in national economic statistics.

Importance of Dry Forests and Woodlands to Ecosystem Services, Livelihoods and National Economies

Dry forests and woodlands in sub-Saharan Africa are rich in biodiversity that is important for the supply of ecosystem services, such as regulation of water flows, water quality, climate and protection of land from soil erosion. For example, woodlands in sub-Saharan Africa are of crucial importance to water resources management because all the major river basins in sub-Saharan Africa are either located or have most of their headwaters in the woodlands. Therefore they play a crucial role in sustaining river flows and water supplies. The conservation of these woodlands in watersheds is therefore crucial for maintaining the supply of water for irrigation, sanitation, industry, hydropower and human consumption. People also derive numerous products and services from ecosystems and the biodiversity they contain and this book focuses on a limited number of these products and services.

Non-wood forest products

Poverty in Africa is rife; almost 60 per cent of rural Africans live on less than US$1 a day (Kaimowitz, 2003). In many of the continent's rural areas, poverty appears entrenched and intractable with few opportunities for relief, especially in the context of the huge and devastating impacts of HIV/AIDS (Bryceson and Fonseca, 2006; Shackleton, 2006; Wiegers et al, 2006). The importance of non-wood forest products (NWFPs) for livelihood security, in particular for food security and alleviating dietary deficiencies, and for assisting households to cope with, if not escape, poverty is widely acknowledged in sub-Saharan Africa. In particular, these products have been shown to be important for women and children, both extremely vulnerable groups. The use of NWFPs by urban, in addition to rural households, has also been pointed out, and is likely to grow with the increasing urbanization of Africa's population (UNEP, 2002). In many ways, urban demand helps to create sustainable markets for NWFPs, contributing to their potential as a means for rural people and traders to earn a cash income. Furthermore, NWFPs play a significant role in mitigating some of the devastating impacts of HIV/AIDS. Both plant and insect wild foods are highly nutritious and could assist in meeting some of the nutritional requirements of people living with HIV/AIDS. The demand for traditional medicines has also risen as a result of the AIDS pandemic, with potentially negative outcomes for forest and medicinal plant stocks. Many NWFPs have significant links to culture and identity and contribute to building social capital. Despite this, and the fact that many millions of poor people benefit daily from NWFPs, their crucial importance for livelihood security and significant economic contribution, primarily in the informal sector, is generally poorly recognized and appreciated and sometimes even ignored in terms of national policy and forest management

(Bird and Dickson, 2005; Petheram et al, 2006). Such neglect may undermine the potential of these products to deliver benefits in the future, erode vital safety nets and exacerbate the already persistent poverty endemic to Africa.

Woodfuel

Firewood and charcoal use, especially in urban areas, has socio-economic benefits. The charcoal business employs a large portion of the population along the chain from the producer in rural areas to the consumer in urban areas. Charcoal production contributes significantly, in some cases 60–80 per cent, to rural household income and is therefore important in poverty reduction. Sustainable dry forest and woodland management is thus key to the maintenance of forest-based income generation in rural areas. In some cases, income from charcoal sales is used to buy agricultural inputs and in this way, dry forests and woodlands subsidize agricultural production and therefore contribute to household food security. Income from woodfuel sales cushion rural households against loss of agricultural incomes when producer prices of agricultural crops decline due to economic and other structural adjustment policies. Similarly when people lose jobs, such as in mining and other industries, they find charcoal production an attractive means of income generation.

Timber and wood products

Timber and wood products, such as poles, from indigenous trees in African dry forests and woodlands are used locally to meet basic needs and to generate income. Timber products constitute the base for small-scale industries in many communities, including those centred on woodcrafts, canoe making and the manufacturing of a variety of household tools and utensils. These industries enable communities to generate social and economic benefits. Apart from the direct involvement of communities in the timber business, sustainable forest management creates possibilities for the timber industry to share benefits from the logging operations with local communities. Many countries in dry forest and woodland regions of Africa have adopted measures for benefit sharing between local communities and those conducting logging operations, be they the private sector or the state. The establishment of industries to produce wood products in the rural areas is often accompanied with infrastructure development (hospitals, schools, roads, etc.) and the roads increase accessibility to remote rural areas.

Livestock and wildlife

Rangelands, including those in the woodlands, occupy about 90 per cent of the agricultural land in Africa and sustain the livelihoods of 25 million people.

Livestock production systems in the subsistence economy are usually geared to the production of multiple products, including meat, milk, blood, hides and skins, dung for fuel, transportation, flexible household capital reserves and risk management, while commercial ranching systems are generally geared more narrowly towards meat production (Mearns, 1996). The livelihoods of millions of people in Africa are therefore dependent on livestock (Shackleton et al, 2001, 2005; Dovie et al, 2006). Animal draught power and nutrient cycling through manure compensate for lack of access to modern inputs, such as tractors and fertilizers.

Livestock production makes a significant contribution to gross domestic product (GDP) although its importance in the economy varies among African woodland regions. Livestock are expected to play an important role in fulfilling the Millennium Development Goal of reducing poverty by 2015.

In southern and eastern Africa wildlife management is an important complement to livestock keeping on rangelands. Income from game viewing and/or trophy hunting on private ranches and state game management areas can exceed the income from livestock, and a combination of both provides higher income than livestock or wildlife alone (Kiss, 1990). Although large game animals are now rare in western Africa, smaller game animals, such as duikers, grasscutters and giant rats contribute substantially to local meat supply (Caspary, 1999). Lindsey et al (2007) estimated that sub-Saharan Africa receives about US$201 million per year from trophy hunting, making trophy hunting an important driver of conservation. In spite of the conflicting reports about benefits from community-based wildlife management schemes, this natural resources management approach has the potential to contribute to poverty alleviation and local economic development, especially in woodland areas with a high diversity of wildlife species.

Plantations and woodlots

Plantations and woodlots generate revenue and foreign exchange for national governments. At the local level, they provide jobs offering economic opportunities for rural residents (Whiteman and Lebedys, 2006). In addition, there may be opportunities for local residents to use the residues and by-products left behind after trees have been harvested for woodfuel or timber. Indirect benefits may include government reinvestment of the revenue generated from plantations into education, medicine and infrastructure development in local communities (Morrison and Bass, 1992).

Managing Dry Forests and Woodlands in Sub-Saharan Africa: Challenges and Concerns

With the ever-growing pressure on dry forest and woodland resources to meet human development needs and livelihood demands, these vegetation forms are increasingly being utilized unsustainably in Africa. Often, the high levels of poverty and growing political pressure force governments in Africa to encourage overexploitation and conversion of dry forests and woodlands to other seemingly more profitable land uses at the expense of the environmental and ecological services that they provide.

The issues addressed in this book concern the role and potential of dry forests and woodlands as sources of products and services, and how these can sustainably be harnessed to alleviate poverty and support livelihoods and socio-economic development. Much of the global focus in African forests has been on tropical rainforests; as a consequence of this bias, dry forests and woodlands have received little attention in terms of research, investment and policy development. This book is an attempt to get dry forests and woodlands back on the agenda of national, regional and global debates. However, while recognizing the value and potential of African dry forests and woodlands to livelihoods and national economic development, the book raises a number of concerns about sustainable utilization of these areas. In particular, it discusses the threats posed by resource tenure, governance, international conservation and trade policies. The book highlights the knowledge gap that exists about the inherent ability and capacity of dry forests and woodlands to regenerate, especially in the face of climate change and land-use extension and intensification. The key question is whether there are management practices and models that can be strategically applied to maintain and improve the productivity of African dry forests and woodlands to meet the ever-growing demand for forest products and services in a dynamic global environment.

The main purpose of the book is to lay a firm foundation for improving the management of dry forests and woodlands for a range of products and services, thereby contributing to sustainable livelihoods and poverty reduction. This purpose is achieved by highlighting the socio-economic and environmental importance of African dry forests and woodlands and providing possible approaches to meeting the livelihood needs of dry forest/woodland communities and nations. At the same time, the book points to approaches that can maintain the vitality of these forests and woodlands and secure their capacity to provide goods and services for future generations. Maintaining the balance between utilization to meet current human needs and conservation for meeting future needs will not be easy and demands sacrifices at all levels: individual, community, national, regional and international.

Layout of the Book

The book has ten substantive chapters. Chapter 1 introduces African dry forests and woodlands and their setting in the socio-economic context of sub-Saharan Africa and is immediately followed by a chapter that gives a detailed description of these vegetation types in sub-Saharan Africa, their characteristics and potential to provide products and services. Chapter 3 describes the floristic diversity and value of African dry forests and woodlands and presents possible approaches for managing the rich plant biodiversity. Chapter 4 links the biological resources in African dry forests and woodlands to livelihoods and critically analyses the potential of forest products to contribute to poverty reduction and wealth creation.

Chapters 5 to 10 address the management of African dry forests and woodlands for specific products. They describe opportunities for scaling-up production and expanding trade. They identify possible management practices and link these to institutional and policy issues, such as tenure, governance, gender and commercialization. Non-wood forest products, such as honey, wild foods (plant and insect), oils, medicines and grasses have rarely been comprehensively analysed at such a large geographical scale as sub-Saharan Africa and Chapter 5 is an attempt to fill this gap. The chapter is a synthesis of what is currently known about non-wood forest products at an African scale and considers each of the major categories of non-wood forest products. For each category it presents a description and management practices used to enhance the production and trade of these products. Chapter 6 focuses on timber and other wood products, while Chapter 7 is solely devoted to issues of woodfuel (firewood and charcoal), a resource of paramount importance to both rural and urban communities in sub-Saharan Africa. Chapter 8 focuses on livestock and wildlife, important products of African woodlands. The chapter presents an analysis of livestock and wildlife as sources of livelihoods and economic development and proposes ways of improving the management of rangelands. Finally Chapter 9 focuses on forest plantations. Natural forests may not provide all the products that people in sub-Saharan Africa need and some forms of forest utilization are likely to be unsustainable. Thus, plantations and woodlots might play a critical role in bridging the gap between demand for forest products and depletion of natural supply sources. The chapter also highlights the high potential of plantations and woodlots to provide products and services in the form of wood, browse, fodder and other products.

Chapter 10 is devoted to environmental and ecosystem services that are the focus of emerging global debates. The chapter describes the value of dry forests and woodlands in carbon sequestration and trade in environmental services and briefly explores the role of forests in soil and water conservation for agriculture and hydropower. In addition, the chapter highlights the value of dry forests as spiritual and cultural assets and proposes ways of enhancing the provision of environmental services and the equitable distribution of benefits realized from managing dry forests for these services. The book presents a

prognostic synthesis of the management of dry forests and woodlands and proposes the way forward in Chapter 11.

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2

Distribution and Characteristics of African Dry Forests and Woodlands

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Introduction

It is important to define and characterize dry forests and woodlands as these forms of vegetation mean different things to different people depending on their discipline and background. This chapter provides the reader with a description of the dry forest and woodland types of sub-Saharan Africa and illustrates some of their basic biological features. Here we define dry forest and woodland as vegetation dominated by woody plants, primarily trees, the canopy of which covers more than 10 per cent of the ground surface, occurring in climates with a dry season of three months or more. Such a broad definition – wider than those used by many authors – incorporates vegetation types commonly termed woodland, shrubland, thicket, savanna and wooded grassland, as well as dry forest in its strict sense. However, it does not include moist evergreen forest (rainforest), grasslands and dwarf shrublands, such as heathlands and fynbos. Where more specific vegetation types are being described, the appropriate term (e.g. dense woodland, wooded grassland) is used.

Forest Structure at Landscape Level

The terminology used in describing African vegetation is often confusing, with many different approaches. In the 1950s, a continent-wide framework was established at a meeting in Yangambi, Belgian Congo (now Democratic Republic of Congo) (CCTA/CSA, 1956), but this was considered by many as too biased towards the moist forest and dense woodland formations of humid western Africa. Workers more concerned with rangeland and land-use planning developed a well-structured system based on percent canopy cover and canopy height (Greenway, 1973; Pratt et al, 1966), while the worldwide UNESCO vegetation mapping legend (UNESCO, 1973) provided a middle ground, but was only really usable at very broad scales. The most recent, and perhaps most thorough overview of African vegetation is that by White (1983), who made a point of avoiding the use of terms such as steppe and savanna owing to difficulties in their definition and usage. White himself, for example, uses the term 'dry forest' very specifically to mean vegetation dominated by a continuous stand of trees over 10m in height which experience a dry season of a few months during which atmospheric humidity is low – a quite restricted vegetation type. In this book we use the term 'dry forest' for the tall closed-canopy seasonal or deciduous forests that separate tropical rainforest from the mesic woodlands to the immediate south and north of the equator. The term woodland is used to include vegetation types ranging from open woodlands and wooded grassland with greater than 10 per cent woody cover, sometimes loosely termed savanna. Also included are shrublands with a canopy at only 2m or so high. Dry forests and woodlands therefore incorporate seven of White's structural vegetation formations including forest, woodland, transition woodland, bushland and thicket (see Box 2.1), scrub woodland, shrubland and wooded grassland.

Box 2.1 Itigi-Sumbu thicket

A thicket is a low forest consisting of a closed stand of bushes and climbers between 3 and 7m tall (White,1983). Itigi-Sumbu thicket is a unique vegetation form surrounded by almost unrelated vegetation types (Almond, 2000). The thicket occurs in Tanzania (central parts of the country) and Zambia (between Lakes Mweru Mweru-Wantipa and Tanganyika (Wild and Fernandes, 1967) and covers a total area of about 7800km^2. Little is known about the ecology of the Itigi-Sumbu thicket but it has a woody flora of about 100 species (Fanshawe, 1971) and characteristic species include *Baphia burttii*, *B. massaiensis*, *Bussea massaiensis*, *Burttia prunoides*, *Combretrum celastroides*, *Grewia burttii*, *Pseudoprosopsis fischeri* and *Tapiphyllum floribunda*. The vegetation type is considered endangered with about 50 per cent of it in Tanzania and as much as 71 per cent in Zambia having been cleared; apparently clearing takes place even in protected areas (Almond, 2000). In Tanzania none of this vegetation is in protected areas. However, protection status does not appear to prevent clearing of Itigi-Sumbu thicket.

Source: Based on World Wide Fund for Nature (2001)

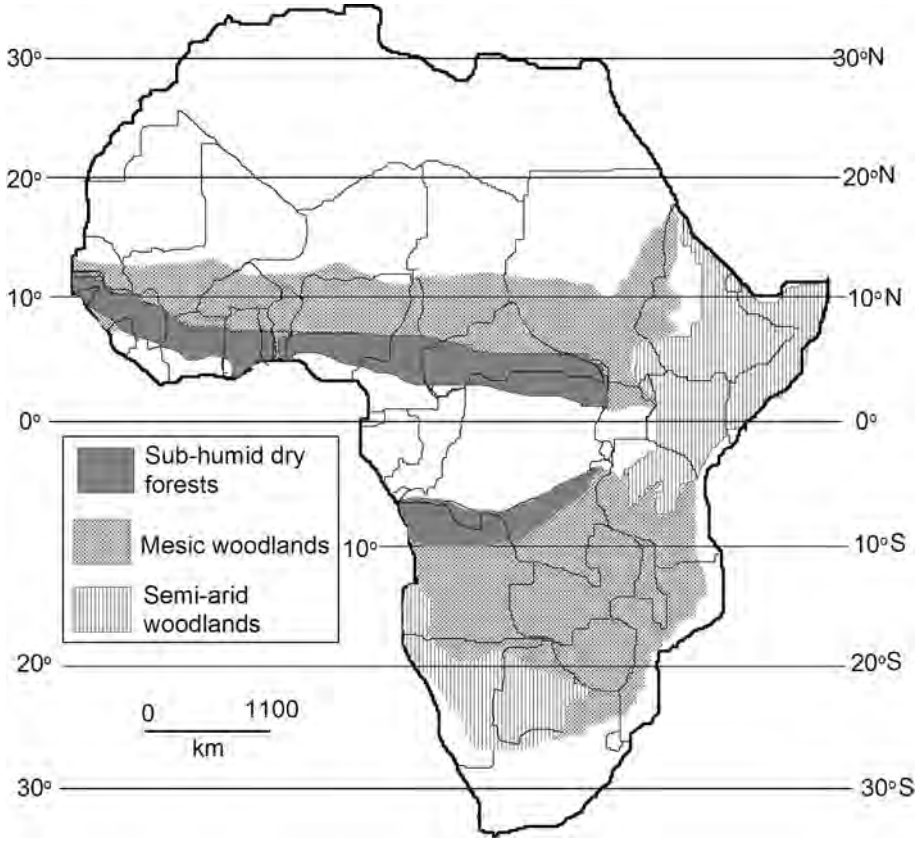

Figure 2.1 *Distribution of dry forest and woodlands across sub-Saharan Africa*

Source: Based on White (1983)

Another important consideration is the difference – in composition, structure and ecological processes – between woodlands dominated by broader-leaved species, such as *Brachystegia*, *Isoberlinia* and *Combretum*, and those dominated by fine-leaved or microphyllous species such as *Acacia* (Frost, 1996). Most of the dry forests and woodlands discussed here are dominated by trees of the legume family (Leguminosae or Fabaceae), but broad-leaved woodlands are mostly composed of species from the Caesalpinoid subfamily of the legumes, while microphyllous savannas are dominated by species from the Mimosoideae subfamily. The difference is not just in species composition, but also in ecology, and hence response to management. Broad-leaved woodlands, such as miombo, teak woodland and *Isoberlinia* woodlands in western Africa, tend to occur on nutrient-poor soils, are slower-growing when regenerating from seedlings and also comprise species that do not fix nitrogen. Whereas microphyllous savannas, such as the Kalahari *Acacia* woodlands of southern Africa,

the eastern African *Acacia–Commiphora* savannas, and those across the Sahel region, often occur on nutrient-richer soils with more nitrogen-fixing species. This is partly a function of climate – soils under higher rainfall conditions are more leached of nutrients than those in much drier areas. These features are of great significance in determining the responses of different dry forest and woodland types to utilization and management interventions.

Physical Environment

Climate

According to the Köppen classification, the climate types associated with dry forests and woodlands in sub-Saharan Africa include 3Af (warm sub-humid), 4Af (warm dry) and 5Af (very dry). These types are tropical with alternating wet and dry seasons in which precipitation is caused by the penetration of the inter-tropical convergence zone during the period of high sun. The period of low sun is characterized by trade winds associated with a distinct dry season. On the basis of these climatic features, we can divide dry forests and woodlands into three main types: warm sub-humid dry forests, warm mesic dry woodlands and warm semi-arid woodlands. The warm sub-humid dry forests occur in two of White's (1983) floristic regions – the Guinea-Congolia/Zambezian regional transition zone and the Guinea-Congolia/Sudanian regional transition zone. Warm mesic dry woodlands occur in the Zambezian and the Sudanian regional centres of endemism, while the semi-arid dry woodlands cover most of the Somali-Masai regional centre of endemism, and the Kalahari-Highveld regional transition zone. These vegetation formations, which occur between 20°N and 30°S, are shown in Figure 2.1.

In western Africa, the sub-humid dry forests and warm mesic dry woodlands correspond to the Guinea savanna and the Sudan savanna of Keay (1959), respectively. In eastern Africa the semi-arid dry woodlands correspond to the *Acacia–Commiphora* region, and in southern Africa the warm mesic dry forests correspond predominantly to the *Brachystegia–Julbernardia* (miombo) woodlands while the semi-arid dry woodlands correspond to *Acacia–Combtretum* formations. Within the miombo woodlands are embedded other vegetation types such as undifferentiated woodlands and mopane woodlands.

The broad climatic features associated with dry forests and woodlands are summarized in Figure 2.2. The sub-humid dry (Guinea) forests of western Africa have a shorter rainy season of about 7 months compared to 8 months in the southern sub-humid dry forests; mean annual rainfall is similar and ranges from 1200 to 2000mm. In contrast, the warm mesic dry (Sudanian) woodlands of western Africa experience a longer wet period of about 4.5 months compared to 4 months in the warm mesic dry (Zambezian) woodlands of southern Africa, but the range in mean annual rainfall of 600 to 1200mm is again similar in the two woodland regions. In the semi-arid dry woodlands the rainy season is shorter (2 months) in eastern Africa and 4.5 months in southern Africa. Another

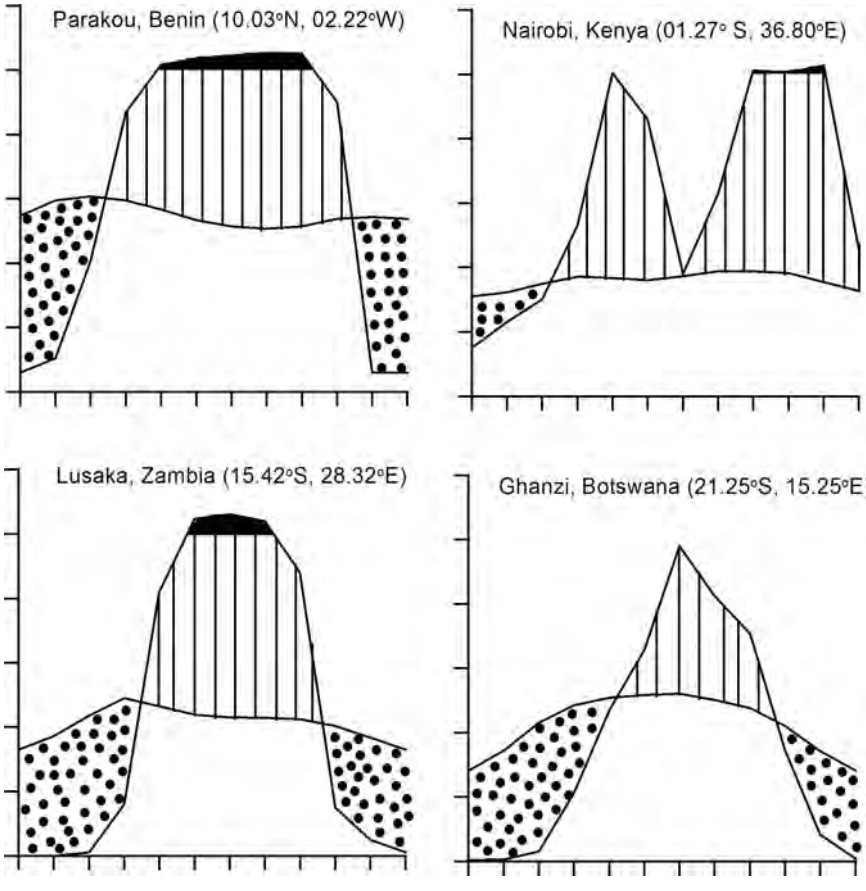

Figure 2.2 *Climate diagrams for stations in the warm dry woodland areas of western Africa (Parouku) and southern Africa (Lusaka), and in semi-arid areas of eastern Africa (Nairobi) and southern Africa (Ghanzi)*

Note: The drought period is shown by dots while the humid period is vertical hatched
Source: Chapter authors

characteristic feature of semi-arid formations of eastern Africa is the bimodal rainfall pattern, which contrasts with other semi-arid formations in which the rainfall pattern is basically unimodal (see Figure 2.2). Annual precipitation is lower (around 250mm) in the semi-arid areas of eastern Africa and higher (around 450mm) in southern Africa.

Soils

Soils in the dry forest and woodland areas are usually shallow (less than 1.5m deep) with a high sand content in the range 30–90 per cent, while the clay content is 5–20 per cent and silt is 5–45 per cent. Texturally they range from silt loam in eastern Africa to sandy loam in western Africa and the Zambezian dry forests and woodlands of southern Africa, and loamy sand in the Kalahari-Highveld area. Total soil nitrogen is very low (0.02–0.10 per cent), as is the organic matter content (1–3 per cent) and available phosphorus (2–30mg kg^{-1}). Soils are generally acid in the Zambezian dry forests, (pH 4–5), intermediate in western Africa and the Kalahari-Highveld semi-arid dry forests (pH 6.0–6.5) and with a tendency towards alkalinity in the eastern African semi-arid dry forests (pH 7–8).

Floristic Composition

Much of what follows under this section is based on White (1983) as we are not aware of more recent work on floristic composition of the vegetation in sub-Saharan Africa.

Western Africa

The dry forests and woodlands of western Africa stretch west–east from the Atlantic coast, across the southern fringes of the Sahara Desert to the Ethiopian Highlands and Red Sea coast. They can be categorized under the three broad climatic zones – sub-humid, warm mesic and warm dry – each forming a relatively narrow band. Much of the area is low (under 750m altitude) and gently undulating, with a few higher areas such as the Jos Plateau in northern Nigeria. It has also been extensively modified by human activities such as cultivation and fire so that the natural vegetation is often not easy to determine – most vegetation now present is secondary wooded grassland and grassland.

The Guinea sub-humid dry forest stretches from the Atlantic coast in Guinea across the middle regions of Ivory Coast, Ghana, Nigeria and Cameroon to the Central African Republic and northern Democratic Republic of Congo (DRC), covering an extent of around 1.4 million km^2. Locally it verges into Guineo-Congolian rainforest in both structure and species composition, while elsewhere, to the north, it can be difficult to separate from the warm mesic dry Isoberlinia woodlands. Rainfall ranges from 1200–1500mm per year in the east to 1500–2000mm per year in the west. A characteristic species is *Parinari excelsa*, sometimes forming a forest 18–20m high, along with *Erythrophleum suaveolens*, *Detarium senegalense*, *Khaya senegalensis* and *Afzelia africana*. At the western extent *Berlinia grandiflora*, *Cynometra vogelii* and others are typical, while in the eastern parts in the Central African Republic *Isoberlinia doka*, *Afzelia africana*, *Anogeissus leiocarpus*, *Burkea africana*, *Borassus*

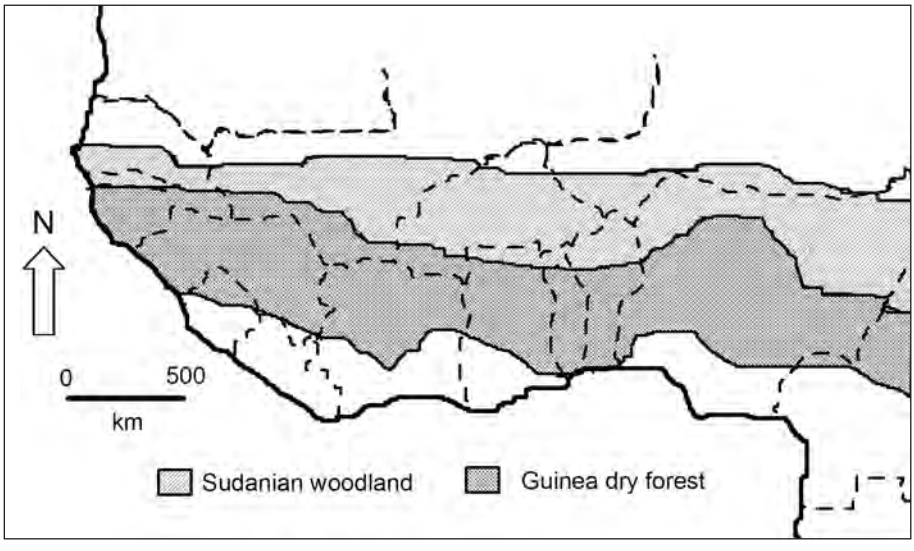

Figure 2.3 *Distribution of dry forest and woodland in western Africa*

Note: Broken lines represent national boundaries.
Source: Based on Keay (1959)

aethiopicum and *Terminalia* species are found. The oil palm *Elaeias* and *Parkia* are commonly found across transformed landscapes.

The Sudanian warm mesic dry woodland lies in a parallel band, perhaps 500–700km wide, to the north of the Guinea dry forest belt, and covers around 2.6 million km^2. Stretching from the Atlantic coast in Senegal, it includes much of Mali, northern Ghana and northern Nigeria, to the southern Sudan and southwest Ethiopia. Soils are predominantly recent and sandy. The major part of the vegetation is disturbed, consisting of open broad-leaved woodland to wooded grassland and bush fallow, often maintained by frequent fire. The moister southern portion, from Guinea to Nigeria, is typified by low woodland, rarely more than 5m high, of *Isoberlinia doka*, *I. angolensis*, *Burkea africana*, *Daniellia diveri* and *Erythrophleum africanum*, with tall *Hyparrhenia* grass. It has been likened to a depauperate miombo woodland, but without the *Brachystegia* and *Julbernardia*.

To the drier north, the environment is marginal for agriculture and the microphyllous vegetation types are naturally more open, characterized by species of *Acacia* (especially *Acacia laeta*, *A. nilotica var. adansonii*, *A. senegal*, *A. seyal*, *A. macrostachya*), *Balanites aegyptiaca*, *Bauhinia rufescens*, *Boscia salicifolia*, *Capparis tomentosa*, *Commiphora africana*, *Dalbergia melanoxylon*, *Grewia flavescens*, *G. vilosa*, *Pterocarpus lucens*, *Saba senegalensis*. The combretaceae family is well represented with *Combretum micranthum*, *C. glutinosum*, *C. nigricans*. Scattered remnant trees, such as baobab (*Adansonia digitata*) and Shea tree (*Vitellaria paradoxa*) are common in the landscape. The most common grass species are *Aristida hordeacea*, *Schoenefeldia gracilis*,