A NATURE CONSERVATION SOURCE-BOOK FOR FORESTRY PROFESSIONALS

Simon Grove

The Republic of Uganda

Commonwealth Secretariat

Cover photographs:

Front cover: Chimpanzees, *Pan troglodytes,* are important seed dispensers in tropical forests and contribute to the regeneration of the forest. *Andrew Plumptre.*

Back cover: Helichrysum dominated high-altitude moorland, Mount Elgon National Park. *Simon Grove.*

A NATURE CONSERVATION SOURCE-BOOK FOR FORESTRY PROFESSIONALS

Simon Grove

Commonwealth Secretariat
Marlborough House, Pall Mall
London SW1Y 5HX

Printed and Published by: Commonwealth Secretariat
Marlborough House
Pall Mall
London SW1Y 5HX

May be purchased from the Commonwealth Secretariat's distributors:
Vale Packaging Ltd
420 Vale Road
Tonbridge
Kent TN9 1TD
Britain

Telephone: +44 (0)1732 359387
Fax: +44 (0)1732 770620

ISBN: 0 85092 561 4

Preface

In 1995 the Food and Agriculture Organization (FAO), of the United Nations estimated that African forests accounted for some 15 percent of the world total and that half of the continent's potential forest cover had been converted to other forms of land use. Over the period 1980 to 1995, Africa experienced a greater percentage of forest loss than any other region in the world, and in the decade from 1980 some 40 million hectares of natural forest were cleared or degraded.

Against this background the protection and conservation of forest land has become a global issue and is beginning to attract the political will at national and international levels necessary to slow and reverse the trend of forest removal. However conservation is both an emotive and complex issue. The former approach of simply locking up vast tracts of land for 'preservation' is no longer an option. Tropical forests have long been a source of livelihood for millions of people and there is no reason why this should not continue. The question then becomes one of making informed decisions on the appropriate balance between utilisation and protection. This is the essence of conservation.

This book aims to bring the ideas and science that underlie nature conservation to the attention of those whose professional remit is to manage tropical forests for a range of users. The book grew from a series of notes prepared for a training course developed for the Forest Department of Uganda in the early 1990s and therefore many of the examples and all the illustrations are from Uganda. Other reports in this series also deal with Uganda including, *The Uganda Timber Users' Handbook. A Guide to Better Timber Use,* by P. W. Kityo and R. A. Plumptre, published in 1997.

It is hoped that this book will be a useful source of information for all those with a concern for the well being of forests and an interest in the African landscape and its wildlife. The intention is not to provide a training manual as such and neither is it envisaged that its use be restricted to Africa or to foresters alone. The chapters follow a natural progression but the structure of the book is such that it is possible for general readers to dip into the text at will. It is also hoped that those engaged in forestry and conservation education will adopt this book as a basis for developing their own courses especially in the training of guides, wardens and rangers to be employed in the growing eco-tourism market, and for those involved in the management of protected areas.

Finally the views contained in this book are the responsibility of the author alone and do not necessarily reflect the opinions or policy of the Commonwealth Secretariat or the Uganda Forest Department. However both the Commonwealth Secretariat and the author would be pleased to receive comments on content and style with a view to producing a second edition.

CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF TEXT BOXES

FOREWORD

BY THE COMMISSIONER FOR FORESTRY
UGANDA FOREST DEPARTMENT

This book originated from the training component of the EC funded Natural Forests Management and Conservation Project, the first phase of which was implemented within the Uganda Forest Department from 1988 to 1995. One of the main tasks undertaken was a series of in-service courses, introducing Forest Officers to nature conservation issues as they relate to forest management. These training courses were co-ordinated by the author of this book and by Mr. Edward Mupada of the Uganda Forest Department and were run by the co-ordinators and staff of Nyabyeya Forestry College. A parallel series of courses for Forest Rangers and Assistant Forest Officers was also run at Nyabyeya.

During this training, it became apparent that one of the key problems faced by professional foresters in Uganda (and probably elsewhere in the tropics), is the lack of accessible information on conservation and particularly how conservation complements other aspects of a forester's work. This book was conceived to fill this gap. It is to be hoped that it will enable professional foresters to gain a greater understanding of conservation issues, which they can then put to good use in their all-important management of the country's forest estate.

E. D. Olet July 1998

DISCLAIMER

Despite wide consultation both within the Uganda Forest Department and outside, there may be instances when opinions expressed in this book do not necessarily accord with those of the Uganda Forest Department or the Ministry of Natural Resources. These remain the sole responsibility of the author.

ACKNOWLEDGEMENTS

The publication of this book would not have been possible without the kind and professional support of many people, both during the two and a half years in which I was in Uganda, and subsequently. Special thanks are extended to the staff of the Uganda Forest Department, particularly those working as trainers or support staff at Nyabyeya Forestry College. Particular thanks to Edward Mupada and Steven Nsita, who oversaw much of the day-to-day organisation of the training courses at Nyabyeya and ensured that they ran smoothly, as well as contributing greatly to the professional training of course participants. Further thanks to the many staff at Forest Department Headquarters in Kampala, especially to the Commissioner for Forestry and to staff working in the Nature Conservation Section, whether they were senior advisers or office support staff. Thanks too to the Uganda-based staff of Voluntary Services Overseas for their continual support, especially in times of need, and to the Commonwealth Secretariat in London for their part in arranging for the book's preliminary publication, albeit rather belatedly. Finally, warm thanks are extended to Mrs. P. Grove for access to her computer for preparation of an earlier draft, and to Christine Herd for cheerfully sharing times, both good and occasionally not so good, during our stay in Uganda.

USING THIS BOOK

This book is divided into sixteen chapters. Ideally, it should be read from beginning to end, since the chapters follow a more or less logical progression. However, it is hoped that there are sufficient cross-references in the text to enable the reader to "dip in" to the book as and where his/her interest lies. The book is thus intended to be a useful work of reference in the event that a reader needs to learn more about any particular subject covered here. Each chapter starts with a outline of what is to follow, so that it should be possible to locate the topic of interest quickly. In addition, each ends with a short summary. The final chapter is a summary of the whole book. A glossary of technical terms is included at the end of the book.

At the end of each chapter, following the summary, is a list of publications that would provide the reader with further information on the subject of the chapter. Since the whole book is basically a summary of other people's work brought together from a wide variety of sources, the reader is encouraged, where possible, to follow up on any subjects covered here by reference to the sources quoted in the text and listed in the reference list at the end of the book. Most of these are available in Uganda, in the libraries at the Forest Department Headquarters, at Nyabyeya Forestry College, at Makerere University Department of Forestry or at Makerere University Institute of Environment and Natural Resources.

Simon Grove
Hampshire, UK
July 1997

COLOUR PHOTOGRAPHY

Simon Grove: back cover; plates 2, 3, 5, 8, 11, 13, 14, 15, 16, 18, 19, 20, 21, 24, 27 and 28.
Andrew Plumptre: front cover; plates 1, 4, 6, 7, 9, 10, 12, 17, 22, 23, 25 and 26.

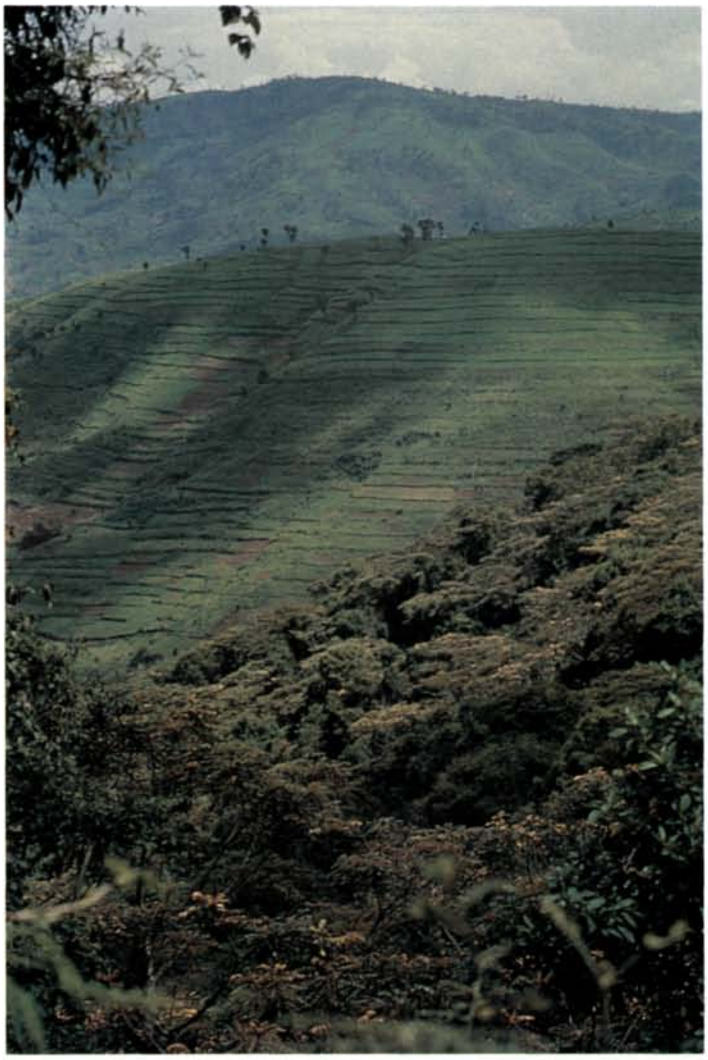
1. Logging track through Budongo Forest.

2. Illegal mahogany-pitsawing site, Kaniyo-Pabidi, Budongo Forest Reserve, Masindi District.

3. Pitsawyer, Budongo.

4. Pit sawing in tropical forest.
Budongo Forest, Uganda.

5. Edge of Bwindi (Imepenetrable) Forest National Park, showing evidence of heavy use by local people for timber and firewood.

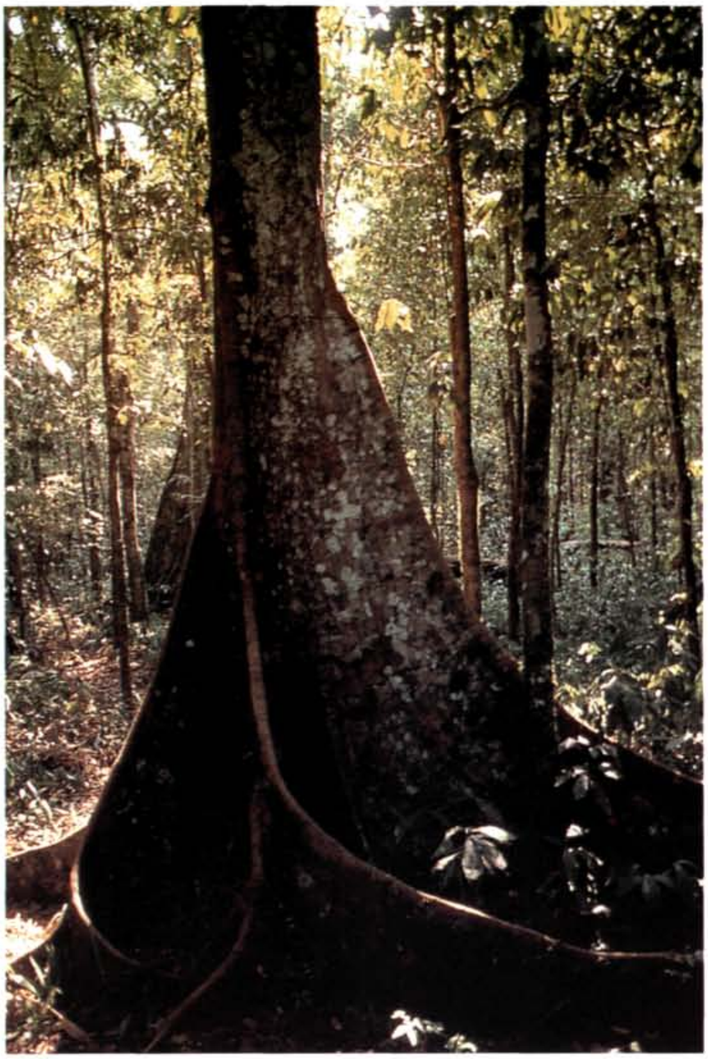


6. Logging site in tropical forest showing skid trail and bulldozer damage in loading areas.

7. Using pyrethrum fogging techniques to study insect diversity in tree canopies.

8. Tropical high forest: Budongo Forest Reserve, Masindi District, from the air.

9. Tree buttress roots that are characteristic of tropical soils where the roots do not go too deep because all the nutrients are at the surface.



10. Much of the biodiversity of forests occur in the canopy.

11. Volcanic crater (caldera), near the summit of Mount Elgon National Park.

12. Giant Lobelias, *Lobelia woolastonii*, in the Ruwenzori Mountains, Uganda. These plants are adapted to living at extremes of temperature which vary from below freezing at night to up to 25-30°C during the day.

13. Intensively farmed and terraced land in the highlands west of Kabale (Kigezi District).

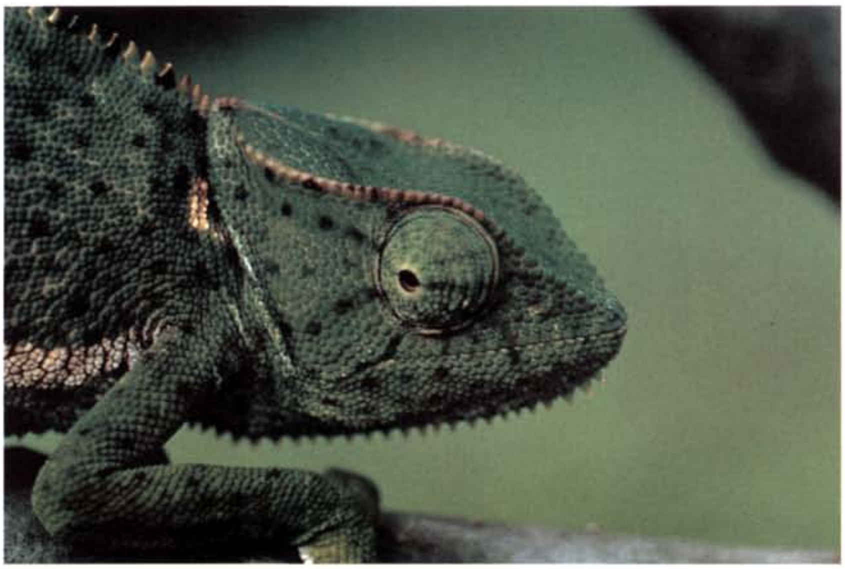
14. Lake Bunyonyi, Kigezi District.

15. View over the plains of southern Karamoja from the western slopes of Mount Elgon National Park.

16. Local fishermen by the crater lake in Maramagambo Forest, Queen Elizabeth National Park.

17. Butterflies often congregate at the edges of streams or puddles where salts from the evaporating water are left.

18. Mantis, Budongo Forest Reserve, Masindi District.

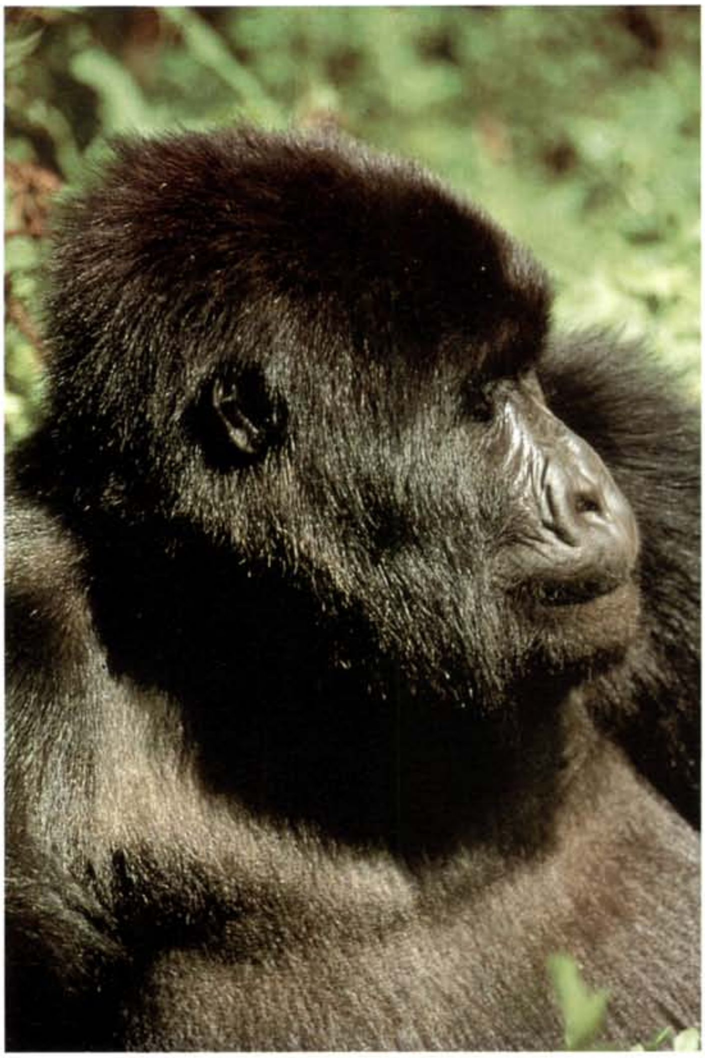


19. Chameleon, Budongo Forest Reserve, Masindi District.

20. Waterbuck in savanna, Kidepo Valley Nationl Park, Karamoja.

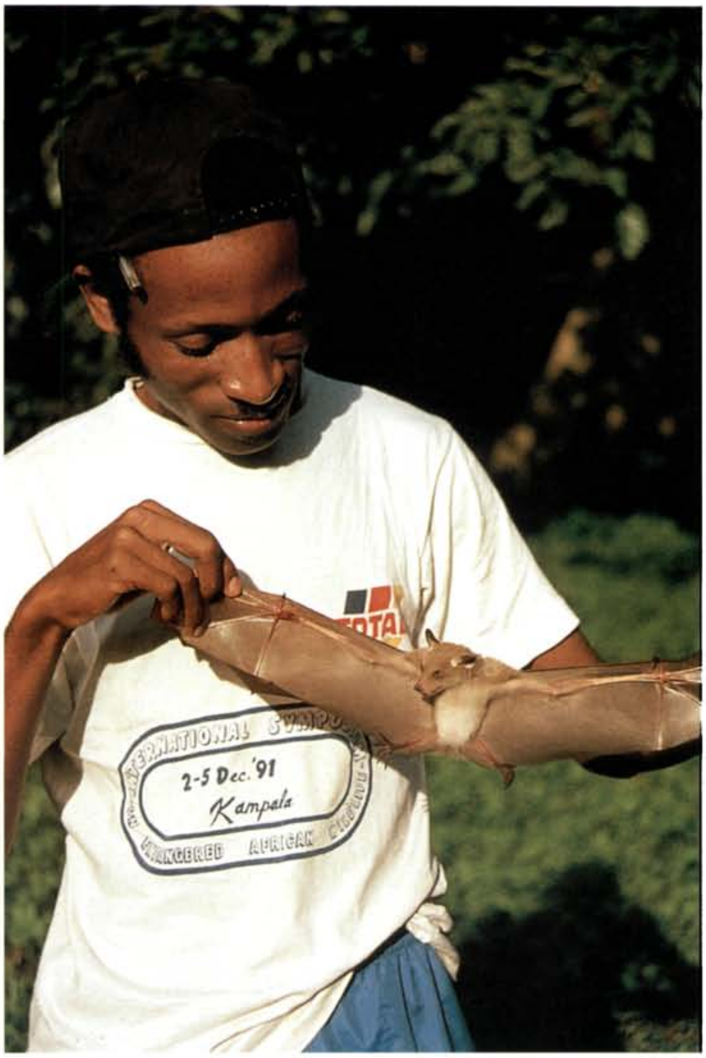
21. Forest tortoise, Busingiro, Budongo Forest Reserve, Masindi District.

22. Chimpanzees, *Pan troglodytes*, are important seed dispersers in tropical forests and contribute to the regeneration of the forest.



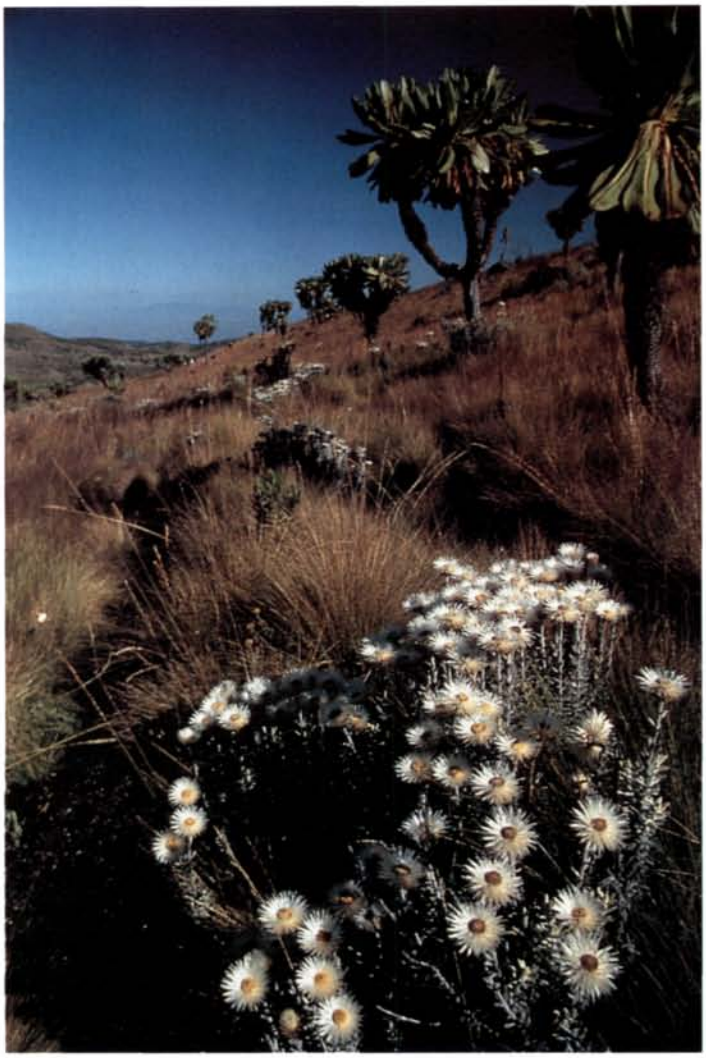
23. Mountain gorillas, *Gorilla gorilla beringei,* are species that attract conservation attention and have been used to generate a lot of money through tourism.

24. Buffalo beside the Kazinga Channel, Queen Elizabeth National Park.



25. Bats such as this epauletted fruit bat are also important for the dispersal of seeds from fruits and can help forests recolonise grasslands because they will leave the forest in search of food.

26. Bird communities in tropical forests are varied and contain many species such as this Chocolate-backed kingfisher.



27. Helichrysum dominated high-altitude moorland, Mount Elgon National Park.

28. Local porters, trekking up Mount Elgon.

CHAPTER 1

AN INTRODUCTION TO NATURE CONSERVATION

CHAPTER OUTLINE

1.1 WHAT IS CONSERVATION?

There are many misconceptions about what conservation is all about, which can all too easily prejudice our views towards it. It is therefore important to note that conservation is now typically defined as ***the management of human use of organisms or ecosystems so that it may yield the greatest sustainable benefit to present generations, while maintaining its potential to meet the needs and aspirations of future generations*** (IUCN/UNEP/WWF, 1991).

Conservation normally involves two main components: **sustainable use** and **preservation**. Sustainable use can be defined as ***using renewable resources at rates within their capacity for renewal***, while preservation can be defined as ***protection of species or natural areas in an undisturbed state, without any human use*** (IUCN/UNEP/WWF, 1991). Neither sustainable use nor preservation alone gives us a good idea of what conservation is about; successful conservation is about balancing these two components in a way which allows optimum human use of natural resources indefinitely without endangering the long-term survival chances of other species with which we share the planet.

A hypothetical relationship between preservation, nature conservation, conservation and sustainable use is illustrated in Figure 1.1.

Putting conservation into practice involves three main activities (Deshmukh, 1986):

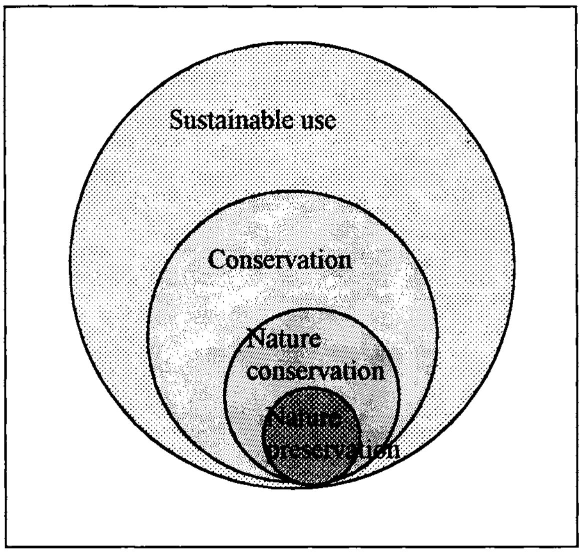


Figure 1.1. A hypothetical relationship between sustainable use, conservation and preservation

- The design and protection of productive and sustainable land-use systems (*environmental conservation*)
- The preservation of species with actual or potential economic benefit to humanity (*nature conservation*)
- Conservation of communities or species for non-economic reasons (*nature conservation*)

So far we have talked about conservation in rather general terms. This book is mostly about something rather more specific, namely **nature conservation**.

In nature conservation, we are particularly concerned about the survival of **wildlife** (for instance plants, animals and the living communities that they form), and so our attention focuses on how we can best manage our use of the land to optimise the chances of long-term survival for as much of nature as possible. In the past, nature conservationists often tended to ignore the human dimension to conservation, resulting in a lot of conflict, but these days, people are becoming more aware of the necessity of taking human needs into account as well. Theoretically, for most wildlife the best form of conservation would be preservation, with no human use, but it is now recognised that this is often not feasible or even desirable, and that some human use is frequently quite acceptable and compatible with nature conservation objectives.

1.2 WHY IS THERE SO MUCH CONCERN ABOUT CONSERVATION?

Many people are now quite used to hearing the words "conservation", "environment" and "biodiversity", words which scarcely anyone would have heard of even a few years ago. Why has there been this explosion of interest in conservation?

1.2.1 Some statistics

The interest stems from a growing realisation that the world today seems to be is in trouble, and that degradation of the environment through human activity is the root cause. The degradation going on around us has caught us unawares, and we are only now beginning to see that unless we change our ways, then the outlook for our descendants, not to mention for all the other species on the planet, is bleak indeed. Conservation, then, is seen as the way out of our problems.

The statistics are not looking very promising at the moment. Here are just a few:

Population

- Humans consume natural resources just like any other organism. The problem is that as human populations grow, so too does human consumption of resources. Today consumption of many natural resources has grown beyond sustainable levels, and the problem is likely to get worse the more humans there are.
- The world's human population is now 5.7 billion, of which 4.4 billion live in developing countries (Harrison, 1994).
- The world's population is growing by three people per second, or 180 people per minute, or 92 million people per year. It took over 1600 years for the total global population in the year AD 1 to double; today it will take just over 60 years. The area of land theoretically needed to support the estimated increase in global populations by the year 2050 is equivalent to 41% of the land area of the African continent (Farrow, 1994).
- Future population growth is inevitable, but the rate of growth may be low, medium or high depending on to what extent people respond to the present rate of growth, and how. The high projection for the year 2050 is 12.5 billion, which is greater than the low projection by the same amount of people as existed in the world in 1984. If the low projection were realised, then this would leave undisturbed at least 4.4 million km^2 of forests, wetlands and mountains that would be needed by people under the medium projection (Harrison, 1994).

Species extinction

- We are rapidly eliminating the wealth of life-forms which have taken four billion years to evolve. We have accelerated the species extinction rate from a natural rate of one species per century, to today's one or more species per day (WWF, 1991a).
- Tropical deforestation may cause the extinction of between 2% and 13% of all life-forms between 1990 and 2015 (Whitmore and Sayer, 1992).

Deforestation and environmental degradation

- Intact tropical forests, home to between 50% and 90% of all species, cover only half the area that they covered fifty years ago, and the rate of loss continues at about the equivalent of six football pitches every minute (WWF, 1991b), or an area of 15.4 million ha (nearly the size of Uganda) every year (FAO, 1993).
- Between 1980 and 2000, 30% of the world's agricultural land is expected to be destroyed or seriously degraded by inappropriate use or overuse (IUCN/UNEP/WWF (1980)).

1.2.2 Deforestation and environmental degradation in Africa

Humans, then, are using more and more of the world's resources, at a faster and faster rate. Some of those resources (such as fossil fuels) are non-renewable; others are potentially renewable but in many cases we are using them at a rate that is exceeding their capacity for renewal. Let us first look at how this is affecting forests, a potentially renewable natural resource.

Figure 1.2 plots the decline of Uganda's tropical moist forests during the course of the twentieth century. Over this period, the proportion of the country covered by closed tropical moist forest has fallen from about 12.5 % to probably less than 2%, this from a probable original forest area of 43%. In other words, about 95% of the forest area has been lost, two-thirds of it this century. By the end of the century, there may be only 4,000 km^2 remaining, out of the original 100,000,000 km^2 or so. Figure 1.3 shows the approximate past and present extent of tropical moist forest in Uganda.

This level of deforestation is by no means unusual in Africa, as Figure 1.4 illustrates for Uganda and neighbouring countries, although Abe and Pomeroy (1988) suggest that Uganda has probably lost a higher proportion of its natural forest than any of its neighbours.

In each country, the present extent of tropical moist forest is a tiny fraction of the probable original area, and the same is probably true of other forest types. According to FAO (1994), nearly half the deforestation in Africa has occurred since the 1940s, and is currently averaging 0.7% per year; if the rate of deforestation does not slow down (and it shows no signs of doing so), most of tropical Africa will be deforested within a few decades.

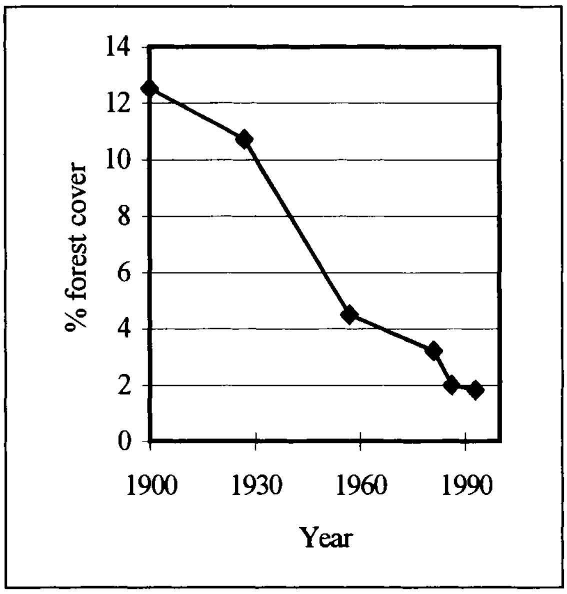


Figure 1.2. Change in the proportion of Uganda covered by tropical moist forest since 1900 (note that about 43% of the country was probably originally forested). From various sources, especially Hamilton (1994).

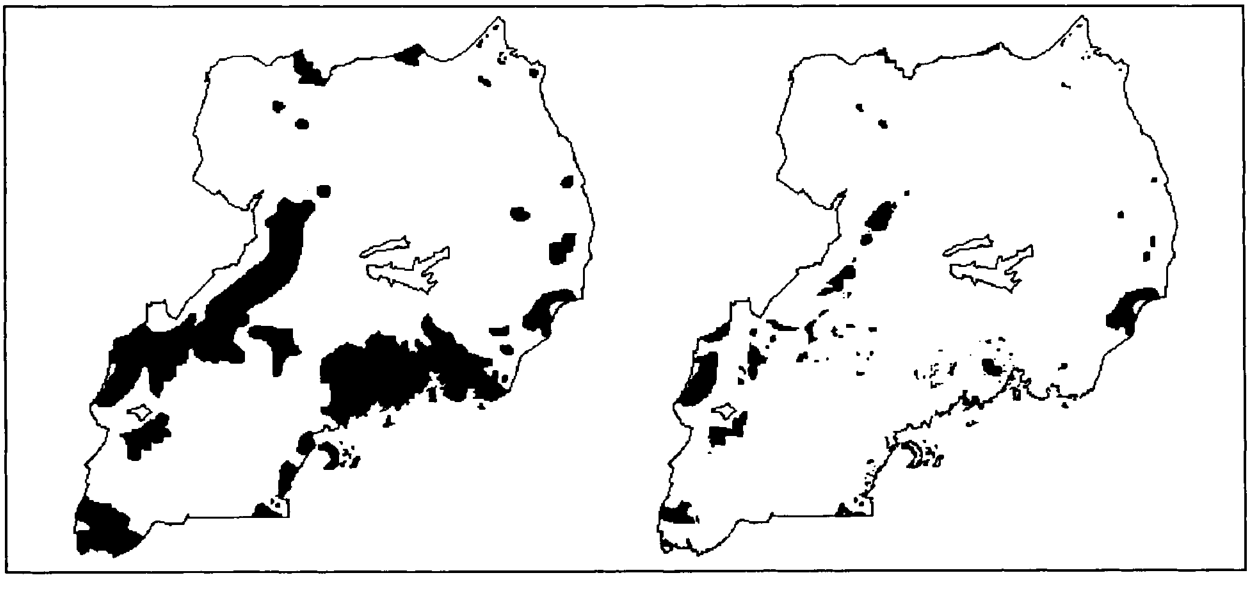


Figure 1.3. The approximate original (left) and present (right) extent of tropical moist forest in Uganda. From various sources, especially Hamilton (1984) and Howard (1991).

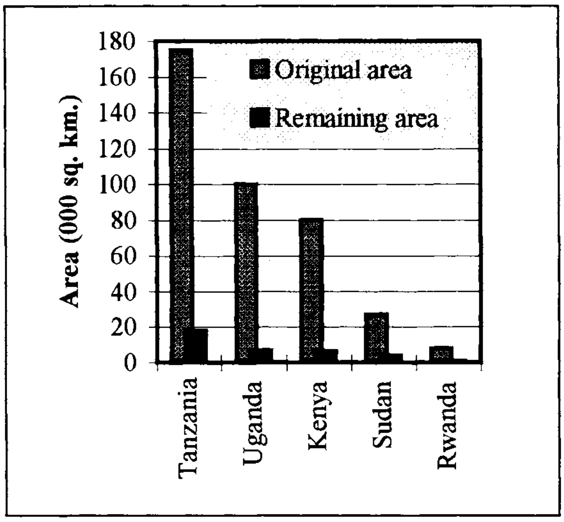


Figure 1.4. Original versus remaining extent (in 1980) of tropical moist forest in some East African countries (FAO 1980 data from WCMC (1992) and McNeely et al.. (1990)).

We should remember, too, that these statistics refer to forest loss (i.e. **deforestation**); they do not include forest **degradation**, which, in Uganda at least, affects large areas of forest. For instance, a recent survey of the twelve principal tropical *moist forest* reserves (Howard, 1991), found that little over half the forest area remained essentially undisturbed (Figure 1.6); the proportion of undisturbed forest in the remaining, smaller reserves is likely to be even lower. Although most of the encroached areas have since been reclaimed, they will take many decades or even centuries to recover to an "essentially undisturbed" condition.

1.2.3 Some causes of deforestation and environmental degradation

Everyone has their own ideas about the causes of deforestation and the associated environmental degradation. Box 1.1 lists some suggestions, divided into direct causes and underlying causes. This book is not the place to discuss them in detail: see the Further Reading section at the end of the chapter, or the Reference List at the back of the book for more information.

Although it is clear that there is no one cause, increasing human populations are probably the direct cause of much of the environmental degradation, primarily through increased consumption levels: more people take up more land and consume more resources. There is a negative correlation between human population and natural forest cover, as shown by Figure 1.7, although a cause-effect relationship is a bit more contentious. Furthermore, the issue is not as simple as this, because there are gross discrepancies in peoples' standards of living, but these discrepancies only make an existing problem worse, because as standards of living improve, consumption of resources tends to rise.

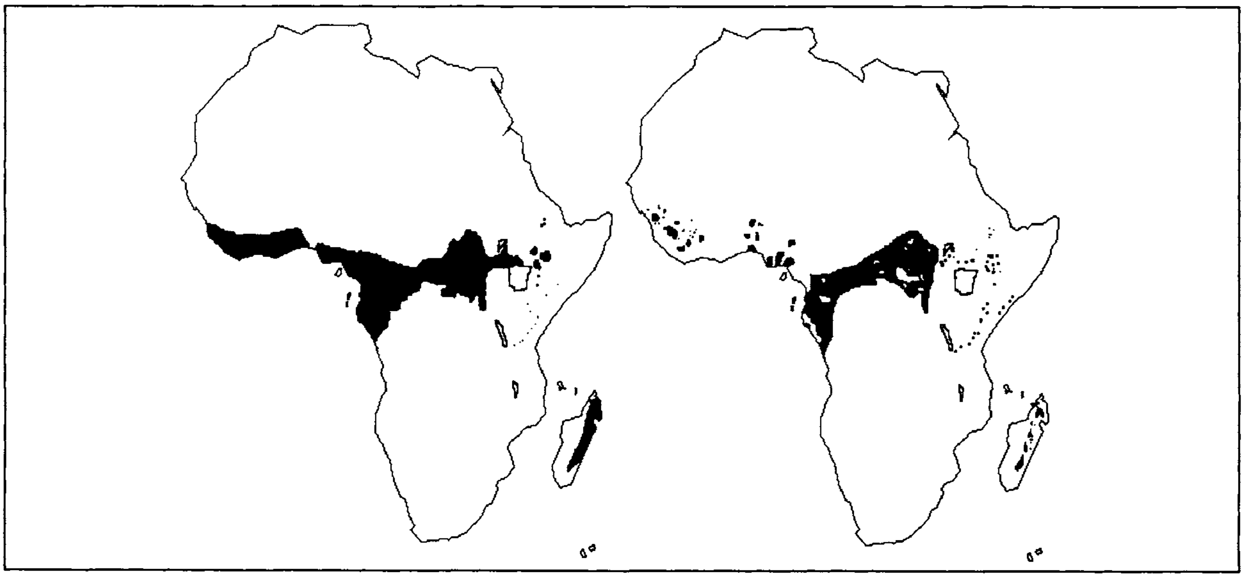


Figure 1.5. The approximate original (left) and present (right) extent of tropical moist forest in Africa. After Sayer, Harcourt and Collins (1992).

Box 1.1
Some of the causes of deforestation and associated environmental degradation

Direct causes	Underlying causes
• Subsidies, tax breaks, fiscal policies and legislation which promote deforestation • Destructive commercial logging • Over-grazing and repeated burning • Lack of, or poor, forest management, resulting in poor regeneration and low rates of reforestation • Over-exploitation of forests, woodlands, and farm trees for fuelwood, poles and other forest products • Neglect of traditional biomass fuels in energy sector assistance • Few incentives and weak extension for private tree-planting • Failure to sustain/encourage trees in farming systems • Degradation of currently cropped land • Shortened fallows and increased consumption of forest land by shifting cultivators • Encroachment by landless farmers • Lack of community participation in development planning and project design • Erosion of traditional community controls over land use and communal resource management strategies • Displacement and disruption of indigenous forest dwellers • Ineffective protection and management of national parks, forest reserves and public forest lands • Low valuation of biological diversity • Faulty analysis of full costs and benefits of land conversion • Inattention to sustainability issues in economic development and natural resource use • Inadequate information base and monitoring of forest land use and forest resources • Inattention to forestry institutions • Low priority to forestry in development plans • Lack of suitable investment in forestry	• Poor policies and incentives • Consumer demand in developed countries • Debt burden; macroeconomic and trade inequities • Need for foreign exchange • Climate change and drought • Shortages and inefficient use of fuelwood • Shortages and lack of alternative sources of fodder • Lack of alternatives to fuelwood • Rapid population growth • Increased demand for cropland • Inequitable land ownership patterns • Failure of agrarian reform • Insecure land tenure • Lack of support for sustainable agriculture • Export commodity/production focus of development projects • Poorly planned agricultural resettlement • Increased access along logging roads • Land use conflicts • Poorly planned, large-scale development projects (e.g. transport infrastructure, energy, commercial agriculture etc.) • Low level of development assistance in forestry, especially for forest protection • Short-term profit-taking, corruption • Lack of awareness of economic and environmental costs of deforestation • Weak institutional capacity • Misuse of forest lands among political decision-makers • Poor inter-sectoral co-ordination

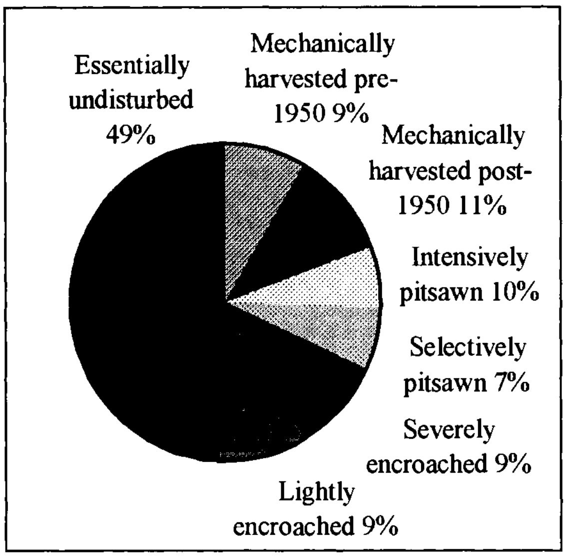


Figure 1.6. The extent of disturbance in Uganda's twelve principal Forest Reserves. After Howard (1991). (Note that some of the areas considered are now National Parks).

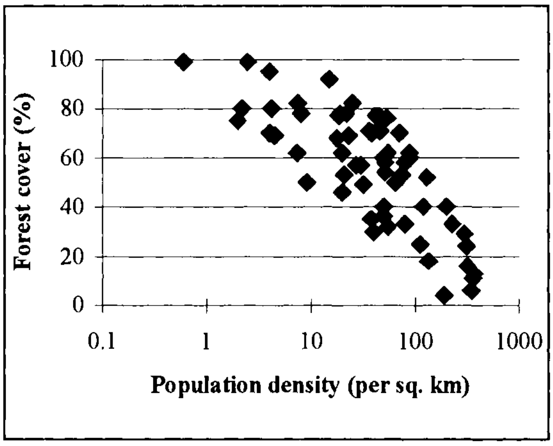


Figure 1.7. The relationship between human population density and forest cover, based on 1980 data for 60 tropical countries. Redrawn from Palo and Salmi (1987).

Figure 1.8 shows population growth in Uganda since the first census of 1921. The shape of the graph indicates a classic case of exponential population increase, such that the current rate of increase is between 2.5% and 3% per year. This corresponds to a population doubling time of just 25 years or less, meaning that over the next century the population could theoretically increase at least eight-fold (HBEW, 1994). As Figure 1.9 shows, Uganda's situation is typical of most developing countries; indeed, Africa's human population has doubled in 23 years (Mabberley, 1992); by contrast, most developed countries show much slower population growth, and some even show a decline. Between 1950 and 1990, the population of developing countries increased by 140%, and is expected to increase by a further 112% over the next century, whereas for developed countries the corresponding figures are 50% and 15%. Overall, global population is doubling every 37 years (UNESCO, 1993).

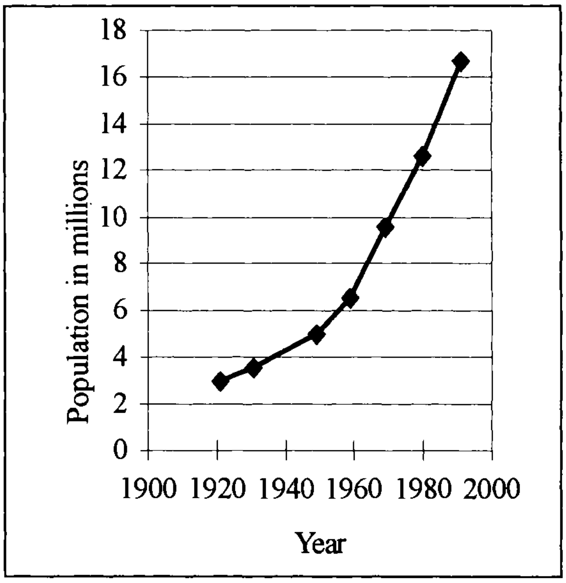


Figure 1.8. Population growth in Uganda since the first census of 1921. From various sources.

Most Ugandan families have no option but to try and scrape a living off smaller and smaller parcels of land which is of lower and lower quality. Woodlands, swamps and forests have progressively been cleared to accommodate more and more people or to provide fuelwood. In Uganda, most major towns now have to bring in fuelwood from outside their districts because of local over-collection (HBEW, 1994).

Most people in Uganda depend directly on the land for their sustenance; indeed 93% of Uganda's population is rural, and many people are subsistence farmers, such that up to 57% of agricultural gross domestic production does not even enter the monetary economy (FAO, 1992). This dependence on the land is both a strength and a weakness. As long as there is sufficient good quality farmland, it is a strength. But between 1975 and 1990, although the area of land under cultivation in Uganda increased by 9% (NEAP, 1992), the human population increased by something approaching 50%. As a result, the amount of arable land per person in Uganda has continued to shrink, from 3.6 ha in 1948 to 1.4 ha in 1984; by 2000 it is set to reduce further to less than 0.6 ha (FAO, 1992). The consequences of this are revealed in recent statistics that record that 20% of Ugandan children are malnourished.

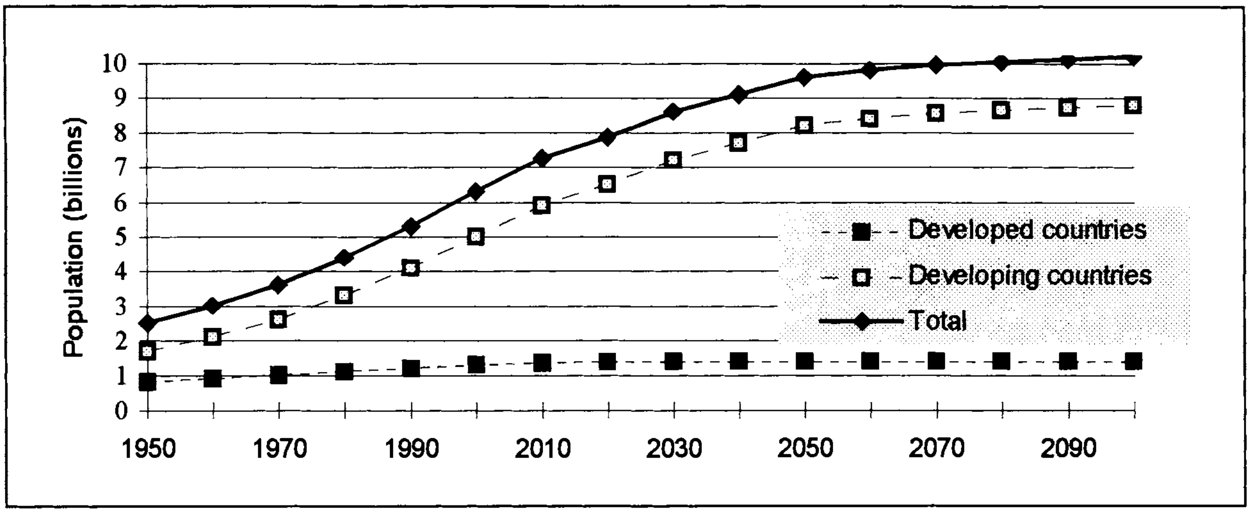


Figure 1.9 Global population increase since 1950, actual and predicted. From various sources.

Meanwhile, land that cannot be cultivated is usually grazed, and sometimes overgrazed, resulting in further degradation. Between 1966 and 1986, the recorded number of cattle in Uganda increased by 44%, goats by 74% and sheep by 117% (Ministry of Energy, Minerals and Environment Protection, 1991), yet the area of grazing land probably remained the same or even declined. Overall in Uganda, the degree of medium to severe land degradation is said to be high (ODA, 1992a). So in Uganda's situation, environmental degradation is continuing as population increases, even though material standards of living remain very low for most people. A similar situation exists in much of Africa: 70% of all Africans are subsistence farmers, and expansion of small-scale agriculture is thought to account for about 70% of the deforestation in Africa, compared with 50% in Asia and 35% in the Americas (WCMC, 1992). The conclusions of a report by UNEP (in Struhsaker, 1988) are worth quoting: "*the impacts of an increasing population on any developing country, and especially on Uganda, are enormous. Continued high rates of populations growth will systematically undermine all programmes aimed at restoring and improving economic development, and will continue to deplete the basic resource base of the country in environmentally unsound ways... there is patently a need for population policies that match Uganda's growth with available resources*".

In developed countries, the issue is more of consumption levels rather than population growth, since population growth is generally much slower. Nevertheless, every birth in the developed countries puts as much extra pressure on natural resources as tens of births in the developing countries (UNESCO, 1993). Overall, 20% of the world's population consume 80% of its natural resources, and it is said that each American child born today will use as much energy in its life as about 500 people born in central Africa (Farrow, 1994) , while the average American family's level of consumption has 100 times the global environmental impact of the average Kenyan family (Ehrlich and Ehrlich, 1990). In the four decades to 1990, global consumption exceeded the level reached by all past generations since humans first appeared (Hurtado, 1994).

1.3 WHY CONSERVE TROPICAL FORESTS?

Although the focus of this book is on nature conservation, we should remember that forests are also important for numerous other reasons. Conserving the forests can not only benefit nature, but can also provide for a whole range of human needs. Box 1.2 lists some of the "goods and services" provided by tropical forests, divided into the five so-called "domains of human welfare".

Box 1.2
Some of the goods and services provided by tropical forests, divided into the five domains of human welfare. After Laarman and Sedjo (1992)

1. Protective services and influences

- Climate regulation
- Regulation of atmospheric composition
- Stabilisation of slopes, stream banks, water catchments and sand dunes
- Shelter belts, soil moisture retention
- Stream flow regulation, flood reduction
- Land reclamation
- Buffers against the spread of pests and diseases
- Nutrient storage, distribution and cycling
- Wildlife habitat
- Conservation of biodiversity

2. Consumption of plants, animals and derivatives

- Timber: logs, pulpwood, posts, poles
- Fuelwood: firewood and charcoal
- Food products: fish, game, fruit, nuts, berries, seeds, mushrooms, spices, eggs, larvae, honey, syrups, teas, other beverages
- Herbs, flowers, medicinal plants
- Gums, resins, lacs, oils, tannin, waxes, distillates
- Livestock fodder (grass, leaves)
- Thatch, ropes and string, weaving materials, silk
- Non-wood structural materials (e.g. bamboo, rattan)
- Skin, feathers, teeth, bones, horns
- Game meat
- House plants and pets

3. Psychophysiological influences

- Recreation, tourism, sports
- Sense of stewardship, peace, harmony with nature
- Inspiration for art, literature, music, myths, religion and philosophy
- Historic sites and values

4. Source of land and living space

- New lands for cropping and grazing
- Habitat of indigenous people

5. Education and scientific services

- Research on ecosystems and organisms
- Zones for monitoring ecological changes
- Specimens for museums, zoos, botanical gardens
- Wild stocks of foods, chemicals, biological control agents
- Environmental education

1.4 CONSERVATION WAYS AND MEANS

1.4.1 Environmental conservation

It should be clear now that conservation is not a simple issue. How are we going to put the world back on a sustainable footing? Again, everyone probably has their own ideas about what needs to be done. Box 1.3 lists just a few suggestions, particularly as they relate to forests and forestry, from the perspective of developing and developed countries. Many of them came out of discussions held during the conservation training courses held at Nyabyeya Forestry College.

1.4.2 Nature conservation

The goal of nature conservation can probably only succeed in the long-term within the overall framework of environmental conservation. Having said that, there are several specific approaches which, when taken together, provide an effective mechanism for meeting nature conservation objectives. Some of these approaches are, individually, more effective than others. In general, approaches that seek to conserve nature in its natural environment (***in situ conservation***) are more effective than those that rely on conserving nature outside the natural environment (***ex situ conservation***). *In situ* conservation will therefore form the main focus of the rest of this book.

Box 1.3
Conservation ways and means: some suggestions

Developing countries

- Development of networks of protected areas with buffer zones
- Policy and institutional reform
- Elimination of inefficient and destructive subsidies, tax breaks, etc.
- Incentives and support for improved forest management and improved forest utilisation
- Strengthen relevant institutions
- Increase capacity for research, training and extension
- Better data and monitoring of forest resources
- Improve land use planning and inter-sectoral co-ordination
- Increase awareness among decision-makers
- Improve political commitment to conservation
- Agrarian reform and more secure land tenure
- Redirect agricultural settlement to already degraded/deforested areas
- More investment in sustainable agriculture, especially in areas adjacent to natural forests
- Family planning and increasing the status of women in society
- Recognition of the rights of indigenous peoples
- More community participation
- Incorporate development concerns into conservation programs (e.g. buffer zones)
- Increase the area of woodlots and agroforestry, through incentives if necessary
- Promotion of multi-purpose trees
- Fuelwood conservation and increased access to fuelwood substitutes
- Development of markets for alternative forest products
- Afforestation of degraded land with multi-purpose and/or high yield tree species

Developed countries

- Debt rescheduling and cancellation
- Lobbying for reform of the international policies of governments, international agencies and multinational companies
- Joining environmental pressure groups
- Boycotting banks, timber and oil companies that support activities leading to deforestation
- Paying more realistic prices for tropical forest products
- Developing markets for alternative forest products
- Education and extension
- Pressing for democratic reform of international agencies
- Long-term change in lifestyle from one valuing consumption to one valuing quality of life

1.4.21 In situ conservation

The most effective form of *in situ* conservation, and the most effective form of conservation all round, is the establishment and maintenance of **protected areas** of natural or semi-natural ecosystems. Natural Forest Reserves are a good example of this; others include National Parks and Game Reserves. Carrying out conservation in protected areas is the most effective way of protecting all the species of a given ecosystem. All other approaches, such as those that follow, can be useful in certain situations.

For example, if a particular species needs special protection, such as from hunting or trade, then specific **species protection** measures can be taken, such as passing new laws, but it would be impossible to have a law for every species and every situation, and anyway wildlife laws are notoriously difficult to implement. Alternatively, **controls on resource use** can be introduced, such as closed seasons for hunters, size limits for cutting trees, or restrictions on public access at certain times of the year. These can be useful adjuncts to protected area establishment, but are seldom a good substitute. Once again, such controls are often difficult to implement in practice.

Sometimes, it is desirable to **reintroduce** species to areas where they have become extinct, and sometimes some form of **habitat manipulation** is necessary for conservation, for instance, removing an invasive exotic species that is threatening to take over a protected area, or culling herbivores such as duikers in the absence of their natural predators. Occasionally, it is even worth the effort of **providing a critical resource** needed by a certain species, for instance, making sure that fig trees are left in logged forest to provide food for monkeys and fruit-eating birds.

1.4.22 *Ex situ* conservation

Ex situ approaches to conservation are usually only useful when *in situ* approaches cannot be used. The biggest limitation of *ex situ* approaches is that they cannot cater for every single species that lives in a natural ecosystem: there are simply too many species and we do not know enough about them to even identify them all, let alone manage them outside their natural areas. Nevertheless, for some species, **botanical gardens** and **zoos** can be very important; indeed, some species which are extinct in the wild now only survive in such places. They are particularly useful if the species kept there can later be used to reintroduce the species to the wild once the problems that lead to its extinction in the wild have been sorted out.

Finally, because botanical gardens and zoos take up so much space and resources, people are increasingly setting up **seed banks** and **sperm/egg banks**, where the viable genetic material of many more species can be safely stored. Again, such banks work well for plants and some larger animals, but are next to useless for the majority of species.

1.4.3 The cost of conservation

We have been emphasising the costs of deforestation and environmental degradation, and the benefits of conservation. But we should not imagine that conservation comes free: it too has a cost, whether social, political or financial. They can be grouped into **direct costs**, and indirect or **opportunity costs**:

Direct costs

- The costs of managing protected areas
- The institutional costs of management
- The costs of *ex situ* conservation
- The costs of damage to crops by wildlife

Opportunity costs

- The monetary value of resources left unexploited
- The potential value of land if it were put to other productive uses

Unless we intervene, some of these costs end up being borne by those least able to afford them, while the benefits are often to society at large. For instance, it is normally local people who bear the cost of crop damage by monkeys or bush-pigs. Similarly, it may often be the national authority (such as the Forest Department) that has to meet the cost of managing a protected area, even though it may have been the international community who pushed for its protection in the first place. In each of these cases, there may be a need to (1) redistribute the costs, so that they fall more fairly on those who can afford to pay and on those who want to push conservation (especially the international community), and (2) ensure that those paying the costs are fully aware of the benefits they receive in return.

1.5 SUMMARY

- As human population and consumption levels increase, we are using more and more of the earth's renewable resources unsustainably.
- This unsustainable use creates many problems, both for humans and for the rest of nature.
- One visible symptom of our consumption is deforestation and its associated environmental degradation, which has never been going on at higher levels than it is today.
- Deforestation leads to further consequences, such as species extinction and the loss of many benefits to humans.
- Conservation seeks to put the world back on a sustainable footing.
- There is something that everyone can do, and conservation will not succeed without the support of all sectors of society.
- The forestry sector has a particularly important role to play, because of the high value of tropical forests for nature and for humans.
- Conservation costs money, and requires expertise.

1.6 FURTHER READING

Hamilton, C.A. 1984. *Deforestation in Uganda.* Oxford University Press, Nairobi.

Howard, P.C. 1991. *Nature conservation in Uganda's tropical forest reserves* . IUCN, Gland.

IUCN/UNEP/WWF. 1991. *Caring for the earth: a strategy for sustainable living.* IUCN, Gland.

CHAPTER 2

BIODIVERSITY AND NATURE CONSERVATION

CHAPTER OUTLINE

2.1 WHAT IS BIODIVERSITY?

Biodiversity is a contraction of the term *biological diversity*, and refers to the **variety of life in all its forms, levels and combinations** (IUCN / UNEP / WWF, 1991) or to the **total variety of life on earth**. Although the word is quite new, the idea is not: to many people, there is little difference between biodiversity and wildlife. However, biodiversity refers to more than simply the total number of species of plants and animals, although this is how it is often used. Strictly speaking, biodiversity can be considered at three levels (figure 2.1).

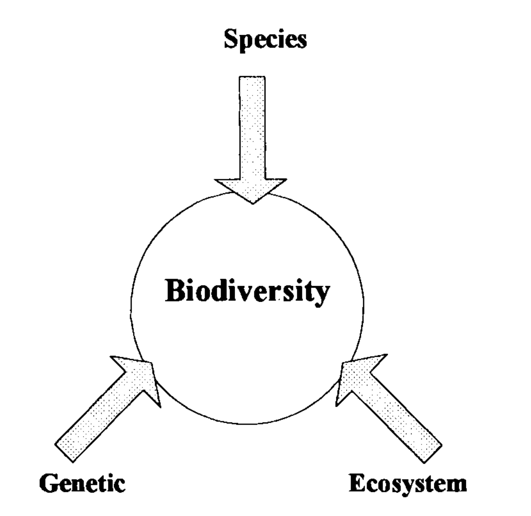


Figure 2.1. The three main levels or components of biodiversity.

Genetic diversity is a concept of the variability within a species, as measured by the variation in genes within a particular species, variety, subspecies or breed (McNeely, 1988). Each species of organism on the planet has, for instance, from 1000 to 400,000 or more genes, composed of deoxyribonucleic acid (DNA) and arranged in chromosomes in every single cell in the body of that organism. Genetic diversity is so great that no two individual organisms (apart from clones) have identical DNA, even if they are closely related. The DNA of distant relatives belonging to the same species is less similar than that of closer relatives of the same species, while different species have even less similar DNA. Some populations of a particular species have relatively uniform DNA, while others are more variable.

Species diversity is what most people think of when they think of biodiversity, and is the easiest level at which to appreciate the concept: the more species an area has, the higher its overall biodiversity (including genetic diversity) is likely to be. Strictly speaking, species diversity should not just measure species richness (i.e. how many species are present), but also evenness (i.e. how many of species X there are compared with species Y and Z). Conservationists seldom worry about evenness, and rely on species richness as one of the fundamental measures of how important an area is.

Ecosystem diversity relates to the diversity of the ecological complexes within which species occur. An area with several ecosystems is likely to be more species-diverse than an area with only one ecosystem.

2.2 GLOBAL SPECIES DIVERSITY

Since taxonomists first started describing and naming organisms scientifically about two hundred years ago, we have managed to name about 1.5 million species. Of these, about 250,000 are flowering plants, 750 are gymnosperms, 43,000 are vertebrates (mammals, birds, reptiles, amphibians and fish), 47,000 are fungi, 5,000 are bacteria, 27,000 are algae, 17,000 are bryophytes and the rest are invertebrates (WCMC, 1992).

This figure may sound impressive, but it probably only represents a very small proportion of the species that actually exist. Recent estimates (such as Erwin, 1982) suggest that there may be anything from 10 million to 100 million species, which means that we have only catalogued between 2% and 7% of all the world's species. Figure 2.2 gives a breakdown of the likely distribution of all these species amongst the major groups of plants and animals (WCMC, 1992). It helps explain why we have made such little progress in cataloguing species, because it reveals that most species are small and apparently insignificant. For example, the insects alone are thought to account for about two-thirds of all species (with one in every four species of organism being a beetle), whereas higher plants (including flowering plants and gymnosperms) account for only 2.4%, and all the vertebrates together only 0.4%.

Most species, therefore, hardly even enter our consciousness when we think of the plants and animals around us: even scientists and conservationists have tended to focus on higher plants and vertebrates and neglect the rest, if only because it has proved difficult to get funding for studies of less "glamorous" groups.

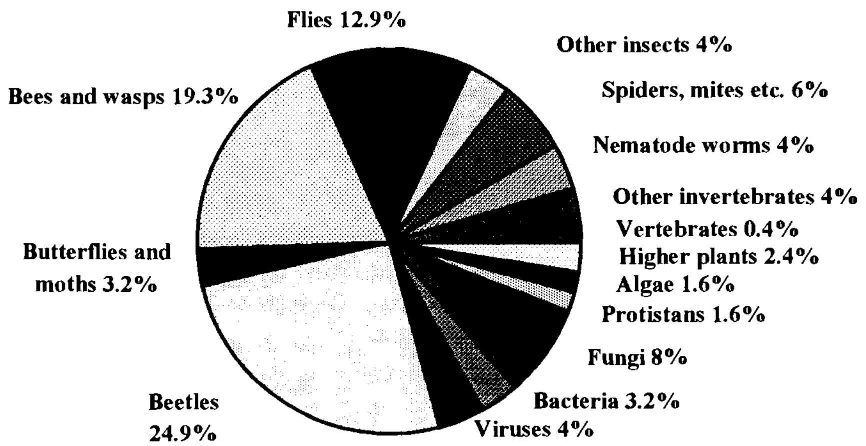


Figure 2.2. Global species diversity: probable breakdown by major groups. After WCMC (1992).

2.3 WHICH AREAS ARE MOST IMPORTANT FOR BIODIVERSITY CONSERVATION?

Species richness is not uniform across the planet: some areas are richer than others. Because conservationists are interested in conserving as many species as possible, some areas will be more important for conservation than others. Three main gradients of species richness exist (figure 2.3). Areas that, because of their location, are rich in species, are likely to be more important for conservation than areas that are poorer in species, although we should remember that even species-poor areas can support rare or unusual species.

2.3.1 Latitude

There is a very strong and clear gradient in species richness with latitude, which means that areas of the planet nearest to the equator are generally much more species-rich than areas towards the poles. This applies to nearly all groups of plants and animals, and is true of aquatic as well as terrestrial environments. The gradient is probably due to differences in the amount of the sun's energy reaching the earth's surface at different latitudes: fewer species can tolerate the increasingly cold or fluctuating climatic conditions that are found as one moves away from the equator. Figures 2.4 and 2.5 illustrate this gradient for swallowtail butterflies and termites. Some further comparisons follow:

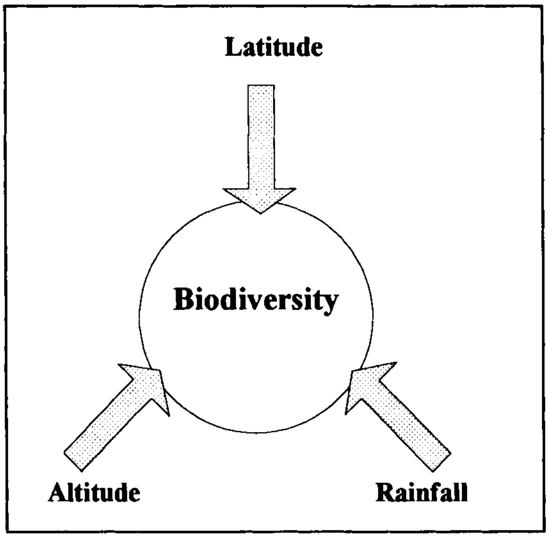


Figure 2.3. The three main factors contributing to geographical variation in the diversity of life.

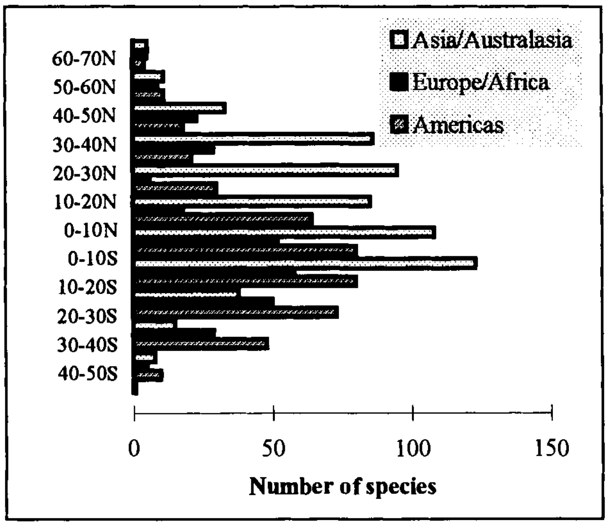


Figure 2.4. Variation in number of species of swallowtail butterflies with latitude. After Collins and Morris (1985).

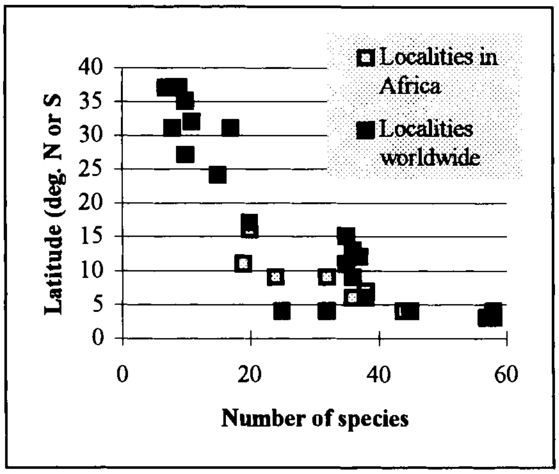


Figure 2.5. Variation in number of species of termites with latitude, from selected localities. After Lepage (1983) and Collins (1983).

- There can be as many or more tree species in a single hectare of tropical moist forest in Uganda (11 to 70 according to Howard, 1991) as there are in the whole of Britain.
- Budongo Forest alone supports about half as many plant species (866 according to Synnott, 1985) as the whole of Britain.
- Uganda has at least ten times as many butterfly species as the whole of Britain.
- Over 1000 bird species have been recorded from Uganda, almost twice as many as have been recorded from Britain, and nearly three times as many as have been recorded from Sweden.
- Lake Victoria contains almost as many species of fish (at least 177) as all the freshwater systems of Europe (192) (WCMC, 1992).

2.3.2 Altitude

Within any one region, there tend to be more species at low altitudes than at higher ones. This is probably a reflection of increasing cold or climatic extremes with altitude, to which relatively few species have managed to adapt. Figures 2.6 to 2.8 illustrate this relationship with data for trees and birds. Figure 2.7 is especially revealing in the context of Uganda, since it shows that, whereas over 70% of Uganda's trees can be found in forests at about 1000 m altitude, only about 10% of them can be found in forests at 3000 m altitude, and even fewer above this.

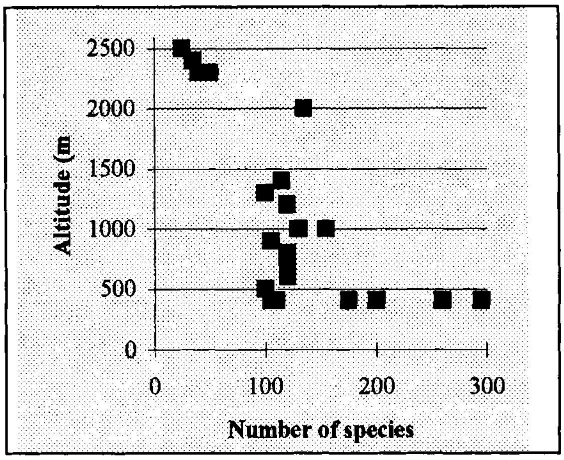


Figure 2.6. Variation in tree species richness with altitude from forest plots in central Africa, based on trees >20 cm dbh. After Pierlot (1966).

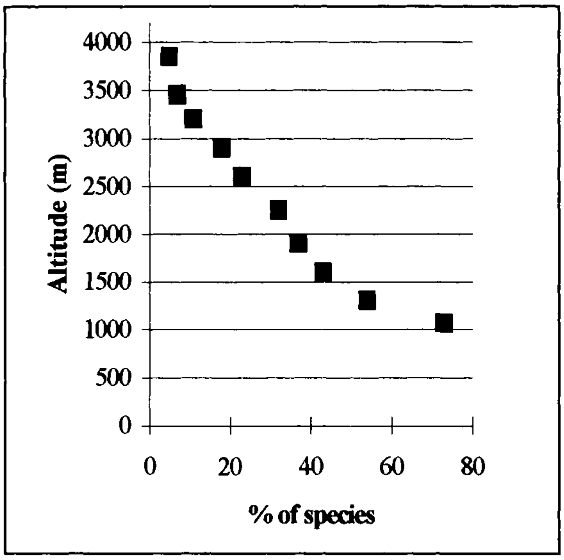


Figure 2.7. Proportion of forest tree species that occur at various altitudes in Uganda (based on a 35% sample of all known species). After Hamilton (1975).

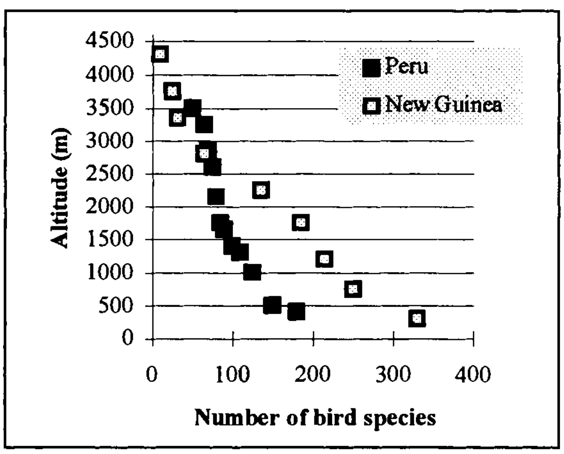


Figure 2.8. Variation in number of bird species with altitude. After Myers and Giller (1988).

2.3.3 Rainfall

For terrestrial environments, variation in rainfall produces a third gradient of species diversity: wetter areas tend to be more species-rich than drier areas. All organisms need water to survive, even if they do not have to actually drink water, and it seems that the wetter the climate, the more species can survive. This effect is illustrated for trees in Figure 2.9. A similar trend exists for birds in Africa, as shown by Pomeroy and Lewis (1987). They found that, for tropical Africa, moist areas or countries tend to support more bird species than dry areas or countries of a similar size; this effect was noticeable whatever size of area that was investigated. Thus Uganda, a moist country, has nearly twice as many bird species as the much drier countries of Senegal and Gambia have when considered together, even though they have almost the same surface area. Similarly, Uganda has very nearly as many bird species as its relatively dry neighbour, Kenya, even though Kenya's surface area is several times that of Uganda's.

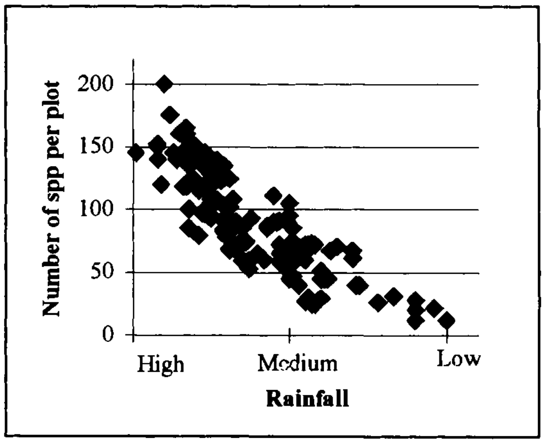


Figure 2.9. Variation in tree species richness with rainfall in Ghanaian forests. After Hall and Swaine (1976).

2.3.4 The most species-rich areas

Putting these three gradients together, we can see that the richest terrestrial ecosystems should be:

- in the lowlands
- near the equator
- in high rainfall areas

The ecosystem that dominates such areas is lowland equatorial rainforest, and numerous studies from Africa, Asia and Latin America confirm the richness of this ecosystem. For instance, the mostly forested South American country of Ecuador has only 3% the land area of

Europe, but may support 50% more plant species (Repetto and Gillis, 1988), and a study in Amazonian Peru produced 1200 species of beetle from the canopy of just nineteen trees of the same species (Erwin, 1982).

For reasons which are not entirely clear, and are anyway beyond the scope of this book, the equatorial and tropical rainforests of Latin America seem to be more species-rich than those of Asia, which are in turn richer than those of Africa, but even so, Africa's lowland equatorial and tropical rainforests are probably richer in species than any other ecosystems on the African continent. For each country in sub-Saharan Africa, Pomeroy (1993) has examined the data that exists on species richness amongst mammals, bird, fish, butterflies and flowering plants. On the basis of his analysis, he concludes that the most species-rich countries are Cameroon and Tanzania, closely followed by Uganda and Zaire, and then Kenya and Rwanda (Figure 2.10). He suggests that the main reason for this is that each of these countries is equatorial and contains at least some (in fact over 3000 km^2) tropical moist forest.

But we should remember that biodiversity also includes ecosystem diversity, and the more ecosystems there are in an area, the more species may be present there overall. Within Uganda's borders there is a wide range of ecosystems, ranging from moist forests at 600 m altitude, through medium-altitude moist and dry forests, swamps, woodlands, savannahs and semi-deserts, to high-altitude rainforests and moorland. This is one of the reasons why Uganda is thought to have one of the highest densities of species of any country in Africa. A further analysis reported by Pomeroy (1993), this time restricted to terrestrial birds, suggests that in Africa the area of maximum diversity is centred on central East Africa, and in particular in south-west Uganda (Figure 2.11). This is probably a reflection of the diversity of ecosystems that exist in this part of Africa, as well as the presence of tropical forest and many endemic species (see Chapter 4).

Some further examples of Uganda's relative species richness follow (from Stuart and Adams (1990) and McNeely et al. (1990)). Uganda is:

- The most species-rich country in Africa for mammals given its area, and the second-most species-rich regardless of area (only Zaire has more).
- The most species-rich country in Africa for birds given its area, and the third-most species-rich regardless of area (after Zaire and Kenya).
- The fifth-most species-rich country in Africa for swallowtail butterflies regardless of area (after Zaire, Cameroon, Congo and Tanzania).
- The tenth-most species-rich country in Africa for reptiles regardless of area.
- The tenth-most species-rich country in Africa for flowering plants regardless of area.
- The thirteenth-most species-rich country in the world for primates regardless of area.

So it is clear that, for its area, Uganda is particularly rich in species. This is one of the main reasons why international attention is being focused on conservation in Uganda, and why the conservation of Uganda's tropical forests in particular is seen as such a high global priority.

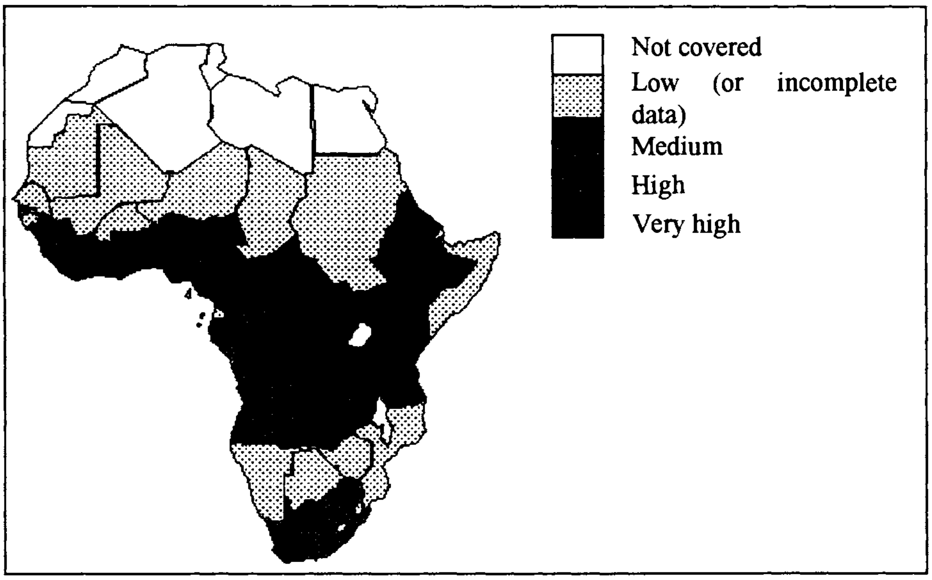


Figure 2.10. Relative species richness for mainland countries in the Afrotropical region. Countries are ranked based on numbers of mammals, birds, fish, butterflies and flowering plants recorded from each. Redrawn from Pomeroy (1993).

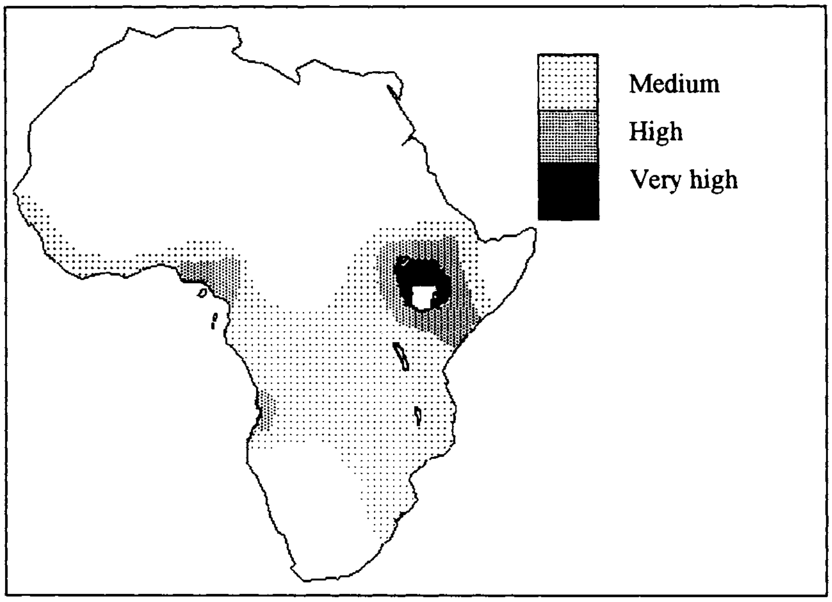


Figure 2.11. Geographical variation in African land-bird species-richness (adapted from Pomeroy (1993)).

2.4 SUMMARY

- The term "biodiversity" embraces the degree of nature's variety.
- Biodiversity levels vary from place to place.
- The wet, equatorial lowlands are the most species-rich, supporting tropical rainforest.
- Biodiversity levels in Uganda are probably the highest in Africa, bearing in mind the size of the country, because it has a wide range of climates from wet to dry, of altitudes from low to high, and yet it straddles the equator where biodiversity levels are naturally highest.

2.5 FURTHER READING

Pomeroy, D.E. 1993. Centers of high biodiversity in Africa. *Conservation Biology*, Vol. 7(4). 901-907.

Stuart, S.N. and Adams, R.J. 1990. *Biodiversity in sub-Saharan Africa and its Islands.* IUCN, Gland.

WCMC. 1992. *Global biodiversity: status of the earth's living resources.* World Conservation Monitoring Centre/Chapman and Hall.

Wilson, E.O. 1988. *Biodiversity.* National Academy Press, Washington D.C.

CHAPTER 3

RARITY AND NATURE CONSERVATION

CHAPTER OUTLINE

3.1 WHAT DO WE MEAN BY RARITY?

A **rare** species is one whose total population is comprised of relatively few individuals. Rarity can be considered at various levels, such as local, national and global. In general, species which are globally rare are worthy of greater conservation effort than those that are only locally rare but common elsewhere.

Why is it that conservationists are so often concerned with rare species? The argument is that, because of all the human-induced changes that are going on all around us, rare species may need some special protection if they are to survive in the long-term. Furthermore, if we look after rare species, commoner species will also benefit and will be better able to look after themselves.

3.2 DIFFERENT FORMS OF RARITY

Species may be rare for various reasons, some of them **natural**, and others **human-induced**. It is important to make this distinction between natural rarity and human-induced rarity, because the approaches to conservation may be very different.

3.2.1 Natural rarity

In any ecosystem, such as a tropical forest, some species are naturally rarer than others. For example, predators are normally rarer than their prey, and species that require certain precise habitat conditions that are themselves rare, or species with narrow ecological niches ("specialists") will also usually be rarer than species with more catholic requirements or broader ecological niches ("generalists") (section 5.5.2). Rarity is a subjective measurement, however, and different people use it in different ways. Some use it as one end of a spectrum of abundance, which goes from describing species as dominant, through abundant, then frequent, then occasional, to rare. This is the so-called "DAFOR" scale of abundance, much used by plant ecologists.

An alternative approach is simply to divide species into "common" and "rare". A classification along these lines has been developed by Rabinowitz (1981) based on a consideration of three criteria: geographic distribution, habitat specificity and local population size. Examples of how this classification might work for Ugandan species are given in Table 3.1.

Conservation of species that are naturally rare should be straightforward: as long as the ecosystem where a naturally rare species lives is left untouched by humans, no further conservation action should be necessary to ensure its survival. Problems arise where a naturally rare species is further threatened by human activities, in which case conservation can be much more difficult.

3.2.2 Human-induced rarity

These days, there are very many species which are rare because of human activities. Some of these species were once common, while others would always have been rare and have been made more so by human activity. It is also likely that many species are commoner today because of human activities, including some that may once have been rare. From a conservation point of view, though, we are more concerned about species in the former group that may be driven to extinction by our activities if we do not take steps to conserve them.

Table 3.1.
A three-way classification of natural rarity, with Ugandan examples. After Rabinowitz (1981).

Geographic distribution	Habitat specificity	Local population size	Status	Ugandan example
Wide	Broad	Somewhere large	Common	**Baboon** *(found throughout sub-Saharan Africa, in all sorts of habitats from closed forest to semi-desert, and often in large numbers).*
Wide	Broad	Everywhere small	Rare	**Leopard** *(found throughout sub-Saharan Africa, in all sorts of habitats from closed forest to savannah, but always in very low numbers)*
Wide	Restricted	Somewhere large	Rare	**Crowned crane** *(widespread in southern and central Africa, but largely confined to swampy grasslands, where it can sometimes be found in large numbers)*
Wide	Restricted	Everywhere small	Rare	**African giant swallowtail** *(a butterfly found throughout the Guineo-Congolian forest zone, but probably only in unlogged mature or riverine forest, and always in very small numbers).*
Narrow	Broad	Somewhere large	Rare	**Scarce swift** *(a bird restricted to the highlands of East Africa, feeding on the wing over a wide range of habitats. Breeds in colonies).*
Narrow	Broad	Everywhere small	Rare	**Taita falcon** *(a bird restricted to East Africa, breeding in small numbers on rocky crags in a variety of different environments).*
Narrow	Restricted	Somewhere large	Rare	**Grauer's rush warbler** *(a bird confined to south-west Uganda and neighbouring parts of Zaire and Rwanda, and restricted to montane swamps, where it can be one of the most numerous bird species).*
Narrow	Restricted	Everywhere small	Rare	**Mountain gorilla** *(confined to south-west Uganda and neighbouring parts of Zaire and Rwanda, and restricted to montane forests, where it occurs at very low densities).*

There are certain characteristics that might make some animal or plant species more vulnerable to humans than others. We could speculate that the animal most likely to become rare because of human activities would have the following characteristics:

- it would be large
- it would be a predator
- it would have narrow habitat tolerance
- it would naturally have a restricted distribution
- it would have valuable skin
- it would be subjected to uncontrolled hunting
- it would migrate across international boundaries
- it would be intolerant of the presence of man
- it would breed only in large herds
- it would reproduce slowly
- its behaviour would be repellent to humans

Probably no such animal species exists, but many species exist that have some of these characteristics, and these are usually the ones that become rare through the activities of humans. Even just one such characteristic can be enough to make a species vulnerable to human activities.

Table 3.2 examines each characteristic in turn, giving examples of species that occur in Uganda, along with examples of species that have corresponding characteristics that make them relatively invulnerable to human activities. Note that the list is by no means exhaustive, and that the table refers to animals only. A similar table could be constructed for plants, although the choice of characteristics would be a little different. Some of the characteristics that would make a plant species particularly vulnerable to human activities are shown on page 20.

Table 3.2.
Characteristics of animal species that determine whether they are at risk or invulnerable to human activities. Adapted from Deshmukh (1986)

Characteristics of high-risk	Ugandan example	Corresponding characteristics of lower-risk species	Ugandan example	Comments
Individuals of large size	*Python*	Individuals of small size	*Rat-snake*	Large species may be seen as more of a threat to humans than smaller ones, or they may simply require larger areas of habitat than smaller ones. Pythons are probably killed more often than rat-snakes because they are large and obvious whereas rat-snakes are smaller and therefore appear less dangerous to humans.
Predator	*Crowned eagle*	Non-predator	*Marabou stork*	The top predators are normally the first to suffer when humans appear on the scene, either because they are seen as a direct threat to or competitor with humans, or because they need large areas to ensure adequate supplies of their prey. Crowned eagles only survive where there are large areas of forest, as smaller areas will not support enough prey species (monkeys) to maintain a viable population. Hence they suffer if forests are fragmented. Marabou storks, on the other hand, survive very well alongside humans because they scavenge his waste.
Narrow habitat tolerance	*Grauer's rush warbler*	Broad habitat tolerance	*African reed warbler*	Specialists will survive as long as their specific habitat continues to exist, but cannot adapt to or fall back on other habitats if their specific habitat disappears through human activity. Thus Grauer's rush warbler, confined to montane swamps, cannot survive if the swamp is drained or cultivated, whereas the African reed warbler is found in various sorts of swampy vegetation as well as in scrub and gardens.
Valuable for skin etc.	*Leopard*	Not valuable for skin etc.	*Lion*	Killing a species for its skin puts extra pressure on the population that species without valuable skin do not face. Thus leopards, which are naturally rare anyway, can easily be driven to extinction by the fur trade, whereas lions, which are also naturally rare, are not.
Illegal, uncontrolled hunting	*Black rhino*	Legal, controlled hunting	*Uganda kob*	Many species can be harvested sustainably, but if harvesting is not controlled then the species may be at risk. Many timber trees fall into this category, as does the black rhino, which is now extinct in Uganda. Uganda kob, on the other hand, are legally hunted in Kyambura Game Reserve (injured individuals only) yet they remain common there.
Restricted distribution	*Mountain gorilla*	Broad distribution	*Baboon*	A species is more at risk if it is only found in a small area, because if that area is destroyed then the species will vanish too. Thus mountain gorillas are at risk because they are only found in a tiny area of central Africa, whereas baboons are not because they are found throughout much of the continent.
Migrates across international boundaries	*Sand martin*	Populations remain within one country	*African sand martin*	A species may be protected in one country but unprotected in others through which it migrates. Alternatively, its breeding areas may be secure but its non-breeding range less so. Thus the sand martin, a bird which breeds in Europe but spends the non-breeding period in tropical Africa, has suffered from desertification in the Sahel over which it must pass. The African sand martin, however, stays in tropical Africa year-round and does not have to cross the Sahel.
Intolerant of the presence of humans	*Giant forest hog*	Tolerant of humans	*Bush-pig*	Some species shun contact with humans, or are easily hunted by them. Thus giant forest hogs tend not to be found in forests with high human populations around them, whereas bush-pigs may even increase if the surrounding land is cultivated as they take advantage of the new food-source and manage to avoid being hunted.
Breeds in large herds or flocks	*Elephant*	Breeds as solitary pairs or small groups	*Bush-buck*	Some species need to form groups for successful survival. Thus, if a herd of elephants is reduced by humans to a few individuals, they may no longer breed and will eventually die out, whereas it only takes two bush-buck to found a new population.
Slow reproductive rate	*Chimpanzee*	Fast reproductive rate	*Black-and-white colobus*	If a species is a slow breeder, then populations will take a long time to recover from reductions caused by humans. Before then, they may have been driven to extinction. Thus chimpanzees, which produce one offspring every few years, are more at risk than black-and-white colobus, which may produce more than one offspring per year.
Behaviour repellent to many human societies	*Chameleon*	Behaviour well-adapted to living alongside humans	*Gecko*	Some species are persecuted simply because humans find them repellent. Thus chameleons are often killed because they are supposedly evil or poisonous (they are actually harmless), whereas geckos are welcomed in many homes because they eat insects.

- it would be slow-growing
- it would have narrow habitat tolerance
- it would have valuable wood, bark, seeds or other body parts
- it would be subjected to uncontrolled harvesting
- it would naturally have a restricted distribution
- it would be subject to international trade
- it would be intolerant of disturbance, fire or grazing
- it would be gregarious and monoecious
- it would reproduce slowly
- it would be poisonous or thought to harbour evil spirits

Again, probably no such plant exists, but it is useful to think of plants this way as it helps us to understand why some are more vulnerable to human activities than others.

3.2.3 Conservation implications of rarity

Because there are many different reasons why a species might be rare, it follows that there is no one conservation method that will work for all species, so if we want to succeed in conservation, we have to be flexible in our approach. Usually, the best method is to provide the species with an area where it can exist without human interference (***in-situ* conservation**), but sometimes this is not possible or even not necessary. Sometimes law enforcement, or a change in the law, or a change in public attitudes is required; sometimes we still do not know what is best for the species in question, in which case more research or monitoring is required; and sometimes, the only hope is to keep the species in a zoo, botanic garden or seed bank (***ex-situ* conservation**).

3.3 THREATENED SPECIES

3.3.1 Extinction

We have seen that species may be rare for natural or human-induced reasons, but conservationists are most concerned about those that are under threat of suffering further decreases through human activities, possibly to the point of extinction. There are plenty of them, and extinction rates seem to be increasing all the time. Of course, extinction can be an entirely natural process. If it was not, then we would be sharing the planet with dinosaurs and mammoths. As new species evolve, so others go extinct. This natural, background rate of extinction is today estimated at one species per year. But on top of this we now have human-induced extinctions, at a rate of 100s or 1000s per year. (Wilson, 1988). By the end of the century, the rate may reach one species lost per hour. A typical suggestion from the experts is that 2.8 % of all species on earth may be driven to extinction within the next 25 years (Hamilton, 1993). Most extinctions probably go unnoticed, because they mostly occur amongst the lower plants and invertebrates. But even for well-known groups such as birds (Figure 3.1), far more species are becoming extinct nowadays than ever before.

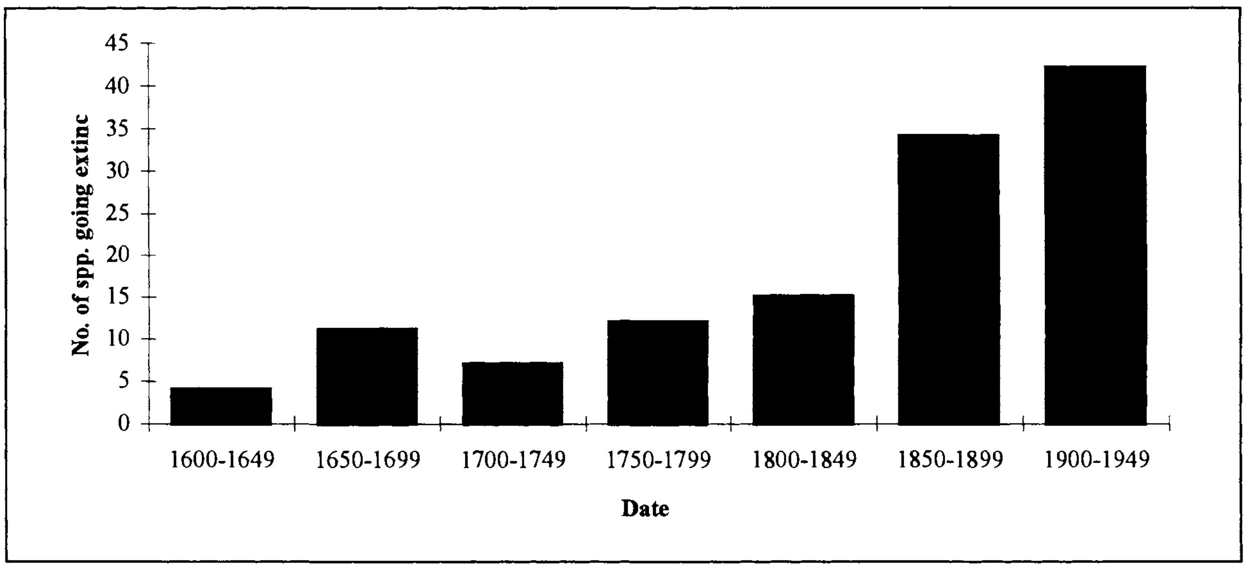


Figure 3.1. Global extinction rates for birds over the past four centuries. The data only extend to 1949, but the rate of loss since then is likely to be even higher. After WCMC (1992).

3.3.2 Categorising the degree of threat

Some species are more threatened than others. In order to prioritise conservation effort, an internationally accepted series of categories has been devised by IUCN , to cover all species recognised as being internationally threatened. These are listed in Box 3.1. The categories are based on several criteria that, when taken together, indicate to what extent a species (or other taxon such as sub-species or race) is threatened with extinction. The criteria that IUCN has chosen include the degree to which the taxon is showing a decline, and whether it has a small range and fragmented, declining or fluctuating populations. Note that the general term ***threatened*** is used to refer to a species considered to belong to any one of the categories. This set of categories replaces an earlier one also devised by IUCN, which is still in wide use amongst conservationists as well as planners and law-makers.

It is important to remember that we do not know the status of most of the world's plants and animals. Those that are recognised are mostly from well-known groups of plants or animals (such as the African elephant, figure 3.2, whose recent decline is all too evident), but they probably represent just a small fraction of the true number of threatened species worldwide.

IUCN has developed a series of *Red Data Books* for the more prominent groups, which give accounts of all species and other taxa designated as being internationally threatened. These books may be based on a certain taxonomic group (such as primates), or on a particular region. By 1991, 4589 threatened animal species were officially listed, including 555 mammals, 1073 birds, 186 reptiles, 596 fishes and over 2000 invertebrates (WWF, 1991b); the figure for plants is about 60,000. In each case the number is rising all the time; the current proportion of species that fulfil the criteria for listing is probably about 10%.

Box 3.1.
IUCN Threatened Species categories (from Collar, Crosby and Stettersfield, 1994)

EXTINCT: A taxon is extinct when there is no reasonable doubt that its last individual has died.

EXTINCT IN THE WILD: A taxon is extinct in the wild when it is known only to survive in cultivation, in captivity, or as a naturalised population well outside the past range.

CRITICALLY ENDANGERED: A taxon is critically endangered when it is facing an extremely high risk of extinction in the wild in the near future.

ENDANGERED: A taxon is endangered when it is not critical but is facing a very high risk of extinction in the wild in the near future.

VULNERABLE: A taxon in vulnerable when it is not critical or endangered but is facing a high risk of extinction in the wild in the medium-term future.

CONSERVATION DEPENDENT: Taxa which do not currently qualify as critical, endangered or vulnerable may be classified as conservation dependent. To be considered so, a taxon must be the focus of a continuing conservation programme which directly affects the taxon in question. The cessation of this programme would result in the taxon qualifying for one of the threatened categories above.

LOW RISK: A taxon is low risk when it has been evaluated and does not qualify for any of the categories critical, endangered, vulnerable, conservation dependent or data deficient. This category will include those that are close to qualifying for the threatened categories, those that are of less concern, and those that are presently abundant and unlikely to face extinction in the foreseeable future.

DATA DEFICIENT: A taxon is data deficient when there is inadequate information to make an assessment of its risk of extinction based on its distribution and/or population status. Listing in the category indicates that more information is required, and acknowledges the possibility that future research will show that threatened classification is inappropriate.

NOT EVALUATED: A taxon is not evaluated when it has not yet been assessed against the criteria.

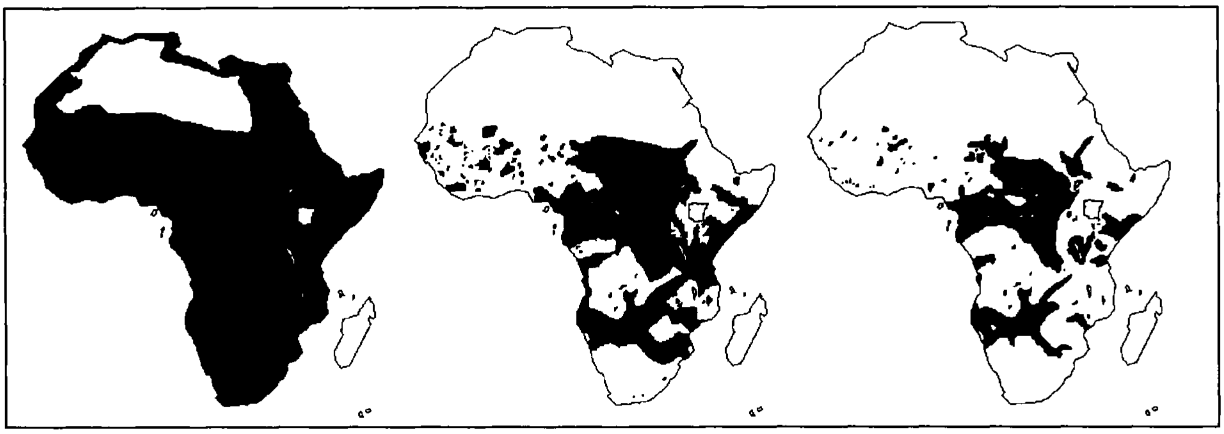


Figure 3.2. The decline in the range of the African elephant. Left: historical range. Centre: 1970s range. Right: 1980s range. After Chadwick (1991).

3.3.3 What are the main human-induced threats to species?

We have already seen why some species are more at risk than others. In general, three broad categories of human activities account for most of the threats world-wide:

- habitat destruction (through expanding agriculture, forestry and urbanisation);
- direct exploitation (for instance hunting and logging); and
- introduction of exotic species (acting as either competitors with or predators on native species).

Figures 3.3 and 3.4 illustrate this, based on analyses of the world's threatened mammal species (WCMC, 1992) and threatened "restricted range" bird species (Bibby et. al, 1992). Habitat destruction comes out as the clear leader in both analyses.

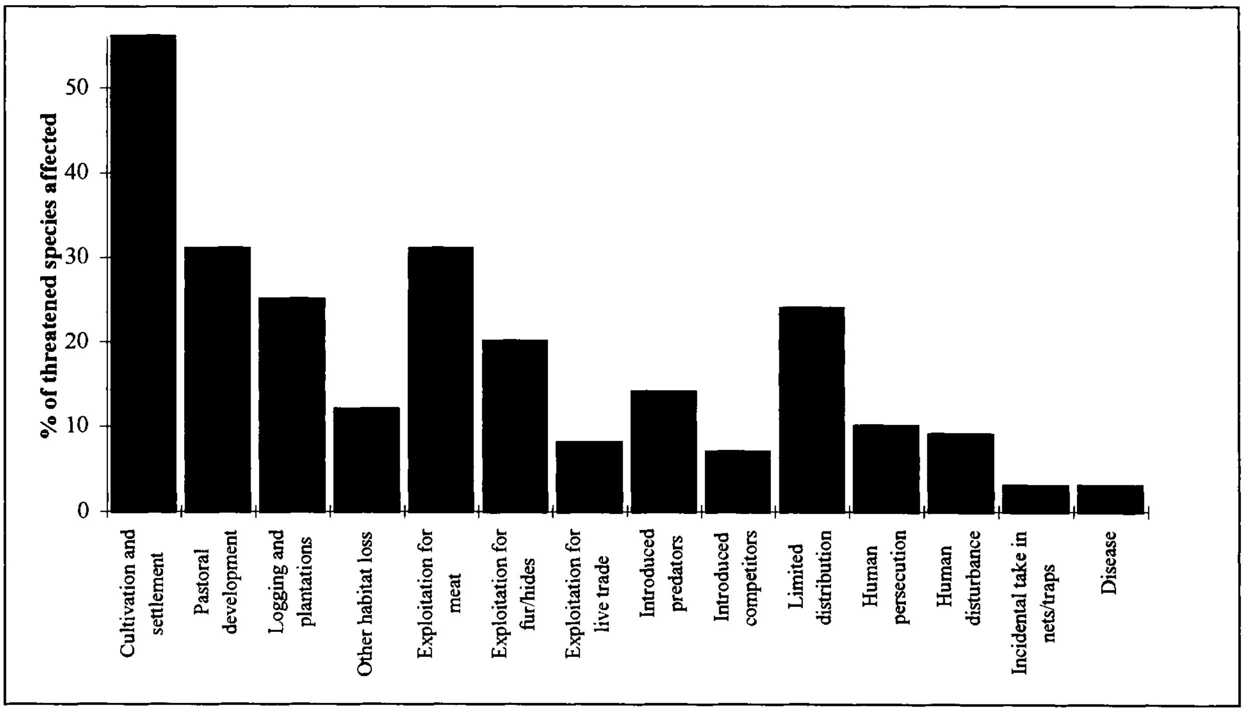


Figure 3.3. The main threats to threatened mammal species. After WCMC (1992).

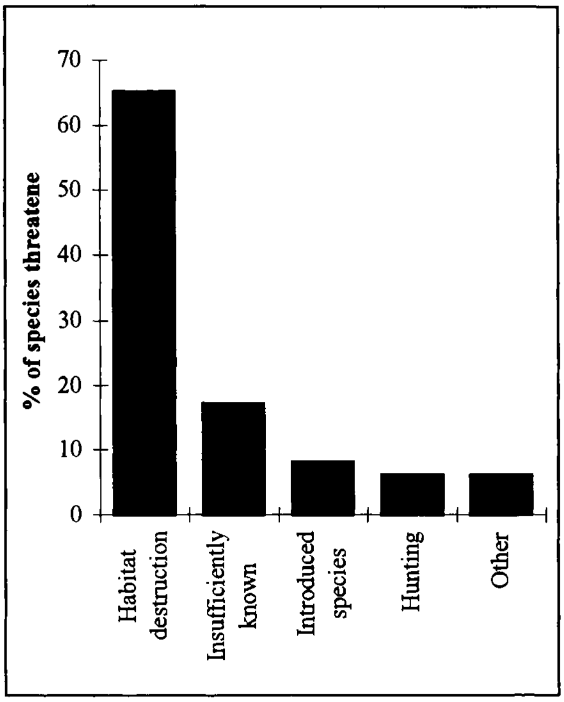


Figure 3.4. The main threats to threatened "restricted range" bird species. After Bibby et al. (1992).

3.3.4 Threatened species and the tropical forests

Having seen what makes some species rare, and what threats species face, it is worth considering the global distribution of threatened species. As Figure 3.5 suggests, more threatened species (at least amongst the birds and mammals) are natural inhabitants of tropical forest than of any other ecosystem. This provides strong support for the idea that conservation of the world's tropical forests is one of the most important goals in conservation today, and that managers of tropical forests therefore bear a large part of the responsibility for ensuring the survival of many of the world's most threatened species.

3.3.5 Threatened species in Uganda

Several of IUCN's Red Data Books contain species found in Uganda; see for example Sayer, Harcourt and Collins (1992), IUCN (1988), Stuart and Adams (1990), Collar and Stuart (1985b), Collins and Morris (1985), Lee et al. (1988) and WCMC (1990). Altogether, there are 11 plants, 16 mammals, 12 birds and one reptile in Uganda that are considered internationally threatened (WCMC, 1992). Some of those species which occur in forest reserves or forests are described in box 3.2. Also included are some timber trees listed by FAO (1986) and ITTO (1991a) as internationally threatened - see also Table 3.3. Note that these species are listed under the earlier set of IUCN criteria for threatened species, which divided species into five threatened categories, as shown in the list.

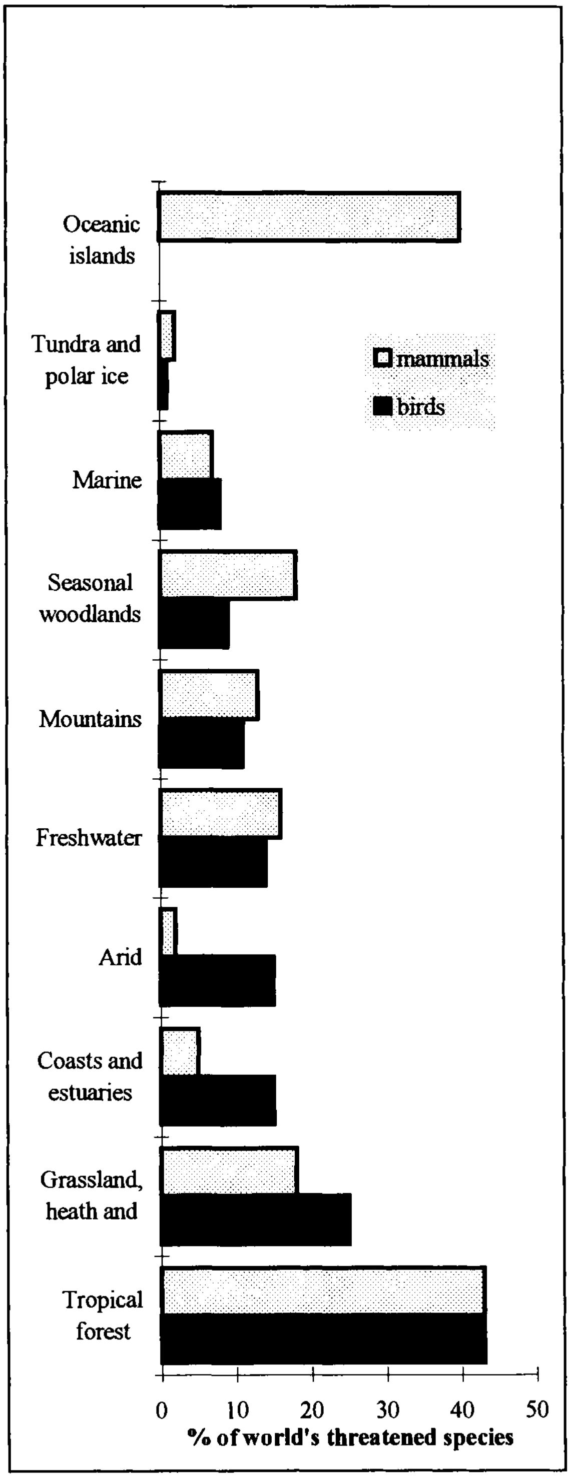


Figure 3.5. The distribution of the world's threatened birds and mammals by ecosystem type. After WCMC (1992).

Box 3.2.

Threatened species that occur in Uganda. The species are listed in decreasing order of likelihood of extinction, according to a previous set of IUCN threatened species criteria to that currently in use.

Extinct species

There are no known species that are now internationally extinct and which used to occur in Uganda. (There are, of course, several species that are now extinct in Uganda but not yet internationally).

Endangered species or races

- **Mountain gorilla (*Gorilla gorilla berengei*).** In Uganda, it occurs only in Bwindi and Mgahinga; elsewhere only in adjacent parts of Zaire and Rwanda, in montane forest (FFPS, 1994). Probably fewer than 600 remain, which sounds quite a few until it is remembered that it is about the same number as there are humans in just 2 km^2 of adjacent farmland. Threatened by forest loss, pit sawing and poaching.
- **Rwenzori black-fronted duiker (*Cephalophus nigrifrons rubidus*).** A race known only from the montane forests of the Rwenzoris in Uganda and Zaire. Threatened by hunting and habitat loss.
- **Golden monkey (*Cercopithecus mitis kandti*).** In Uganda, this race occurs in montane forest in the Virungas. Elsewhere, probably found in similar forests in eastern Zaire and Rwanda. Threatened by forest loss and perhaps hunting. [N.B. category under revision: may not yet have been placed in endangered category].
- ***Haplochromis* and *Tilapia* spp.** Over 250 species of cichlid fishes which are known only from Lake Victoria, threatened primarily by predation by the introduced Nile Perch.

Vulnerable species

- **Chimpanzee (*Pan troglodytes*).** In Uganda, it occurs in several western forests; elsewhere found in the forests of west and central Africa. Probably 50-200,000 remaining (WWF, 1991b).Threatened by forest loss, human disturbance and live trade.
- **L'hoest's monkey (*Cercopithecus l'hoesti*).** In Uganda, occurs in a few south-western forests; elsewhere found in lower montane forests in the Albertine Rift and in a small area of west Central Africa. Threatened by forest loss and hunting.
- **Uganda red colobus monkey (*Procolobus badius tephrosceles*).** In Uganda, this race occurs only in Kibale forest. Elsewhere, it occurs in western Tanzania. Threatened by forest loss and disturbance, and perhaps by hunting.
- **African elephant (*Loxodonta africana*).** In Uganda, confined to a few large forests and savannah areas. Elsewhere, found in many parts of Africa but range now much reduced (see Figure 3.6). Numbers down from 5-10 million last century, to 2-3 million in 1970, to 600,000 today , 45% of which live in central African forests (WWF, 1991a; Chadwick, 1994),. Threatened by expansion of agriculture and forestry, and poaching.
- **Leopard (*Panthera pardus*).** In Uganda, confined to a few large forests and savannah areas. Elsewhere, found in many parts of Africa but range now much reduced. Threatened by forest loss, poaching and reduced abundance of prey species.
- **Cheetah (*Acinonyx jubatus*).** In Uganda, still survives in Kidepo/Karamoja. Elsewhere, found in savannah and semi-desert in many parts of Africa, but many populations now isolated. Threatened by habitat loss, disturbance and reduced abundance of prey species.
- **Nile crocodile (*Crocodylus niloticus*).** In Uganda, confined to larger rivers, lakes and swamps. Elsewhere, found in many parts of Eastern and Southern Africa, but numbers and range much reduced. Threatened by hunting and habitat loss.
- **Grauer's rush warbler (*Bradypterus graueri*).** In Uganda, this bird is confined to swamps in Bwindi and Echuya and possibly elsewhere in Kigezi; elsewhere found in upland swamps in adjacent areas of Zaire, Rwanda and Burundi. Threatened by wetland drainage.
- **Cream-banded swallowtail butterfly (*Papilio leucotaenia*).** In Uganda, occurs in several western forests, mostly lower montane. Elsewhere, confined to the Albertine Rift. Threatened by forest loss and disturbance.
- ***Drypetes gerrardi, Premna angolensis*** and ***Vitex keniensis.*** Three tree species recorded from Uganda and thought to be threatened in some parts of their range through harvesting for timber (see Table 3.3).

Box 3.2 continued

Rare species

- **Cape clawless otter (*Aonyx capensis*).**
- **Congo clawless otter (*Aonyx congica*).**
- **Forest ground thrush (*Zoothera oberlaenderi*).** In Uganda, this bird is only recorded from Semliki. Elsewhere, probably only found in lowland forests of the Albertine Rift. Threatened by forest loss and disturbance.
- **Nahan's francolin (*Francolinus nahani*).** In Uganda, this bird is found in several western forests and Mabira. Elsewhere, probably only found in lowland forests of the Albertine Rift. Threatened by forest loss and disturbance, and possibly hunting.
- **African green broadbill (*Pseudocalytomena graueri*).** In Uganda, this bird is only recorded from Bwindi. Elsewhere, it occurs in montane forest in the Albertine Rift. Threatened by forest loss.
- **Chapin's flycatcher (*Muscicapa lendu*).** In Uganda, this bird is only recorded from Bwindi. Elsewhere, it occurs in montane forest in the Albertine Rift. Threatened by forest loss.
- **Turner's eremomela (*Eremomela turneri*).** In Uganda, this bird occurs in Nyondo forest in south-western Uganda. Elsewhere, it occurs in other forests in western Kenya. Threatened by forest loss.
- **Papyrus yellow warbler (*Chloropeta gracilirostris*).** In Uganda, this bird occurs in papyrus swamps around lakes Edward, George, Bunyonyi and Mutanda. Elsewhere, only recorded from one lake in western Kenya. Threatened by habitat loss.
- **African giant swallowtail butterfly (*Papilio antimachus*).** In Uganda, occurs in various western forests. Elsewhere, it is found in forests across central and western Africa. Threatened by forest loss and disturbance, and perhaps by collecting.

Species of indeterminate status

- **Rwenzori otter shrew (*Micropotamogale ruwenzori*).** Known only from the Rwenzori of Uganda and Zaire.
- **Long-tailed forest shrew (*Sylvisorex suncoides*).**
- **Kibale ground thrush (*Zoothera kibalensis*).** Only ever recorded from Kibale forest and nowhere else in the entire world, but not seen since 1966. Threatened by forest loss and perhaps disturbance.

Species of unknown status

- **Rodent shrew (*Paracrocidura maxima*).**
- **Thomas's bush-baby (*Galago thomasi*).**
- **Jackson's mongoose (*Bdeogale jacksoni*).**
- **Karamoja apalis (*Apalis karamojae*).** In Uganda, this bird occurs in Kidepo and on Mounts Kadam, Kamalinga and Moroto, in shrubby woodland. Elsewhere, only known from central Tanzania. Possibly threatened by forest loss or degradation.
- **Entebbe weaver (*Ploceus victoriae*).** Discovered in 1984, in papyrus swamps near Entebbe. Actual range unknown.

3.3.6 Threatened species and forestry

Other organisations have also attempted to produce lists of threatened species for certain regions or countries. Uganda has produced a provisional country list (National Biodiversity Unit, 1992), which includes some of the internationally-threatened species listed above as well as some others that have not been recognised as being internationally threatened, such as giraffe. A similar exercise has been attempted for tropical timber trees, by both FAO (1986) and IUCN (ITTO, 1991). Thirty-one of the species listed occur in Uganda and are shown in Table 3.3. Note, however, that only 12 of them are stated to be specifically threatened in Uganda.

The list may seem a little arbitrary, because of our level of information regarding these trees relative to our knowledge about the distribution of birds and mammals, but it should at least serve as a reminder to foresters that trees, too, may be vulnerable to human activities, and none more so than the mahoganies. Furthermore, it suggests that Uganda has quite a responsibility for ensuring that populations of many other timber tree species remain as healthy as they are, since it is clear that in other African countries they are already dangerously low. It should also be remembered that the list refers only to timber species: there are doubtless many other non-timber species that are equally threatened.

Table 3.3. Tropical timber species which occur in Uganda and are threatened in part of their range (species threatened in Uganda are emboldened)

Species	Where threatened	Source
Acacia albida	Israel	FAO (1986)
Aningeria altissima	Côte d'Ivoire, Ghana	IUCN (ITTO, 1991)
Antiaris toxicaria	China, Philippines	IUCN (ITTO, 1991)
Borassus aethiopum	Benin, Côte d'Ivoire, Zimbabwe	IUCN (ITTO, 1991)
Canarium schweinfurthii	Benin, Liberia	IUCN (ITTO, 1991)
Chrysophyllum delevoyi	Cameroon, Côte d'Ivoire	IUCN (ITTO, 1991)
Chrysophyllum perpulchrum	Cameroon, Côte d'Ivoire	IUCN (ITTO, 1991)
Cordia milleni	Kenya	FAO (1986)
Diospyros mespiliformis	Kenya, Uganda	IUCN (ITTO, 1991)
Drypetes gerrardii	Globally vulnerable	IUCN
Entandrophragma angolense	Cameroon, C. d'Ivoire, Kenya, Liberia, Nigeria	IUCN (ITTO, 1991); FAO (1986)
Entandrophragma cylindricum	Cameroon, Côte d'Ivoire, Uganda	IUCN (ITTO, 1991)
Entandrophragma utile	Cameroon, Côte d'Ivoire, Liberia	IUCN (ITTO, 1991)
Funtumia africana	Ghana, Uganda	IUCN (ITTO, 1991)
Guarea cedrata	Côte d'Ivoire, Liberia, Uganda	IUCN (ITTO, 1991)
Irvingia gabonensis	(not stated)	FAO (1986)
Juniperus procera	Outlying populations	FAO (1986)
Khaya anthotheca	Côte d'Ivoire, Liberia, Uganda	IUCN (ITTO, 1991)
Khaya grandifoliola	Benin, Uganda	IUCN (ITTO, 1991)
Khaya senegalensis	Benin, Uganda	IUCN (ITTO, 1991); FAO (1986)
Lovoa swynnertonii	(not stated)	FAO (1986)
Lovoa trichilioides	Cameroon, Côte d'Ivoire, Liberia	IUCN (ITTO, 1991)
Mammea africana	Cameroon, Côte d'Ivoire	IUCN (ITTO, 1991)
Milicia excelsa	Benin, Côte d'Ivoire, Ghana, Kenya, Zimbabwe	IUCN (ITTO, 1991); FAO (1986)
Nauclea diderrichii	Cameroon, Ghana	IUCN (ITTO, 1991)
Ocotea usambarensis	Kenya, Uganda	IUCN (ITTO, 1991)
Olea hochstetteri	Côte d'Ivoire, Uganda	IUCN (ITTO, 1991)
Pericopsis elata	(not stated)	IUCN (ITTO, 1991); FAO (1986)
Premna angolensis	Globally vulnerable	IUCN
Schrebera arborea	(not stated)	IUCN (ITTO, 1993)
Vitex keniensis	Globally vulnerable	IUCN

3.4 LEGAL PROTECTION FOR RARE SPECIES

Designating a species as threatened does not automatically assure it any protection. However, many governments design laws that protect species listed as threatened, either by limiting trade, hunting, collecting or disturbance. Some countries, notably the United States, go one stage further and have legally binding "recovery programs" for threatened species, designed to get the species off the threatened list through active management.

One international measure that seeks to give some protection to rare or threatened species is the Convention on International Trade in Endangered Species (CITES), of which Uganda is now a signatory along with over 140 other nations. Details of CITES and other agreements are given in Chapter 11.

3.5 SUMMARY

This chapter has brought out a number of points that are relevant to a discussion of conservation and forestry in Uganda:

- Many species are naturally rare
- An increasing number of species are becoming rare through human activities, and some are going extinct
- There are various criteria that dictate whether a species will be at risk from human activities
- There are internationally recognised categories of threat to which many threatened species can be ascribed, but this does not necessarily give any protection to threatened species
- Laws can provide some protection, but often changes in management or attitudes will be more effective
- The three most important threats are habitat destruction, direct exploitation and exotic species
- More threatened species live in tropical forests than in any other ecosystem
- Tropical forest conservation is therefore one of the most important conservation objectives.

3.6 FURTHER READING

FAO. 1986. *Data book on endangered tree and shrub species and provenances*. FAO, Rome.

Lee, P.C., Thornback, J. and Bennett, E.L. 1988. *Threatened primates of Africa: the IUCN Red Data Book*. IUCN, Gland.

WCMC. 1992. *Global biodiversity: status of the earth's living resources*. World Conservation Monitoring Centre, Cambridge.

CHAPTER 4

ENDEMISM AND NATURE CONSERVATION

CHAPTER OUTLINE

4.1 WHAT IS ENDEMISM?

In Chapter 2 we discussed how different parts of the globe support different numbers of species. For instance, there are more species in the tropics than at higher latitudes. Chapters 2 and 3 also discussed how different species are not equally widely distributed: some are found very widely, while others are very localised. In this chapter, we want to look at this issue more closely, particularly with reference to how it affects conservation planning.

If a species is only found naturally in one particular place or specific geographical area, it is said to be **endemic** to that place or area. If that place or area also supports many other species which have equally restricted distributions, then it is said to be an **area of endemism**, because it is rich in endemic species.

In theory, endemism can be considered at any scale. For instance, ostriches and African elephants are endemic to Africa, because they are not found on any other continent. However, most conservationists prefer to restrict the use of the term endemism to describe species restricted to smaller areas than continents. It then becomes a very useful concept for planning conservation areas: areas rich in endemics will be more important for conservation than areas that lack endemics, since the loss of an area rich in endemics may be irreplaceable if those species are really found nowhere else. What we are saying, then, is that not all areas are equally important for conservation, even if they are equally species-rich. In addition to species-richness, conservationists should also value the **level of endemism** amongst the species present.

Endemism is one extreme of a continuum. If a species is found in lots of places across a wide geographic range, it is said to be **widespread**. Most species are relatively widespread. Thus Uganda shares many of its species with neighbouring countries, and a fair proportion of them are also found as far afield as South Africa or Cameroon. It shares far fewer species with countries of other continents. For instance, Africa and South America share just two tropical forest tree species, *Ceiba pentandra* and *Symphonia gabonensis*, while Africa shares only a handful of tropical forest tree species with Asia, for example *Antiaris toxicaria*, *Tamarindus indica*, and *Oncoba spinosa*. The extreme form of "widespreadness", and at the opposite end of the continuum from endemism, is **ubiquitousness**. Humans are an obvious example of a ubiquitous species, since we are now residents of every continent and many oceanic islands too.

4.2 ZONES OF ENDEMISM

The widest scale at which the term endemism has any practical significance is at the level of ***phytochoria***, or zones of plant endemism (White, 1983). Under this system, Africa is seen to be comprised of nine main zones of plant endemism (Figure 4.1). Within any one of these zones is a pool of plant species from which all the plant communities are derived. The boundaries of these zones correspond roughly to the boundaries of the main vegetation types in Africa (see Section 5.4.1). By definition, at least a third of all plant species within a zone are not found in any other zone. Thus most species of plants in Mali, in the West African part of the Sudanian zone of plant endemism, also occur in Sudan, in the East African part of the same zone.

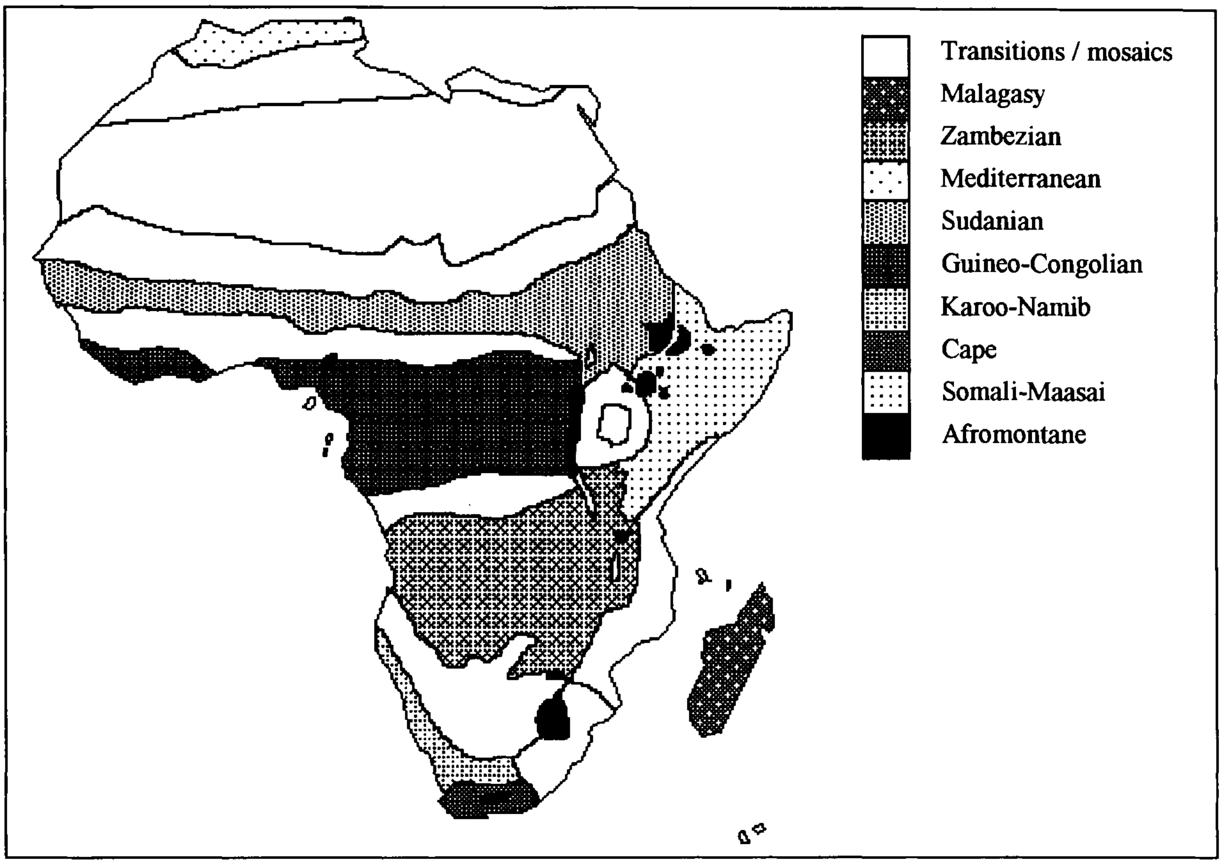


Figure 4.1. The main zones of plant endemism in Africa (shaded areas), plus transitions and mosaics (unshaded). After White (1983).

On the other hand, the plants of Mali are very different from those of, say, Sierra Leone, because they fall within different zones of plant endemism even though they are geographically quite close. Furthermore, the plant species of Mali differ greatly from those of, say, Namibia, even though parts of Namibia have a similar climate and an apparently similar vegetation cover to Mali.

These zones are fairly distinct, but there is some overlap between them. As Figure 4.1 shows, many parts of Africa consist of "transition zones" between two or more zones, containing species characteristic of each zone. In transitions, such as the Sahel, plant endemism is very low. In the Sahel's case, it is probably 0.1% (Hamilton, 1993). Uganda is unusual in that much of it is covered by a 'mosaic', called the *Lake Victoria Regional Mosaic*, which is where three main zones merge; it also has parts of the country covered by four true zones and a transition (Figure 4.2).

This is one reason why Uganda is particularly rich in plant species (4000-5000 species), because it has elements of many distinct zones of endemism within its borders. Despite this, Uganda has relatively few *nationally* endemic plants, something in the order of 0.6% (30 species), because most are shared with one or more of its neighbours which lie in the same zone or zones. Zaire's national level of plant endemism, on the other hand, is about 30%, because most of Zaire falls within one zone. But Niger, Guinea Bissau, Togo and Burkina Faso, all of which lie in transition zones, are each thought to have 0% plant endemism (WCMC, 1992).

Although these zones were based on plant endemism, they have relevance for animal endemism as well. Figure 4.3 shows the levels of endemism amongst mammals and birds, as well as plants, in the seven zones of mainland sub-Saharan Africa. In all cases, endemism is higher amongst plants than amongst birds or mammals. This may be because they are more easily isolated by physical or environmental barriers than are animals, because animals tend to be more mobile. Since speciation tends to follow isolation, plants tend to speciate into localised endemic forms more readily than do animals.

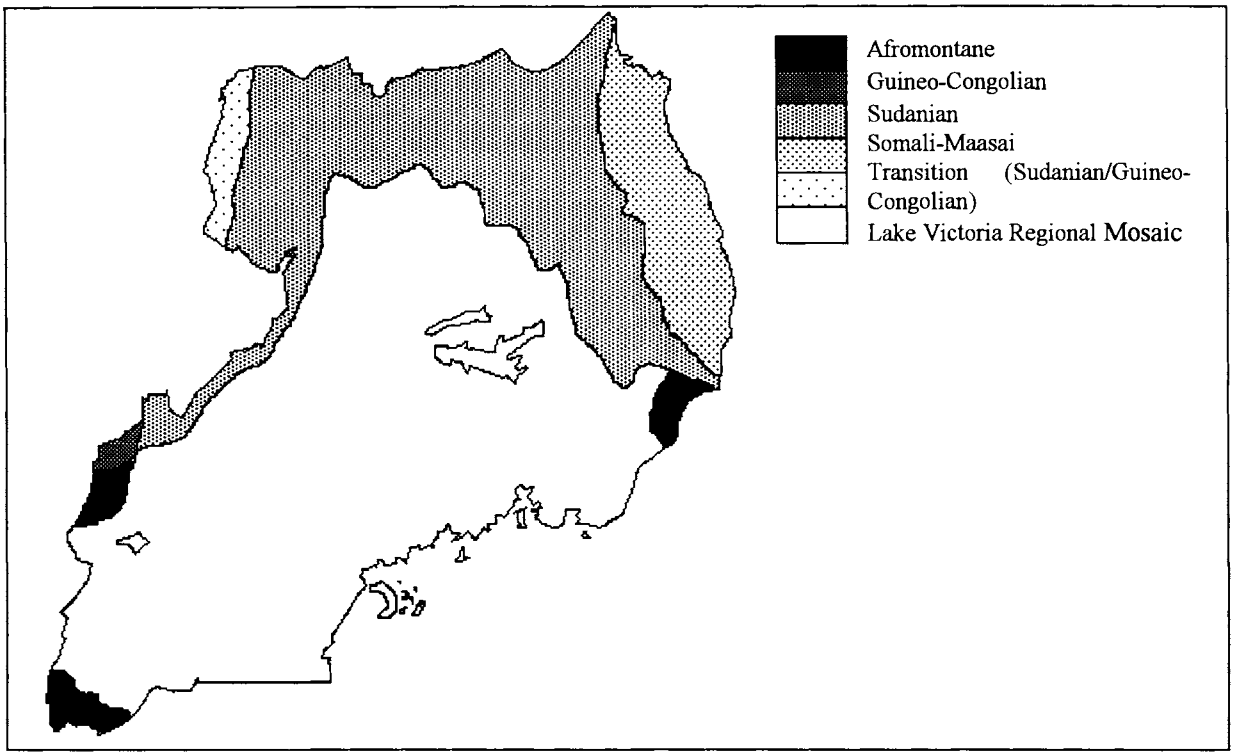


Figure 4.2. An enlargement of White's (1983) map, covering Uganda and showing the Lake Victoria Regional Mosaic.

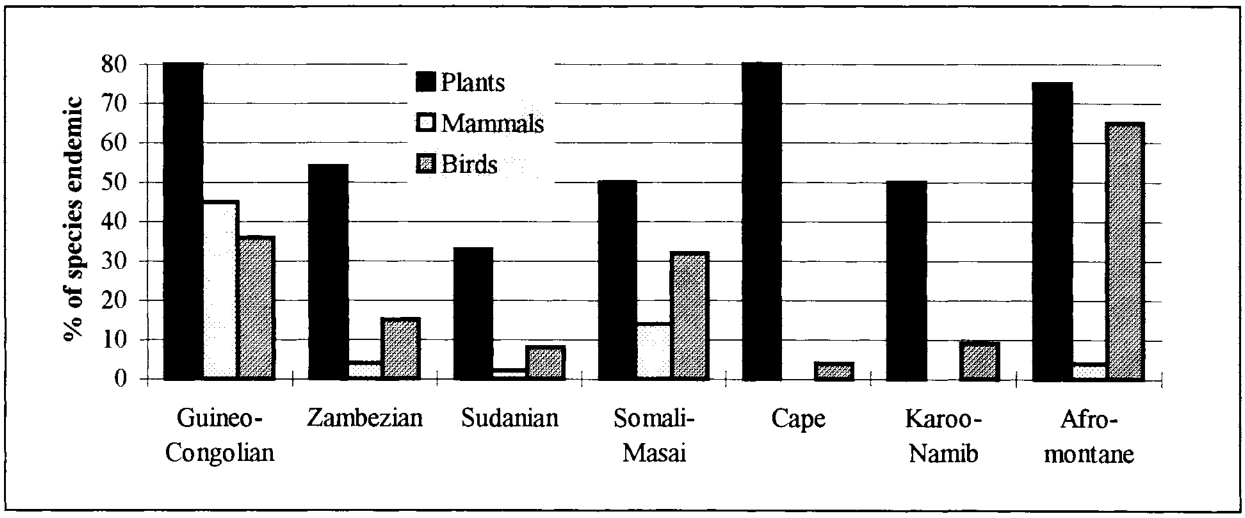


Figure 4.3. Levels of endemism in the seven zones of plant endemism of sub-Saharan Africa. After Stuart and Adams (1990).

4.3 ISLANDS OF ENDEMISM AND REFUGIA

4.3.1 Islands and centres of endemism in Africa

Although most of the zones of endemism described above form continuous blocks, note that the Afromontane zone does not. It occurs as isolated "islands" of high ground within other zones. The use of the term "island" is appropriate, because for the species that live there, the surrounding land is just as inhospitable, and just as much a barrier to dispersal and colonisation, as a true ocean would be. Most of these islands are found in East and Central Africa (such as the Rwenzori, Elgon and Virungas in Uganda) but others occur in Southern

Africa and to a lesser extent in West Africa. These areas have remarkably similar vegetation, but because they are isolated many of the species present may be unique to each "island", even if they are very closely related.

Island ecosystems are particularly important for endemic species. Because of their isolation from other similar areas, the species that live there have often evolved into distinct sub-species or species, making such areas particularly important for conservation. Although mountains with their Afromontane vegetation provide a classic example of areas with high endemism and high conservation value, they are not the only example. The major lakes of Africa can also be considered 'islands' surrounded by 'oceans' of dry land, and, as expected, the more isolated ones are rich in endemic species. For example, 99% of the cichlid fishes native to Lake Victoria are endemic to the lake, while of the 350 or so species of freshwater fishes found in Lakes Albert, Edward, George and Victoria, about 270 are found nowhere else (Huntley, 1988). A very full and readable account of this subject is given by Kingdon (1990).

Endemism in birds has been relatively well studied. They tend not to occur in isolation: often, where one endemic species occurs, other endemic species will also be found. We know, for instance, that about 26% of all the world's bird species are confined to less than 5% of the land area; 20% of them are confined to just 2% of the land area (Bibby et al., 1992). Most of these so-called *endemic bird areas* lie in the tropics, particularly along the equator. What this means for conservation of birds is that one of the best ways is to concentrate efforts on the areas that make up this small percentage. As we will see below, Uganda has an important role to play in this. Since the term endemism is somewhat vague, Bibby et al. (1992) have used the term *restricted range* to get around the problem of definition. In their analysis, a restricted range bird species is one whose global range does not exceed 50,000 km^2. Figure 4.4 lists the main centres of bird endemism in Africa, based on the numbers of restricted-range bird species present (Stuart and Adams, 1990).

The figure suggests that the Albertine Rift is the most important area for bird endemism in Africa. It comprises the largely mountainous country from Lake Albert in the North to southern Burundi in the south, either side of and within the western Rift Valley. The extreme west of Uganda is included, which is one reason why conservation of the forests of western Uganda is so important. For instance, no fewer than 26 of the 40 Albertine Rift endemic (restricted range) birds are recorded from here. Bibby et al. (1992) show that it is likely that such areas that are important for endemic birds will also be important for endemism amongst other groups of animals and plants.

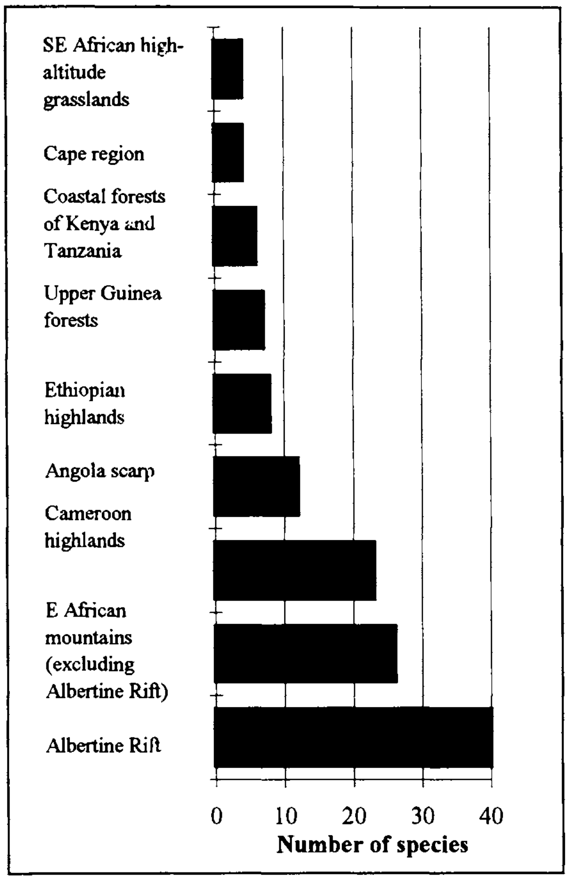


Figure 4.4. The major centres of bird endemism in Africa, based on the number of restricted range bird species found in each area. After Stuart and Adams (1990).

4.3.2 Endemism and refugia

In order to understand how areas such as the Albertine Rift have come to be so rich in endemic species, it is necessary to consider the history of climate in tropical Africa over the past two million years or so. As climate has changed, so too have vegetation zones. Temperatures may not have changed much, but rainfall patterns certainly have, and in fact they probably still are changing. This has meant that forests have been expanding and contracting according to the prevailing rainfall pattern. At certain times, forest could possibly have covered most of sub-Saharan Africa apart from the Horn of Africa and the Kalahari region (Knoch and Schulze, 1956). But at other times, forest would have shrunk to a fraction of its present area.

When this happened, once contiguous patches of forest could become isolated in a "sea" of savannah for thousands of years. During each period of isolation, some of the species thus isolated may become extinct because conditions are not quite right for their survival, or because the area of island is too small for them. But other species will adapt to the conditions, and if the isolation continues for long enough, then some of these may evolve into unique forms (species or sub-species), which are not found outside the island and which are therefore endemic to it.

The major changes are summarised in the next chapter in Section 5.4.34. Particularly important is the fact that about 13,000 years ago, when the temperate zones of the world were experiencing the last (Pleistocene) "Ice Age", tropical Africa was so dry that forests shrank to small areas where rainfall remained particularly high. These areas are known as **Pleistocene refugia**, because they provided a refuge for the plants and animals dependent on the forests. Figure 4.5 shows the probable distribution of these refugia in Africa. A similar situation probably existed in South America, and possibly also in Asia.

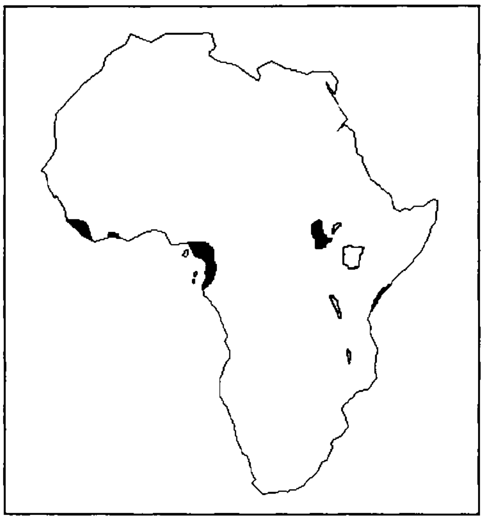


Figure 4.5. Probable distribution of the main tropical moist forest refugia in Africa during the driest period of the Pleistocene Ice Age, about 13,000 years ago. After Diamond and Hamilton (1981).

One of these refugia, known as the 'Central Refugium', extended from eastern Zaire into Rwanda and possibly just into western Uganda too. In other words it included parts of the Albertine Rift. Other parts of the Albertine Rift were above the tree-line anyway, as they are to this day (although vegetation belts were about 1000 m lower then), and supported isolated areas of Afromontane vegetation. Thus, it should not be surprising to find so many endemic species in the Albertine Rift to this day. Even though the forests have extended once again across much of central Africa, the area closest to the supposed refugium is still far richer in endemics, and in species generally. In fact, the forests of central Zaire, although seemingly in the heart of the great central African rainforests, support hardly any endemic bird species at all, and only about half the number of passerine bird species (songbirds) found in forests closest to the refugia (Diamond and Hamilton, 1981). Likewise, as shown in Figure 4.6, there is a strong gradient in forest tree species richness in the forests of Uganda as one moves away from the Albertine Rift, suggesting that some of the forests furthest away from the refugium have rather recent origins (Hamilton, 1974).

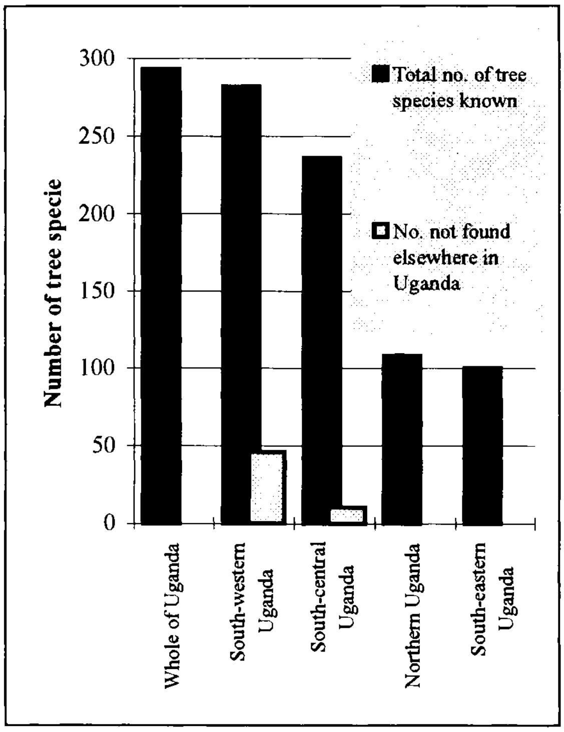


Figure 4.6. Variation in lowland forest tree diversity in different parts of Uganda. After Hamilton (1974).

4.4 ENDEMISM IN UGANDA

We have seen that Uganda is rich in species compared to its neighbours, and this is partly because the country sits at a meeting-point of several zones of endemism, as well as sitting on the edge of a major forest refugium and containing several isolated lakes and mountains. We have also seen that, despite this, there are relatively few nationally endemic species in Uganda, because most of the features that have high endemism straddle Uganda's borders. For instance, the main Afromontane areas in Uganda (the Virungas, Rwenzoris and Mount Elgon), and the main isolated lakes (Victoria, Edward and Albert) are all on international borders, while the main forests of western Uganda can be viewed as relict pieces of a forest refugium that also has fragments in neighbouring countries. Table 4.1 lists some of the species that are either nationally endemic, or endemic to small parts of Uganda and neighbouring countries. The list is confined to higher plants and vertebrates, because these are the groups that have been well studied. It is likely, though, that there are many more endemic species than appear in this table, particularly amongst the invertebrates.

Note that most of the species listed in the table are endemic to the Albertine Rift (or to the Rwenzoris, which lie within the Rift). This emphasises the great conservation importance of the parts of Uganda that lie within this area of endemism. The list of species from this area includes both montane and forest species: both are rich in endemics. It means that some of the most important forests for conservation in Uganda are those in and near the Albertine Rift, such as Bwindi, Echuya, Rwenzoris, Semliki, Kibale, Kasyoha-Kitomi, Kalinzu-Maramagambo, Itwara, Buhoma and Budongo, because these forests support species with very restricted global distributions for which every population is important in ensuring the species' survival.

4.5 SUMMARY

- Some species are restricted to relatively small natural ranges (restricted-range or endemic species), whereas others are widespread or ubiquitous
- Some areas are richer in restricted-range species (centres or zones of endemism) than others
- There are more centres of endemism near the equator than elsewhere
- Uganda is particularly rich in species partly because it lies at a meeting-point for several different zones of endemism, although most of its endemics are also shared with one or more neighbouring country
- Areas near to Pleistocene forest refugia, such as the forests of western Uganda, are likely to be richer in species, especially endemics, than areas further away
- Other natural "island" forests, such as those on the northern and eastern hills of Uganda, may also prove important for conservation of local endemics
- Given widespread instability in surrounding countries, the best chances of conserving many of the endemic species of East-Central Africa lie within Uganda

4.6 FURTHER READING

Bibby, C.J., Collar, N.J., Crosby, M.J., Heath, M.F., Imboden, C.H., Johnson, T.H., Long, A.J., Stattersfield, A.J. and Thirgood, S.J. 1992. *Putting biodiversity on the map: priority areas for global conservation.* International Council for Bird Preservation, Cambridge.

Kingdon, J. 1990. *Island Africa: the evolution of Africa's rare animals and plants.* Collins, London.

Stuart, S.N. and Adams, R.J. 1990. *Biodiversity in sub-Saharan Africa and its Islands.* IUCN, Gland.

WCMC. 1992. *Global biodiversity: status of the earth's living resources.* World Conservation Monitoring Centre/Chapman and Hall.

Table 4.1.
Some examples of species with a restricted range that occur in Uganda.
Mostly from IUCN (1988) and Kingdon (1973)

Species	Global distrib.	Distribution in Uganda
Thunbergianthus rwenzoriensis (shrub)	Albertine Rift	Rwenzoris and Bwindi
Polystachia sp. (orchid)	Albertine Rift	Virungas
Cyathea camerooniana var. *ugandensis* (tree-fern)	Uganda	?
Cyathea dregei var. *burkei* (tree-fern)	Uganda	?
Euphorbia dichroa	Uganda	?
Euphorbia petraea	Uganda	?
Aloe mubendiensis	Uganda	?
Aloe schweinfurthii var. *labworiana*	Uganda	?
Aloe fororoana	Uganda	?
Aloe wilsonii	Uganda	?
Aloe wollastonii	Uganda	?
Senecio amblyphyllus	Albertine Rift	SW Uganda
Senecio elgonensis	Mount Elgon	Mount Elgon
Mus acholi (pygmy mouse)	NW Uganda	NW Uganda
Pelomys hopkinsi (creek rat)	Around L. Victoria	Around Lake Victoria
Pelomys isseli (creek rat)	Ssese Islands	Ssese Islands
Thamnomys venustus (mouse)	Albertine Rift	SW Uganda
Delanymys denti (Delany's mouse)	Albertine Rift	SW Uganda
Otomys denti (groove-toothed rat)	Albertine Rift	SW Uganda
Funisciurus carrutheri (Carruther's mountain squirrel)	Albertine Rift	Rwenzoris
Rhynchocycon cirnei stuhlmanni (elephant shrew)	Albertine Rift	SW Uganda
Dendrohyrax arboreus ruwenzorii (Rwenzori tree hyrax)	Rwenzoris	Rwenzoris
Procolobus badius tephrosceles (Uganda red colobus)	SW Uganda	SW Uganda
Cercopithecus mitis kandti (Golden monkey)	Albertine Rift	Mgahinga
Gorilla gorilla berengei (Mountain gorilla)	Albertine Rift	Bwindi and Mgahinga
Panthera pardus ruwenzorii (Rwenzori leopard)	Rwenzoris	Rwenzoris
Chamaeleo johnstoni (Three-horned chameleon)	Rwenzoris	Rwenzoris
Francolinus nobilis (Handsome francolin)	Albertine Rift	Rwenzori, Bwindi, Virunga
Francolinus nahani (Nahan's francolin)	Albertine Rift	W and SW Uganda
Halcyon badia (Chocolate-backed kingfisher)	Albertine Rift	W Uganda
Columba albinucha (White-naped pigeon)	Albertine Rift	Semliki and Kibale
Tauraco johnstoni (Rwenzori turaco)	Albertine Rift	SW Uganda
Tockus hartlaubi (Black dwarf hornbill)	Albertine Rift	Semliki
Turdus kibalensis (Kibale ground thrush)	Kibale Forest	Kibale Forest
Turdus oberlaenderi (Forest ground thrush)	Albertine Rift	SW Uganda
Cercotrichas leucosticta (Northern bearded scrub robin)	Albertine Rift	Semliki
Alethe poliophrys (Red-throated alethe)	Albertine Rift	Rwenzoris, Bwindi
Muscicapa lendu (Chapin's flycatcher)	Albertine Rift	W and SW Uganda
Pseudocalyptomena graueri (African green broadbill)	Albertine Rift	Bwindi
Graueria vittata (Grauer's warbler)	Albertine Rift	Bwindi
Sylvietta sp. (Lemon-bellied crombec	?Albertine Rift	Budongo
Hemitesia neumanni (Short-tailed warbler)	Albertine Rift	Bwindi
Apalis ruwenzori (Collared apalis)	Albertine Rift	Rwenzori, Kibale & Kigezi
Bradypterus graueri (Grauer's rush warbler)	Albertine Rift	Bwindi and Echuya
Melaenornis ardesiaca (Yellow-eyed black flycatcher)	Albertine Rift	Bwindi
Batis diops (Rwenzori batis)	Albertine Rift	Rwenzoris and Bwindi
Batis ituriensis (Ituri batis)	?Albertine Rift	Budongo
Nectarinia purpureiventris (Purple-breasted sunbird)	Albertine Rift	Rwenzoris, Bwindi , Kalinzu
Nectarinia regia (Regal sunbird)	Albertine Rift	Rwenzoris and Kigezi
Phyllastrephus lorenzi (Sassi's olive greenbul)	Albertine Rift	Semliki
Cryptospiza shelleyi (Shelley's crimson-wing)	Albertine Rift	Bwindi and Rwenzoris

CHAPTER 5

FOREST ECOLOGY

CHAPTER OUTLINE

5.1 INTRODUCTION

This chapter aims to provide the reader with the ecological knowledge that is considered important for anyone seeking to develop a working understanding of conservation and of natural forest management. Although it is possible to manage natural forests without in-depth ecological understanding, experiences from around the world suggest that, in the long term at least, such management will fail. No-one would suggest that forests are best managed exclusively by ecologists, but in ecology must play its part. In today's forestry, with its emphasis on multiple values and sustainability, it is more vital than ever before that foresters have a broad understanding of ecology.

5.1.1 What is ecology?

Ecology is the study of the processes and interactions between organisms and their environment, both **biotic** (living) and **abiotic** (non-living), and their resultant patterns of distribution and abundance.

5.1.2 Why do we need to know about ecology?

Nature conservation can be interpreted at many levels. For some people, it may mean the conservation of particular species of plant or animal, for instance ones which are particularly rare or threatened. But it is impossible to divorce any one species from its natural environment, so to conserve any species successfully we need to know something about its environment too. Ecology is concerned with distribution and abundance, and helps to explain why particular organisms are where they are, and in what quantity.

Likewise, we may want to manage the natural environment to meet our own needs or desires, for instance for timber or for bush meat, or for multiple use. Even man-made ecosystems, such as plantations, still have to obey basic ecological principles. We risk running into problems if we try to manage any ecosystem this way without a good understanding of the processes and interactions that are going on between organisms in that environment, and between organisms and the environment around them. Understanding ecology enables us to make predictions about the likely impact of any management on both the target species or area and those with which the species or area interacts. An understanding of ecology is therefore essential if we are to make informed decisions about management.

It is therefore in our own self-interest, and in the interests of conservation, that we know something about the ecology of the environments around us and in which we are working.

5.2 SOME BASIC ECOLOGICAL CONCEPTS

There are many things about the natural world that we need to understand. First, we must look for patterns in the natural world. We must appreciate that the natural world is diverse and complex; that it is dynamic but also stable and self-replenishing; that it is organised by physical and biological processes; and that to study it we need to use observation, theory and experiment. Even then, our understanding of nature will never be perfect, limited as it is by our very human perception. These are the basic premises underlying ecology (Krebs, 1985).

Ecology has its own vocabulary to express certain concepts. If we were to study the relationship of an individual organism to its non-living (physical and chemical) environment then we would be looking at the **biology** of that type of organism or species. However, organisms do not usually live in isolation. If any particular area is studied, it will be clear that species form **communities** consisting of large numbers of **populations** of several or many different species (plants, animals and micro-organisms). The relationship of each community with its non-living environment makes up an **ecosystem**. Ecosystems are the fundamental unit of study in ecology, but they can be as small as isolated swamps or as large as an entire forest zone depending on where one chooses to draw the line of study. More pragmatically, it is much more easy to describe an ecosystem by using only its visible structure, i.e. the plant community, or more usually the dominant vegetation type, for example forest or grassland. In practice, many ecologists now use the word **habitat** to describe such features, although the term originally meant the particular environment or home inhabited by a particular species, such as fungi on rotting wood.

Since we have seen that ecology is primarily about processes and interactions, let us look first at some of these interactions.

5.3 INTERACTIONS BETWEEN SPECIES AND THEIR ENVIRONMENTS

No ecosystem has ever been found to consist of just a single species, and most consist of many thousands or even hundreds of thousands. So in any ecosystem, there will be numerous interactions going on between species. These are known as **interspecific interactions**. Each individual organism belonging to each species is striving to maximise production of its own kind. Sometimes this results in competition with other species, sometimes one species will take advantage of another (such as predators and their prey), and sometimes two or more species will act in a way that is mutually advantageous. Many interactions are still not fully known.

Whatever the form that the interaction takes, it means that the destinies of species in an ecosystem are often intricately linked, one with another: the loss of one link can easily have knock-on effects on other species. Broadly speaking, interactions may be classed as either positive or negative. In **positive interactions**, one or both species benefit from the arrangement, and neither is harmed. In **negative interactions**, one or both species is harmed by the arrangement. Table 5.1 outlines a classification of interactions with some examples.

5.3.1 Fig pollination and dispersal

Because tropical forests contain so many species, they are particularly rich in interactions too. Some of these interactions are highly specialised. A classic example of this is the mutualistic relationship between fig trees and their fig wasps (Pomeroy and Service, 1986; Whitmore, 1990). The fruits of fig-trees (*Ficus* spp.) are remarkable structures, highly adapted to their associated fig-wasps (insects of the order Hymenoptera: family Agaonidae). The fruit is derived from an inverted flower-head, forming a hollow structure (the synconium) which has only a narrow opening to the outside, called the ostiole. Every species of fig-tree is pollinated by a single species of fig-wasp. Thus Budongo Forest, which supports over twenty fig species (Synnott, 1985), may also support the same number of species of fig-wasp.

A female fig-wasp enters the synconium by squeezing through the ostiole. Once she is inside, she lays eggs in some of the female flowers. She also pollinates other female flowers with pollen brought in her pollen sacs from the synconium where she was born, and in this way cross-pollinates the tree. The female wasp dies, but the female flowers containing eggs enlarge into galls, providing food and shelter for the next generation of wasp larvae.

After pupation the adult wasps emerge, first the wingless males, and then the females. They mate, and the male then makes a hole through the wall of the synconium, after which he dies. The hole enables the female to escape, but before she goes she collects pollen from stamens which have ripened later than those previously visited by her mother. Female fig-wasps pollinate more flowers than they lay eggs in, so the synconia produce seeds and their flesh ripens. The process of pollination stimulates the ostiole to close, thus excluding more wasps from entering, whilst the presence of eggs in the female flowers inhibits the fruit from ripening too quickly or dropping. Eventually it does ripen, but not before most of the wasps have emerged.

Table 5.1.
A classification of species interactions. After Pomeroy and Service (1986).

POSITIVE INTERACTIONS one or both species benefit, neither is harmed			
MUTUALISM both species benefit		**COMMENSALISM** one species benefits, the other is unaffected	
Facultative mutualism	**Symbiosis (obligate mutualism)**	**Normal commensalism**	**Phoresy**
relationship is temporary	one species cannot exist without the other	the benefiting species obtains food or shelter from the arrangement	the benefiting species uses the other for transport
example: *monkeys and the trees whose seeds are usually consumed by them but are occasionally dispersed by them.*	***example:*** *fig tree and fig wasp; termites and the wood-digesting protozoans living in their guts.*	***example:*** *mites living in the roots of primate eyelashes*	**example:** *soil mites that disperse by clinging to insect legs; sticky seeds or burrs from plants growing along tracks sticking to animal fur*

NEGATIVE INTERACTIONS one or both species is harmed				
Harmed species often dies			**Harmed species normally survives**	
Predation	**Parasitoids**	**Competition (interspecific or intraspecific)**	**Parasitism**	**Grazing and browsing**
one organism consumes another	kill their hosts while completing their life-cycles	sometimes leading to death of the loser	the host is not normally killed while the parasite completes its life-cycle	by animals on plants
example: *leopard preying on duikers*	***example:*** *ichneumon wasp larvae developing inside caterpillars*	***example:*** *two cockerels fighting; paper mulberry displacing other pioneer trees; strangler fig on host tree*	***example:*** *cassava leaf mosaic virus, or malaria*	***example:*** *bush buck eating grass; caterpillar eating leaves*

It seems there is a species to exploit every opportunity that exists in nature. For example, the developing wasp larvae inside the fig synconium are "sitting targets" for attack by tiny parasitoid wasps. Females of these parasitoid wasps have extremely long ovipositors, several times the length of their own bodies. They settle on the outside of the young fig and insert their ovipositors through the fig until they pierce a developing fig-wasp larva within. An egg is then laid inside the larva, and, on hatching, the parasitoid's larva consumes the living tissue of the fig-wasp larva, eventually killing it before pupating inside the fig. If a fallen fig is opened, it is often possible to see all the players in this series of interactions: the male fig-wasps (many of them dead), an occasional newly-emerged female fig-wasp, and usually many female parasitoid wasps, easily identifiable by their ovipositors.

Many species of fig that live in tropical forests are known as *stranglers*. Once a fig from such a species has ripened, another mutualistic relationship comes into play. Figs are a highly favoured food for many primates and larger birds, who gorge themselves on the fruit as soon as they are ripe, and end up dispersing the fig's seeds. The flesh surrounding the seeds is easily digested, but the seeds themselves normally pass through the gut intact, and are passed out in the faeces. Since many of the animals that eat figs are arboreal (that is, they spend their lives up in the forest canopy), many of the seeds end up falling into crevices in tree branches. On germinating in the humus in these crevices, a fig seedling will send a long root down the side of the branch and trunk of the host tree. Once it reaches the soil, growth becomes more rapid, and more and more roots descend. At this stage, the fig tree itself becomes a competitor with the host tree, and usually it will succeed in gradually weakening the host tree by a combination of strangulation of its trunk and root system (hence the term "strangler fig") and shading out, until the host is killed off and its space taken by a mature fig tree.

So we can see that for its survival through a single generation, a fig tree requires the presence of at least three other species: a host tree in which to germinate, a fig-wasp to pollinate its flowers, and a frugivorous bird or mammal to disperse its seeds. And each of those species may have equally intricate interactions with a range of other species in the forest, and so a whole web of interactions is maintained.

5.3.2 Food chains and food webs

All organisms need energy to survive and reproduce. There are two main potential sources of energy: the sun, and other organisms, either living or dead. The terms used to describe the sorts of organisms that get their energy from these different sources, along with some examples, are shown in Table 5.2.

The process whereby energy is transferred from the sun to primary producers to primary consumers to secondary consumers, is known as a **food chain**. Transferring energy from one trophic level to another is not very efficient. Generally, only about 10% of the energy in a given source is converted into living matter; the rest is lost mostly as heat.

Table 5.2.
Feeding relationships. Adapted from Pomeroy and Service (1986)

Feeding, or trophic, level	Examples
Primary producers (autotrophs) derive energy directly from sunlight by photosynthesis	Green plants; autotrophic bacteria
Primary consumers (herbivores) derive energy by consuming primary consumers	Grazers: eat low-growing herbage *(e.g. cattle)* Browsers: eat leaves and twigs *(e.g. duikers, colobus)* Frugivores: eat fruit *(e.g. hornbills, chimps)* Granivores: eat small seeds *(e.g. mice)* Nectarivores: eat nectar *(e.g. sunbirds)* Sap-feeders *(e.g. aphids)*
Secondary consumers (carnivores) derive energy by consuming primary consumers or other secondary consumers	Insectivores: eat insects *(e.g. many small birds)* Piscivores: eat fish *(e.g. otters)* Cannibals: eat members of their own species *(e.g. occasionally reported in monkeys)*
Decomposers derive energy by consuming dead producers or consumers or their waste products	Detritivores: eat small particles of organic matter *(e.g. earthworms)* Saproxylics: eat dead wood *(e.g. termites and some beetles)* Coprophages: eat dung *(e.g. dung-beetle)* Saprophytes: plants that get some of their energy as decomposers *(e.g. some forest floor orchids)*

This means that there is only a limited amount of energy available for life in any ecosystem, and most of the energy originally absorbed from the sun by plants will have been lost by the time it has passed through a food chain to the secondary consumers. This is the main reason why carnivores and other so-called **top predators**, which sit at the top of the food chain, are normally much rarer than herbivores, which are in turn rarer than green plants. This effect is known as a **pyramid of numbers**, or, since it is not so much numbers as mass which is important, a **pyramid of biomass** (Figure 5.1).

Because many animals do not restrict their feeding to one food source, feeding relationships in any ecosystem consist of numerous inter-linked food chains, called a **food web**. For example, crowned eagles will normally feed on forest primates (which are primary consumers), but sometimes they will also eat insectivorous birds (which are themselves secondary consumers). Humans are even less choosy: we eat plants, herbivores such as goats and duikers, and occasionally carnivores such as dogs, and decomposers such as fungi. As such, we are called **omnivores**.

Food chains and food webs do not stop at the top predator, of course, because even predators are food to decomposers when they die, and, like all animals, are constantly producing waste products while they are alive, which still contain enough energy to feed other decomposers. Without the decomposers, the whole ecosystem would grind to a halt as dead plants and animals and waste products would just accumulate rather than being decomposed and recycled.

It is impossible to represent all the possible feeding relationships that exist in a forest, but Figure 5.2 attempts to do this for a small selection of forest organisms.

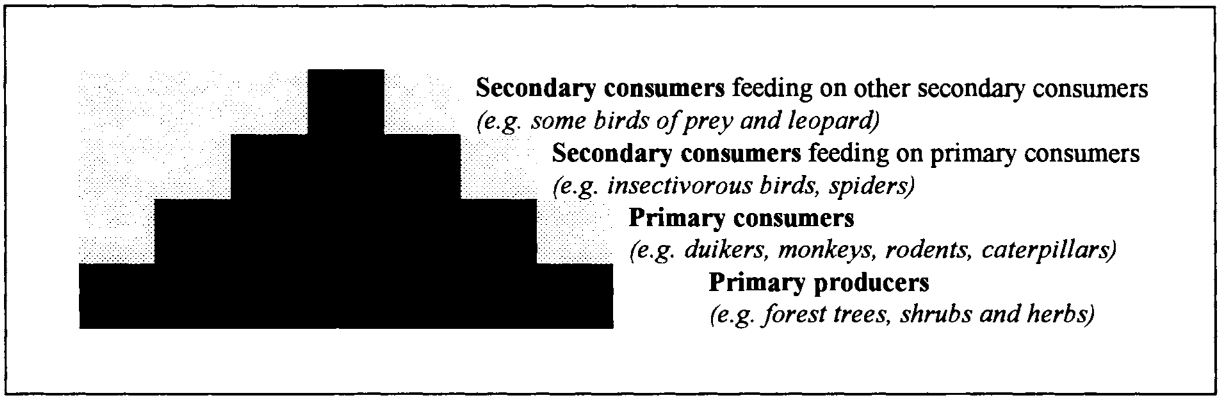


Figure 5.1. A simplified pyramid of biomass for an African tropical forest food chain.

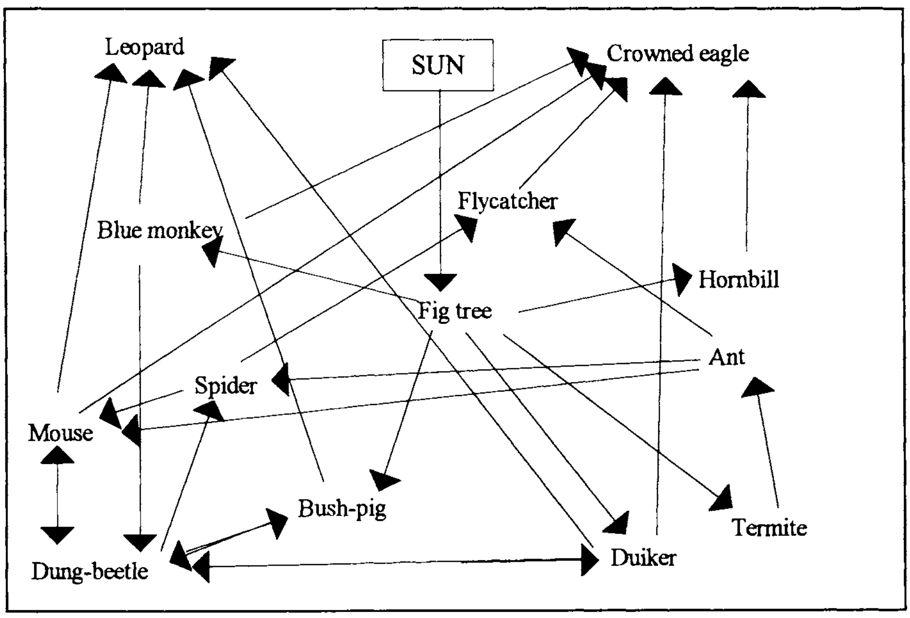


Figure 5.2. A simplified food web for an African tropical forest ecosystem. The arrows point from the consumed to the consumer.

5.3.3 Ecological cycles

Organisms interact with their environment in numerous ways. Perhaps the most important are the various cycles, such as nutrient cycles (involving nitrogen and other elements essential for life), carbon cycles and water cycles. If it were not for living organisms, many of these cycles would not be possible; likewise, if the cycles are interrupted or disrupted by human activities, then whole ecosystems can suffer. Since we are part of those ecosystems, then we need to be aware of the consequences of any disruption. This is not the place to discuss these cycles in detail, but some of the more important cycles are summarised below. See Desmukh (1986) or Pomeroy and Service (1986) for fuller accounts.

5.3.31 Nutrient cycling

There is not space here to go into this subject in detail, but it is worth noting that the main contributors to the recycling of nutrients in any ecosystem, and particularly forests, are the **decomposers**. In a tropical forest, most of the available nutrients normally reside at any one time in living plants and animals; the soil is normally quite deficient even though this is the original source of much of the nutrients. Thus the main way that nutrients can become available for new plant growth is when old plants die. A study reported by Swift, Heal and Anderson (1979) recorded a "litterfall" (leaves, twigs, fruit and flowers etc.) rate beneath lowland tropical rainforest of about 890 $g/m^2/yr$. Once dead, whether it be whole trees or just leaves, a whole army of decomposers, such as bacteria, earthworms, termites and many insects, get to work. The same study also recorded 5,000,000 bacterial cells per gram of soil beneath a tropical rainforest, plus 65,000 organisms classed as microfauna, 22,000 mesofauna and 1,650 macrofauna per square metre. Most of these organisms are involved in decomposition. Thus in quite a short time, most of the nutrients and energy will have been extracted from the plant remains. Animal remains and waste products will be treated in the same way. Some of the nutrients thereby released will be consumed by animals consuming the decomposers, while some will eventually end up in the soil. Almost as soon as they arrive there in a mineral form, plant roots, often aided by symbiotic associations with fungi (called mycorrhizae), will take up those nutrients and build them into their own tissues, so completing the cycle.

Human activities can easily interfere with these cycles. If forest is burnt, or excessive timber, firewood or charcoal is removed, then a sizeable proportion of the nutrients will be lost too, and subsequent regeneration of the forest will be less vigorous than otherwise. If the soil is also exposed and nutrients lost through leaching and run-off, the results can be severe. Many parts of the world which should be able to support forest do not do so because they have lost too many of their nutrients. Sometimes those nutrients end up in other ecosystems. If the land receiving the nutrients is farmland, then this can be put to good use. An example is the very fertile valleys that lie below the eroded slopes of Kigezi, or the West Usambaras in Tanzania. But if there are too many nutrients around, then conditions are said to be *eutrophic*, and only a limited range of plant species will thrive under such conditions.

5.3.32 Carbon cycling

Carbon, in the form of sugars, is the means used by most organisms to store energy. As such, it is passed through the ecosystem when one organism consumes another. Plants initially fix (assimilate) carbon from atmospheric carbon dioxide during photosynthesis; both plants and animals ultimately return carbon dioxide to the atmosphere during respiration, thereby releasing the energy contained in the sugars for other uses. Without green plants constantly absorbing carbon dioxide during photosynthesis, the level in the atmosphere would keep rising.

Recently, levels of carbon dioxide have been rising anyway. This is partly attributed to the loss of forests and vegetation worldwide as a result of human activities, and partly to the burning of fossil fuels which contain carbon that has been "locked away" for millions of years. It is now feared that the increase in carbon dioxide in the atmosphere may lead to global warming through the so-called "greenhouse effect". It does not take much ecological understanding to see that this could have profound effects on ecosystems worldwide, and ultimately on our own species. One solution to this problem that is being given support now is reforestation, to "sequester" or lock away some of the excess carbon dioxide. Since forests grow quickest in the tropics, this is where we can expect to see most reforestation effort. Recent plans for afforestation on Mount Elgon and elsewhere by FACE (a Dutch energy consortium) are part of this concern. It should be remembered, however, that the beneficial effects of afforestation only last as long as the wood: if the wood is burnt or rots, the carbon is again released back to the atmosphere.

5.3.33 Water cycling

Water is essential for life; the wettest places on earth support more species and more biomass than places where water is a limiting factor. The main reservoirs of water are the oceans and lakes. Living plants also act as a reservoir since water is a product of respiration and is constantly lost by plants during transpiration. Through evaporation and transpiration, water ends up in the atmosphere, eventually to fall to earth as rain or snow.

It has long been argued that without forests, there would be less rain. Whether this is true seems to depend on the area in question. For somewhere the size of the Amazon forests, or possibly even the forests of Zaire, it may be so. Clark (1992) found that annual rainfall may decrease by 650-800 mm over large areas that have been deforested, accompanied by a rise in surface temperatures of about 3°C and reduced cloud cover. In Banjul, The Gambia, annual rainfall fell from 1240 mm in 1965, when the surrounding land was well forested, to 650 mm in 1988, when deforestation was almost complete (Sayer et al, 1992). Despite these claims, many people now argue that smaller areas of forest contribute an insignificant amount of moisture to the atmosphere. Sometimes the arguments seem rather circular: for instance, does the high rainfall over Budongo Forest compared to adjacent areas (Figure 5.3) reflect the rain-making properties of the forest, or is the forest there and not elsewhere because the rainfall is higher, due to some other reason such as geographical location? Some people think that it is possible that in areas where most rainfall is convectional (as in much of Uganda), even relatively small forest areas (such as Budongo) might enhance convection sufficiently (because of the "rough" surface of forests and their darker, more heat-absorbing colour) to trigger showers.

It is also argued that some forests, particularly on watersheds, act as sponges, absorbing the impact of heavy or seasonal rains and allowing water to percolate through to the water-table rather than over the surface, and allowing year-round flows in rivers (Hughes, 1950). Since watershed protection is one of the main functions of many of Uganda's forest reserves, it is worth examining this more closely. Generally, anecdotal evidence supports the view that some forests may act in this way. For example, when the forested area of the Parc National des Volcans in the Rwandese Virungas was reduced by 40% in the 1970s (mostly for a pyrethrum-growing project), several of the streams that had previously fed the intensively farmed land below dried up (Ehrlich and Ehrlich, 1990). Similarly, long-term residents of the East Usambara mountains in Tanzania have reported that streams and springs in deforested areas are now dry, and that the climate in general has become hotter and drier (Hamilton, 1989).

A further possibility is that forests produce "occult precipitation", that is, they induce water to settle out of fogs and mists. Nicholson (1930) concluded from studies in Africa and India that in East Africa, occult precipitation was likely to account for about 25% of rainfall in mountain forests.

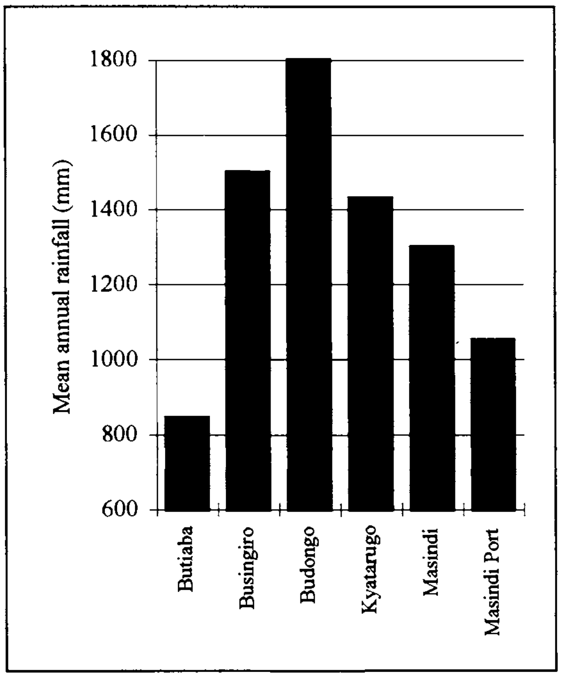


Figure 5.3. Variation in mean annual rainfall in part of north-west Uganda, from west (Butiaba) to east (Masindi Port), through Budongo Forest. Rainfall peaks in Budongo Forest, and declines towards the forest edge at Busingiro and Kyatarugo, apparently tailing off further with distance from the forest. Data are from Eggeling (1947), and refer to ten-year averages to 1943, apart from the figure for Budongo which was a temporary station in the centre of the forest recorded from 1939-1941 only. It is possible that these three years were unusual: more systematic rainfall recording and analysis would be needed to be sure of the apparent trend.

5.4 ECOSYSTEMS AND VEGETATION TYPES

An **ecosystem** is *a functioning, interacting system composed of one or more living organisms and their effective environment, both physical,* of the ecosystem can be used at a variety of scales, since its main value is that it enables us to delineate areas into manageable sizes. How big those areas are depends on what we want from the information.

5.4.1 Biomes

The widest possible scale at which the ecosystem concept applies is the **biome**. Biomes are the major ecological zones of the world, such as tropical rainforest, tropical dry forest, savannah, temperate deciduous forest, tundra and so on. Uganda has three main terrestrial biomes, comprising the first three in this list. One problem is that there is no universally agreed classification. Where, for instance, do we draw the line between tropical rainforest and tropical dry forest? Should we base the classification on what grows there, or on climate? If we just used climate, we would find that some of the savannahs of Africa would have to be grouped with eucalyptus forest in Australia, because eucalypts seem to be able to survive in climatic conditions that in Africa can only support savannah. This means that we still do not know how much of each biome exists on earth. Maps showing the global extent of tropical rainforest differ markedly depending on the classification adopted. Some show tropical rainforest in Uganda, while others do not. Figure 5.4 shows a classification for Africa.

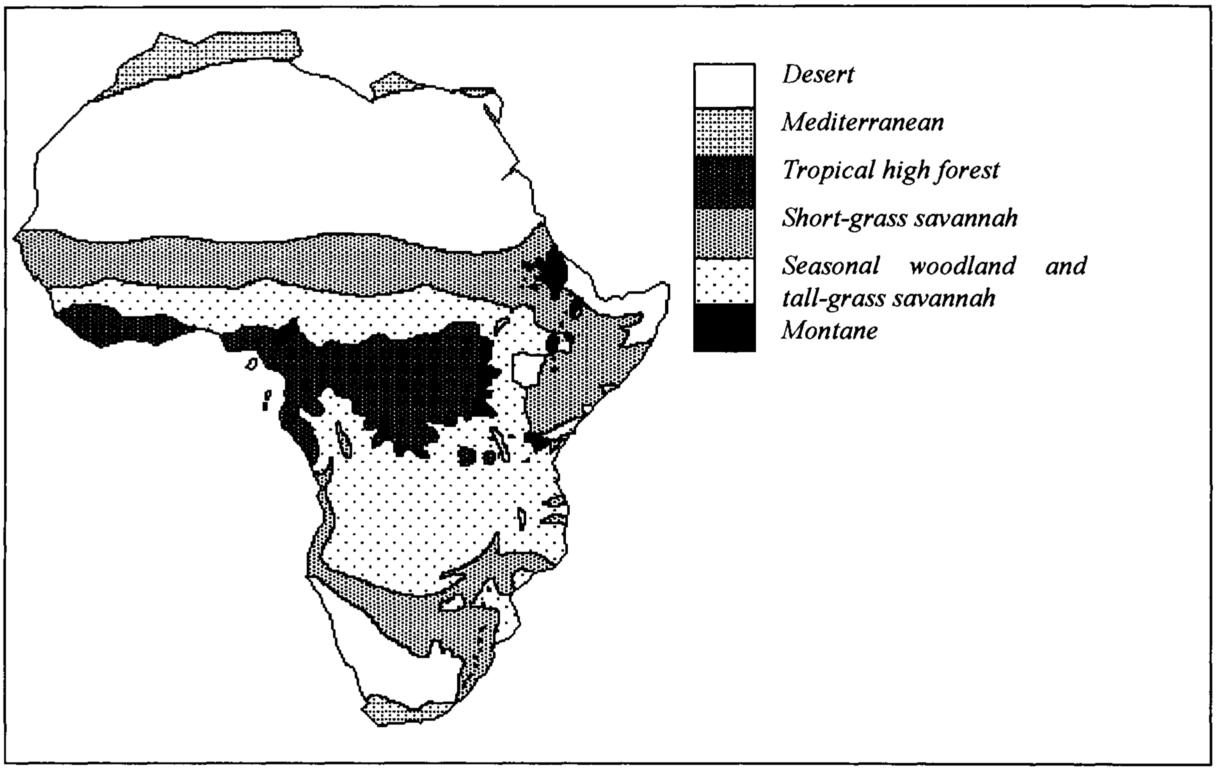


Figure 5.4. A map of the main biomes in Africa. After White (1983).

5.4.2 Vegetation types

Looking at a vegetation map on a finer scale, such as that of Uganda produced by Langdale-Brown, Osmaston and Wilson (1964) (Figure 5.5), one can see that the country is divided into numerous **vegetation types**. These are classified by which plants grow together there, with a particular emphasis on the most dominant types. As such, they are not a full description of the ecosystem, but are descriptions of **plant communities**. Although such a classification does not consider what animals live there, it is often the case that if one can label an area by its vegetation type, one will also be enabling others to know what animals can be expected there too. Box 5.1 outlines Langdale-Brown, Osmaston and Wilson's classification of the vegetation of Uganda. Figure 5.5 is a very simplified interpretation of this classification.

Box 5.1
A classification of the vegetation of Uganda (Langdale-Brown, Osmaston and Wilson, 1964)

A	**High Altitude Moorland and Heath**
A1	*Alchemilla-Helichrysum* moorland
A2	Ericaceae-*Stoebe* heath
B	**High Altitude Forests**
B1	*Pygeum* moist montane forest
B2	*Hagenia-Rapanea* moist montane forest
B3	*Juniperus-Podocarpus* dry montane forest
B4	*Arundinaria* montane bamboo forest
C	**Medium Altitude Moist Evergreen Forests**
C1	*Piptadeniastrum-Uapaca*
C2	*Piptadeniastrum-Albizia-Celtis*
C3	*Parinari*
D	**Medium Altitude Moist Semi-Deciduous Forests**
D1	*Celtis-Chrysophyllum*
D2	*Cynometra-Celtis*
D3	*Albizia-Markhamia*
D4	*Albizia-Chlorophora*
F	**Forest/Savannah Mosaics**
F1	at high altitudes
F2	at medium altitudes
G	**Moist Thickets**
G1	Undifferentiated semi-deciduous thicket
G2	Riparian
G3	Lowland bamboo
G4	Montane
H	**Woodlands**
H1	*Vitex-Phyllanthus-Sapium-Terminalia*
H2	*Terminalia*
H3	*Isoberlina-Daniellia*
H4	*Albizia-Combretum*
J	**Moist Acacia Savannahs**
J1	*Acacia-Albizia-Beckeropsis-Cymbopogon*
J2	*Acacia-Albizia-Chloris-Panicum*
K	**Moist Combretum Savannahs**
K	*Combretum-Terminalia-Albizia-Hyparrhenia rufa*
L	**Butyrospermum Savannahs**
L1	*Butyrospermum-Daniellia-Hyparrhenia*
L2	*Butyrospermum-Hyparrhenia rufa*
L3	*Butyrospermum-Hyparrhenia dissoluta*
M	**Palm Savannahs**
M1	*Borassus-Hyparrhenia rufa*
M2	*Borassus-Hyparrhenia dissoluta*
N	**Dry Combretum Savannahs**
N1	*Combretum-Terminalia-Loudetia*
N2	*Combretum-Hyparrhenia*
N3	*Combretum-Cymbopogon*
N4	*Combretum-Oxytenanthera-Hyparrhenia*
N5	*Combretum-Acacia-Hyparrhenia*
N6	*Combretum-Acacia-Lasiurus*
N7	*Combretum-Acacia-Heteropogon*
N8	*Combretum-Acacia-Themeda*
N9	*Combretum-Acacia-Commiphora*
N10	*Boswellia-Fagara-Heeria*
N11	*Acacia-Combretum*
N12	*Acacia-Heeria-Terminalia*
N13	*Lannea-Combretum-Lonchocarpus*
P	**Dry Acacia Savannahs**
P1	*Acacia-Cymbopogon/Themeda* complex
P2	*Acacia-Hyparrhenia-Themeda*
Q	**Grass Savannahs**
Q1	Moist *Hyparrhenia*
Q2	*Hyparrhenia* grass savannah derived from Type L
Q3	Dry *Hyparrhenia*
Q4	*Themeda-Chloris*
Q5	*Themeda-Loudetia*
Q6	*Themeda-Heteropogon*
Q7	*Eragrostis-Loudetia*
R	**Tree and Shrub Steppes**
R1	*Acacia*
R2	*Lannea-Acacia*
S	**Grass Steppe**
S	*Chrysopogon*
T	**Bushlands**
T1	*Acacia mellifera*
T2	*Acacia-Commiphora-Lannea*
T3	*Acacia-Commiphora*
T4	*Acacia reficiens-Commiphora*
T5	*Commiphora-Euphorbia-Lannea*
T6	*Lannea-Acacia-Balanites*
T7	*Acacia-Albizia-Dichrostachys*
T8	*Acacia mellifera*
T9	*Acacia seyal-Acacia nilotica-Pennisetum mezianum*
V	**Dry Thickets**
V1	Undifferentiated deciduous thicket
V2	*Acacia-Euphorbia*
V3	*Acacia-Commiphora*
V4	*Acacia nubica*
V5	*Acacia mellifera*
W	**Communities on Sites with Impeded Drainage**
W1	*Echinochloa* grassland
W2	*Sorghastrum* grassland
W3	*Brachiaria-Hyparrhenia* grassland
W4	*Acacia-Imperata* savannah
W5	*Combretum-Acacia-Hyparrhenia* savannah
W6	*Combretum-Acacia-Hyparrhenia* savannah
W7	*Acacia-Themeda* savannah
W8	*Acacia-Setaria* savannah
X	**Swamps**
X1	*Cyperus papyrus*
X2	*Miscanthidium*
Y	**Swamp Forests**
Y1	*Rauvolfia-Croton* seasonal swamp forest
Y2	*Baikiaea-Podocarpus* seasonal swamp forest
Z	**Post-Cultivation Communities**
Z1	*Imperata-Panicum-Hyparrhenia*
Z2	*Cymbopogon-Imperata*
Z3	*Hyparrhenia-Pteridium*
Z4	*Eragrostis-Chloris-Hyparrhenia*

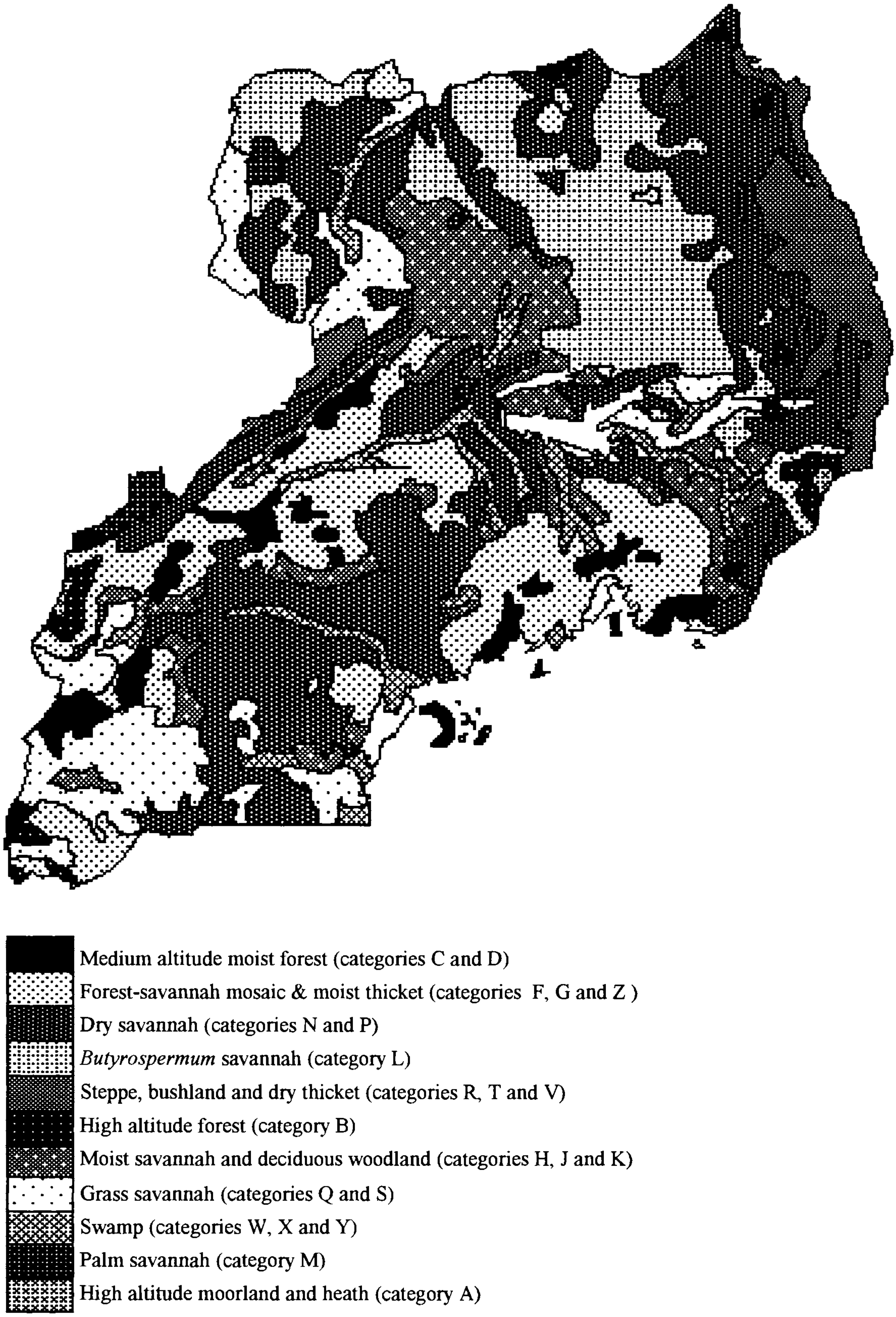


Figure 5.5. A simplified version of Langdale-Brown, Osmaston and Wilson's vegetation map of Uganda. Redrawn from Atlas of Uganda (1967). See Box 5.1 for details.

5.4.21 Why classify vegetation types?

If we know what vegetation types exist in an area, and how common or rare each vegetation type is either locally, nationally or internationally, then we are in a better position to make a rational plan for conserving as wide a variety of vegetation types (and therefore ecosystems and species) as possible. A map of vegetation types also provides a "snapshot" of the situation at the time of the survey, against which future changes in vegetation types can be monitored. Vegetation may subsequently change for natural or human-induced reasons, and comparing standardised surveys made at different times may make it possible to quantify the change and may have implications for management.

5.4.3 What controls the distribution of vegetation types?

Various factors control what grows where. Some of them are shown in Figure 5.6.

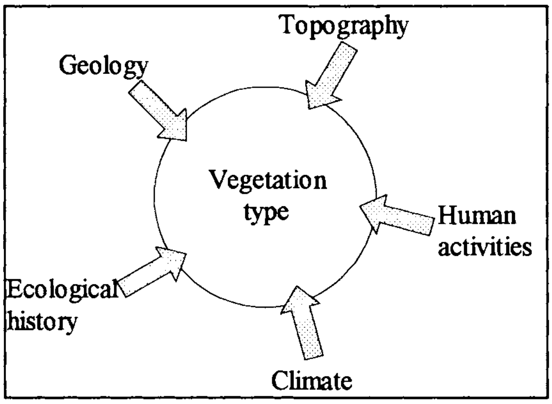


Figure 5.6. Some of the main environmental factors controlling vegetation types. See text for details.

5.4.31 Geology

The nature of the bedrock and soils has some influence on what vegetation can be supported. For instance, there is a large difference between vegetation types growing on calcareous or base-rich bedrock and those on rocks poor in calcium. This is why, for instance, heathland dominated by ericaceous shrubs (A2 in the 1964 classification) is common on the Rwenzoris, where the granite bedrock is extremely base-poor, and rare on the Virungas, where the volcanic bedrock is more base-rich. This means that a conservation area on the top of the Rwenzoris will protect a different range of species from an apparently similar area on the Virungas. Porous bedrocks often support drier vegetation types than impermeable ones for any given set of climatic conditions, although sometimes porous rocks may act as aquifers (underground reservoirs of water) that may enable deep-rooted trees to survive in what appear to be rather dry conditions. Other elements also have some effect on vegetation, but these are not well documented in Uganda, and are likely to be local in effect.

5.4.32 Topography

The biggest influence that topography has is on rainfall and temperature, which are considered under climate below. The way the land slopes also has more local effects on what grows there. Forested slopes often support more light-demanding or short-lived species than flat ground, and swamps in valleys support a different forest type again. Figure 5.6 shows the distribution of various tree species in Bwindi, from a study by Hamilton (1969). It is clear from this study that forest composition changes dramatically according to topography. This means that a conservation area encompassing, for example, just the hilltops and ridges of a forest will be unlikely to protect all the species of that forest, since many species confined to gullies or valleys will be missed.

5.4.33 Climate

Climate is undoubtedly the main factor controlling the distribution of vegetation types at a global and even national scale. The two main climatic factors responsible are **temperature** and **rainfall**.

Global temperatures are, of course, warmest in the tropics and decline towards the poles. This has major implications for vegetation. Polar regions may have sub-zero temperatures year-round, and cannot support vegetation, whereas temperatures in the tropics may be around 30^0C year-round, and can support lush vegetation. Most areas in between these extremes have strongly seasonal climates which favour certain plants over others. Most species of plants (and animals) are dependent on warm conditions, so many are absent from cooler climates. However, some prefer cooler conditions, and cannot tolerate growing in warm regions.

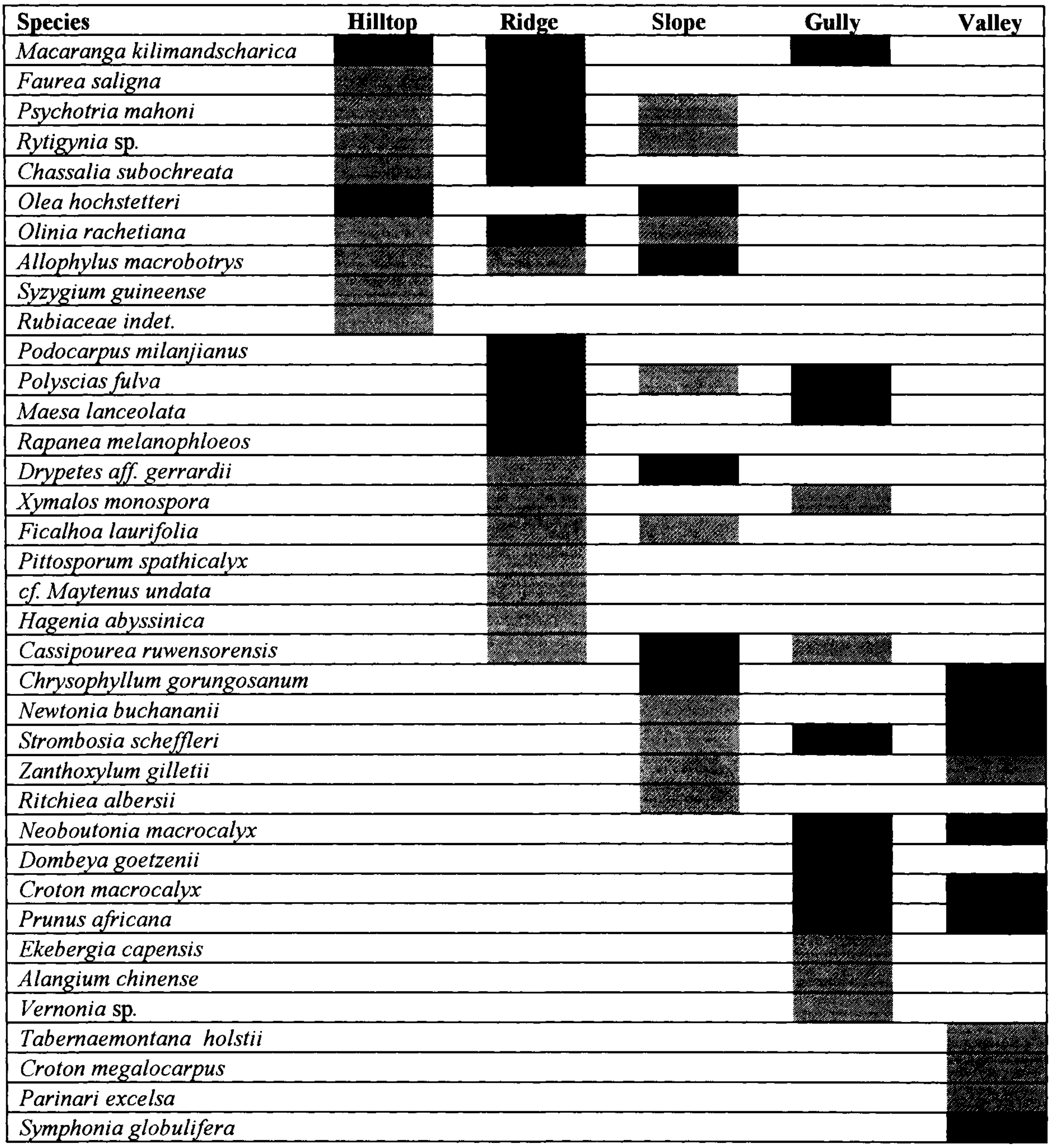


Figure 5.7. The distribution of various tree species near Ruhija, Bwindi Forest, Uganda, after Hamilton (1969). The intensity of shading indicates relative abundance, from abundant (black), through common (dark grey), to present (pale grey). Lack of shading indicates a species is absent.

In a tropical country like Uganda, there are still large variations in temperature, despite the small differences in latitude, because of the presence of mountains. Air temperatures normally vary inversely with altitude. The tops of the Rwenzoris, at over 4000 m altitude, are almost as cold as the Arctic, while the bottom of the Rift Valley around Semliki , at about 600 m, is warm year-round. Vegetation varies greatly as one ascends a mountain in Uganda, largely because of decreasing temperature. Table 5.3 shows how certain characteristics of the vegetation change. Different plant species with different physiologies and appearances will therefore occur at different altitudes, as will different animal species. Figure 5.7 illustrates how these effects determine mountain vegetation types (it also illustrates the effect of rainfall, discussed below). These changes mean that a conservation area situated at, say, 1500 m altitude on a forested mountain will protect a different range of species from another area situated at 2000 m, and different again from one at 1000 m. To ensure adequate protection of all the forest species, a conservation area would have to cover the full altitudinal range of the forest.

Table 5.3.
Changes in rainforest vegetation on tropical African mountains (Deshmukh, 1986)

	Lowland	Lower montane	Upper montane
Ht of taller trees (m)	>30	15-35	<15
Lf area index (cm^2/g)	90-130	80	70
Net wood prodn. (t/ha/yr.)	3-6	1.4	<1.4
Buttresses	Common	Rare	Absent
Predominant leaf size	Large	Large	Small
Conifers	Rare	Common	Common
Vascular epiphytes	Common	Abundant	Common
Non-vascular epiphytes	Rare	Common	Common
Woody climbers	Common	Rare	Rare
Non-woody climbers	Uncommon	Common	Rare

Rainfall varies enormously across the globe, from virtually zero in some deserts to over 5000 mm in some wet montane forests. Even in Uganda, there is great variation, as the map of annual rainfall (Figure 5.8) shows. Parts of Karamoja receive less than 375 mm, most of it falling within a few months of the year, while parts of the Rwenzori mountains may receive over 2500 mm, and possibly much more, falling virtually throughout the year. Furthermore, seasonality of rainfall is also very important in determining what can grow where. Because of this, Kagenda (1975) divided Uganda up into six "rainfall regions" based as much on seasonality as on amount of rainfall

Different plant species tolerate or require different rainfall regimes. In general, closed forest needs more rainfall, and more reliable rainfall, than woodland, which in turn needs more than scrubland or bushland types; most natural grasslands require less still. Most of Uganda's closed forests probably receive about 1200 to 1500 mm of rain per year, in two rainy seasons. Some parts of the country, such as around Gulu, receive sufficient rainfall for forest but none is present, probably because of a long dry season. All Uganda's closed forests lie at the lower end of the range of rainfall regimes under which this vegetation type will grow in the tropics. Tropical closed forest is distributed in Uganda as follows:

- High rainfall belt north-west of Lake Victoria
- High rainfall belt along the eastern side of the Western Rift Valley
- Medium rainfall belt between the first two, where there are some young forests
- Mountains over 1,800 m where sufficient orographic rainfall occurs

5.4.34 Ecological history

What happened in an area in the past will have some bearing on what can grow there now. For example, pine forests are still spreading northwards across Siberia, even though the ice-fields that once stopped them growing there have been gone for hundreds or thousands of years. In Uganda, vegetation belts were about 1000 m lower during the Ice Age peak (21,000-14,000 years ago) than they are now; they are probably still ascending up the mountains. Today, the vegetation zones are not static, and will continue to vary as climates change. Some of the changes in vegetation in tropical Africa over the last two and a half million years are summarised in Box 5.2.

5.4.35 Human activities

One of the biggest factors controlling the distribution of vegetation types and the boundaries of forests these days is the effect of human interference: grazing, burning and cultivation. Although cultivation in Africa's closed tropical forests is generally thought to have begun with the arrival on the continent of suitable crops such as plantains from south-east Asia 2000 years ago, radio-carbon dating suggests that in south-west Uganda, forest clearance may have begun as early as 4,800 years ago (Hamilton, Taylor and Vogel, 1986), although others dispute these dates. Thus the forest-savannah mosaic that covers much of western and southern Uganda is a product not simply of natural processes but of human-induced ones as well, and the same goes for the savannahs and scrublands of other parts of the country. This will be covered more fully in section 5.6.2.

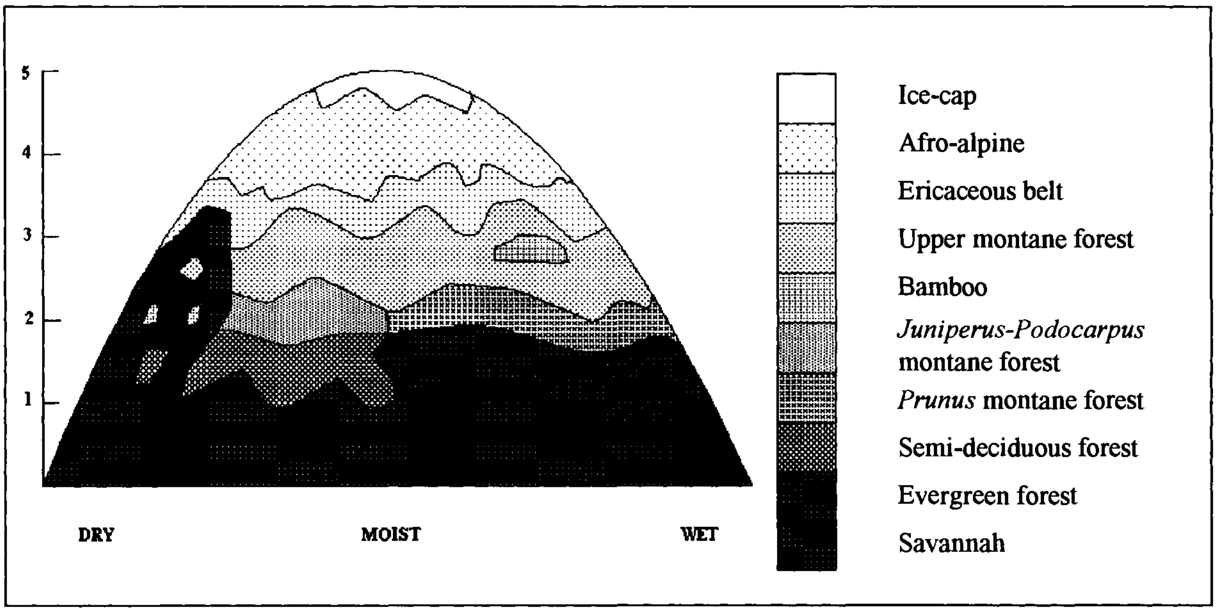


Figure 5.8. Montane and forest vegetation in relation to altitude and moisture in tropical Africa, after Kingdon (1990). This is a generalised diagram; not every mountain may have all zones. In Uganda, ice-caps are restricted to the Rwenzoris. Altitudes are given in thousands of metres.

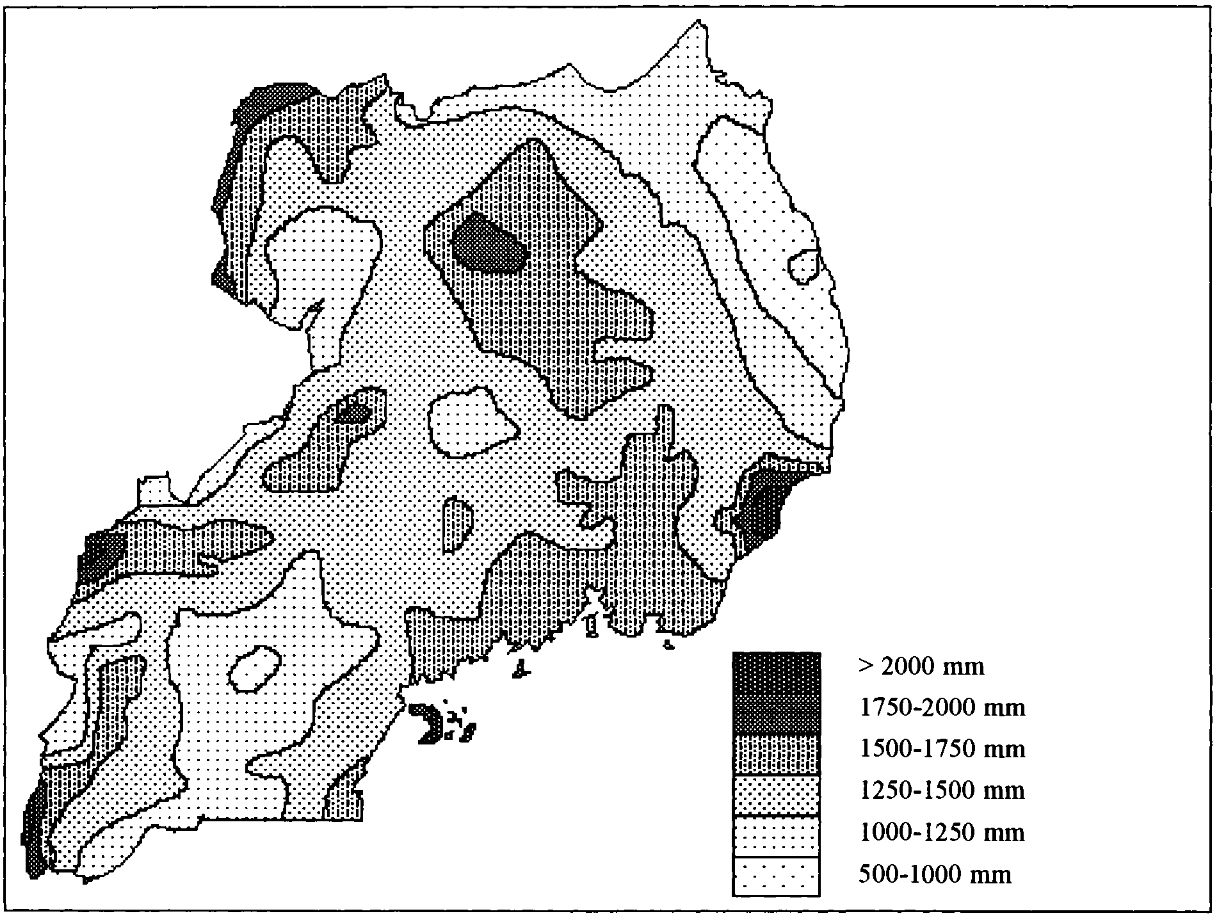


Figure 5.9. Simplified annual rainfall map of Uganda, based on Atlas of Uganda (1967).

Box 5.2
Some of the main changes in climate, and corresponding vegetation changes, in tropical Africa over the last 2.5 million years (After Kingdon, 1990)

- **2,500,000 -1,000,000 Before Present (B.P.)**: 21 "ice ages" leading to cooler and drier conditions alternating with warmer, wetter periods
- **40,000 B.P.**: Oscillating warm to cool to warm; montane forest expanded in cool period
- **33,000 B.P.**: Warm and wet
- **30,000 B.P.**: Cool and dry
- **20,000 B.P.**: Warm and wet
- **13,000 B.P.**: Maximum extent of most recent "ice age", leading to cool, dry conditions and contraction of forest to relatively wet "refugia" (see section 4.3.2)
- **12,000 B.P.**: Rainy seasons wetter; forests begin to expand; Lake Victoria overflows
- **11,000 B.P.**: Wet: forest expansion; warm: ice retreats on Elgon and Rwenzoris
- **10,000 B.P.**: Some evidence for slight forest reduction
- **7,000 B.P.**: Wet - forest at maximum extent
- **5,500 B.P.**: Some moist forests replaced by drier types
- **5,000 B.P.**: First suggestions of forest clearance by humans in Kigezi
- **3,500 B.P.**: Forest decline in West Africa, coinciding with introduction of agriculture
- **1,700 B.P.**: Major forest clearance in East Africa, accompanied by expansion of agriculture and livestock
- **Present**: Most forest cleared from East and West Africa; clearance spreading rapidly in Central Africa

5.5 NICHES AND HABITATS

5.5.1 What is a niche?

A forest or any other ecosystem can only function because all the organisms that go to make up the living part of it (the community) have different roles. Much as within the Forest Department there are staff with widely differing duties, which all help in the day-to-day running of the Department, so too in nature are there organisms with a whole range of roles which all contribute to the functioning of the ecosystem. The role of any organism in the community is called its **niche**. The concept of the niche covers not just what an organism needs to survive, but also how it relates to the rest of its environment. To return to the analogy with the Forest Department, a District Forest Officer needs someone in the Accounts section at Headquarters in order to get a salary processed, but that person in Accounts does not necessarily need that Forest Officer. However, the relationship between the two officers nevertheless contributes to each one's role in the Department. Likewise, in a forest, it may not affect a chimpanzee if there are no dung beetles to consume its dung, since some other scavenger will do the job instead. But it may matter to the dung beetle whether or not there are chimpanzees producing dung for it, and it will also matter to the dung beetle's predators and parasites. So the chimpanzee's niche is not just that of "large arboreal frugivore", it is also that of dung-producer to the forest's dung-beetles.

Let us take the analogy a bit further. Suppose a new DFO was posted to a district that already had a DFO. In the end, one of them would have to move on, or resign, or they would have to divide the job up so that each had a distinct role, as a district cannot support two members of staff with exactly the same job or role. On the other hand, if the new member of staff was a FO in charge of extension, and the district did not already have an extension officer although it did have FOs filling other roles, then there would be no conflict of interest and all staff could remain in post. In a forest, a similar situation exists, in that it is thought that no two species have exactly the same roles or niches. This is called the *theory of competitive exclusion*, because it is predicted that if a new species appears with the same niche as one that already exists in that area, then one of the two species will be completely out-competed in that niche: the forest cannot accommodate both. Either one of the two species will disappear, or one or both of them will shift their roles slightly so that they can both survive.

Niches can be looked upon as an organism's response to environmental variables. Those variables can be the presence or absence of other species (competitors, predators etc.), or non-living things such as climate. Whatever the variable, most species will have some preference for a certain amount of it. For instance, a tree seedling may only germinate over a certain range of temperatures. If it becomes too cold, the seed dies, and if it becomes too hot, it may also expire through heat stress. But this is just one variable. Now consider how that seedling responds under different light conditions. If light levels are too low, it may not germinate, and if light levels are too high, it may germinate but then get killed by intense sunlight. This further limits the range of conditions under which the seedling will survive (Figure 5.10).

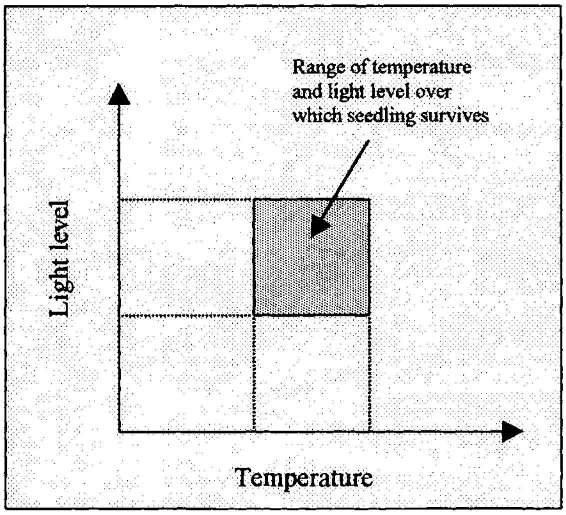


Figure 5.10. Illustration of a niche in two dimensions, using seedling survival under different temperatures and light levels.

Now let us add the effect of different levels of humidity. If the atmosphere is too dry, regardless of temperature or light level, the seedling may desiccate. If it is too wet, it may get killed by mould. We now need a third axis to the graph in Figure 5.9. By considering more and more variables, we would need more and more axes to represent the effect diagrammatically, which is rather difficult to imagine. Nevertheless, we should try to imagine adding hundreds of variables, each one further limiting the range of conditions over which the seedling will survive. Then consider another set of variables for when the seedling has become a sapling, then a mature tree. Because there are so many, the niche has been described as an *n-dimensional hypervolume* (Hutchinson, 1965). Box 5.3 lists just a few of the possible physical variables that may determine the niche of a plant species.

As a further example, this time from an animal, Figure 5.11 illustrates two dimensions in the niche of the tsetse fly. The fly's response to just these two variables means that we can predict roughly where tsetses will survive and where they will not, although we would need to know its response to many more variables to be certain. But even with these two variables, it is clear that certain parts of the country are ruled out completely, as are certain vegetation types. For instance, in closed forest, humidity would be too high, while in shrubless grassland it would sometimes be too low. Hence tsetses tend to occur in bushland where there is some shade which gives the right level of humidity and temperature for their survival. Remember that this is just one species of tsetse fly (*Glossina mortisans*). Other species of *Glossina* may be expected to have slightly different tolerances to these variables, and so may occupy a slightly different environment.

Box 5.3
Some of the physical variables that may determine the niche of a plant species

- Annual temperature
- Temperature in the growing season
- Temperature of coldest month
- Extreme temperature
- Frost frequency
- Frost-free period
- Annual rainfall
- Rainfall in growing season
- Length of dry season
- Rainfall intensity

- Sunshine hours
- Flood frequency
- Relative humidity
- Frequency and severity of wind
- Slope angle
- Aspect
- Exposure index
- Landslide frequency
- Altitude
- Rock type
- Rock chemistry

- Groundwater depth
- Soil salinity
- Effective soil depth
- Evaporation
- Soil structure
- Soil structure
- Soil drainage class
- Soil permeability
- Soil water holding capacity
- Soil nutrient content
- Soil organic matter content
- Soil pH

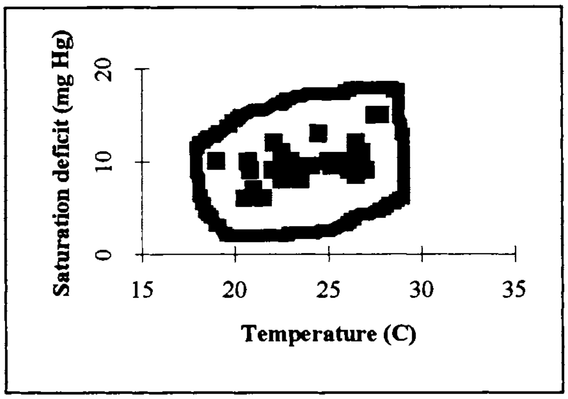


Figure 5.11. Two dimensional representation of the niche of the tsetse fly. Dots indicate combinations of temperature and saturation deficit (a measure of humidity) under which conditions tsetses survive. The dark line encloses an area representing the likely extent of the niche with respect to these two variables. After Rogers (1979).

5.5.2 Fundamental niches, realised niches and resource partitioning

An organism's response to non-living variables determines its maximum possible niche size, or **fundamental niche**, but its **realised niche** (i.e. the niche that is actually occupied) is usually more restricted because of interactions with other species, such as competition and predation. For instance, if there were only one species of squirrel living in a forest, then it might be free to eat nuts, berries, bark and insects. However, if there were several species living in the same forest, they would have to somehow divide up the food resources between them, such that, over the generations, one species became specialised at feeding on nuts and another on insects and so on. This is called **resource partitioning**. It tends to result in species having very specialised niches, and is particularly pronounced in tropical forests where so many species coexist. Table 5.4 illustrates resource partitioning in some African forest squirrel species. Looking at just three characteristics - habitat (see below), food preference and body size, it seems that no two species have the same requirements, even though they all live in the same forest. Tropical forests are, therefore, particularly rich in **specialist** species, and relatively poor in **generalists**, whereas less species-diverse ecosystems, such as deserts and temperate forests, have a higher proportion of generalists. A whole range of variation exists among species of any ecosystem in the gradation of niches from specialist to generalist. Figure 5.12 demonstrates the gradation for some tropical forest species.

Table 5.4.
Resource partitioning in coexisting West African forest squirrels. After Emmons (1980)

Habitat	Food preference	Body size	Species
Canopy of mature and disturbed forest	Bark scrapings	Tiny	*Myosciurus pumilio*
	Insects and other arthropods	Small	*Aethosciurus poensis*
		Medium	*Heliosciurus rufobrachium*
	Nuts	Large	*Protoxerus stangeri*
Ground beneath mature and disturbed forest	Termites	Small	*Funisciurus lemniscatus*
		Medium	*Funisciurus pyrrhopus*
	Hard nuts	Large	*Epizerus ebii*
Dense vegetation	Leaves, insects and other arthropods	Small	*Funisciurus isabella*
Flooded forests	Ants	Medium	*Funisciurus aneryrthrus*

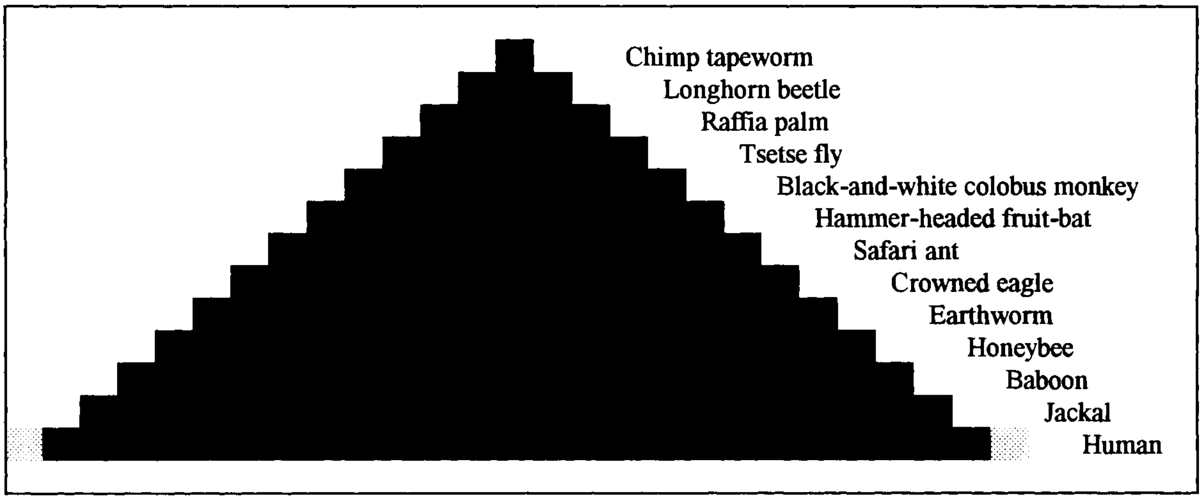


Figure 5.12. Variation in niche-width amongst some African forest organisms. Species with narrow niches (specialists) appear towards the top of the figure, while those with broad niches (generalists) appear towards the bottom. Adapted from Hungerford et al. (1994).

Even within any one group of organisms, there are some species that are more specialised than others. For instance, Bennun et al. (unpubl.) have shown that the forest birds of Uganda and Kenya can be divided fairly readily into three main groups:

- ***forest specialists***: species most characteristic of the interior of undisturbed forest (203 spp.)
- ***forest generalists***: species typical of edges, gaps and secondary forest (167 spp.)
- ***forest visitors***: species which are not dependent upon forest and are usually more common outside it (96 spp.)

As an example of two closely-related birds that fall into different categories, Cassin's spinetail is a bird that is listed as being a forest specialist, since it is only found in large tropical moist forests, while the mottled-throated spinetail is listed as a forest generalist, since it occurs in various woodland and forest types. The authors go on to argue that it is the forest specialists that are most vulnerable to human-induced changes, and therefore merit more conservation attention. For example, the mottled-throated spinetail would probably not suffer much from conversion of dense forest to lighter woodland, whereas Cassin's spinetail would. In general, if we look after the specialists, then the generalists will look after themselves.

5.5.21 Why do we need to know about niches?

It is not necessary, nor would it be possible, to know the precise niche of every species that lives in a forest. However, two things about niches are important:

- The niche of an individual organism belonging to any species confines it to certain conditions, outside of which it cannot survive
- Tropical forests are rich in specialist species with narrowly defined niches

These lead to numerous management implications, and means that altering conditions in a forest will inevitably affect many of its inhabitants. If, for example, we log a natural forest, the humidity and light levels will change so much that we may alter the balance of tree species surviving as seedlings, and ultimately the whole species composition of the forest. This may be desirable or not, depending on the management objectives, but it is certainly worth being aware of. Similarly, if an exotic tree species is introduced into a natural forest that suits it ecologically, it may become invasive, and competitively exclude native species from their own niches (see Section 8.4). If we have an understanding of its niche before we introduce it, we may be able to predict whether it will become invasive and take precautions.

5.5.3 What is a habitat?

A habitat is simply a place where an organism lives. It is made up of a set of conditions which includes other living organisms as well as non-living components. Where an organism is able to live is determined by its niche. To take the example of the tsetse fly (Figure 5.11), its habitat (open bushland) is determined by its preference for certain temperatures and humidity, as well as other components of its niche such as the presence of livestock or game.

5.5.4 Habitats in a tropical forest

There is no theoretical limit to how big or small a habitat may be. Small habitats are often called **microhabitats**, but this just means that they look small to humans. Examples of organisms with small habitats include the mites that live their entire lives in the roots of eyelashes of primates, or the many species of beetle and other insects that complete their life cycles under the bark of old trees, occupying no more than a few cubic centimetres of wood during their lives. In fact, most species in a forest probably occupy habitats in the micro-scale, although our attention tends to be attracted by those few conspicuous species with larger habitats.

5.5.41 Old tree microhabitats

Consider, for instance, an old tree. It may be thought of as just a single organism that is past its prime, and often in forestry it would be considered to be past commercial maturity. But old trees consist of very many distinct microhabitats for a wide range of smaller species, some of them decomposers, others predators and parasites of the decomposers. These are the so-called *saproxylic* organisms, described by Speight (1989) as *species which are dependent, during some part of their life cycle, upon the dead or dying wood of moribund or dead trees (standing or fallen), or upon the presence of other saproxylics.* They include invertebrates and fungi in particular, and are an important group in forests, not only because there are so many species involved (which makes them important for conservation), but also because they help recycle the nutrients in dead wood. Because an old tree is home to so many species, Speight (1989) uses the term "arboreal megalopolis" to draw the comparison with a crowded city. Some microhabitats associated with old trees are listed in Box 5.4. Note that each of the microhabitats listed could be further subdivided according to the microclimate in which each one was found.

Old trees also tend to be rich in **epiphytes**. Epiphytes are plants that use the tree as a substrate or habitat, but do not draw any nourishment from the tree. They get their nutrients either from humus accumulated in crevices in the bark, or from rain, mist, dust or run-off from the tree's bark. Only certain tree species will support epiphytes, but whatever the species, usually the older the tree the more epiphytes it will support. *Cynometra alexandri* and *Parinari excelsa*, both large trees of mature tropical moist forest in Uganda, are particularly important for epiphytes: for instance, Eggeling (1948) recorded nearly 100 species of epiphytes from Budongo Forest, many from mature *Cynometra* trees. Each epiphyte species has its own preferences for microhabitat, which can lead to **zonation** of species along a branch.

Box 5.4
Some microhabitats particularly associated with old, commercially overmature, trees

- Loose bark
- The bark/wood interface
- Heart rots and tree humus
- Rot-holes
- Saproxylic fungi
- Burrows and cavities of saproxylic insects
- Root plates
- Standing dead tree trunks
- Tree stumps
- Fallen twigs
- Underground rotting roots
- Fallen branches and logs, with or without bark

Figure 5.13 shows zonation of 23 species of epiphytes found on a single branch of an old *Parinari* tree. Since about 10% of all vascular plant species are epiphytes (Mabberley, 1992), and most of these live in tropical forests, it is important that we take epiphyte conservation as seriously as tree conservation.

5.5.42 Forest termites

One group of forest organisms that is strongly associated with old trees is the termites. Most species feed on dead wood, although others feed on organic material in the soil, or on leaf litter, or even on living vegetation (much of it derived from the trees anyway). Although to many of us one termite looks much like the next, a single forest may support dozens of species, all with slightly different microhabitats or niches. For example, 32 genera of termites (comprising, therefore, no fewer than 32 species and probably many more) that were found to coexist in a tropical rainforest in Cameroon (Collins, 1989).

5.5.43 Forest bird habitats

Forests offer a large number of possible habitats for plants and animals, which is one reason why they are so rich in species. Part of the reason is to do with their complex three-dimensional structure, for example, the division of the forest into several strata such as canopy, shrub layer and forest floor.

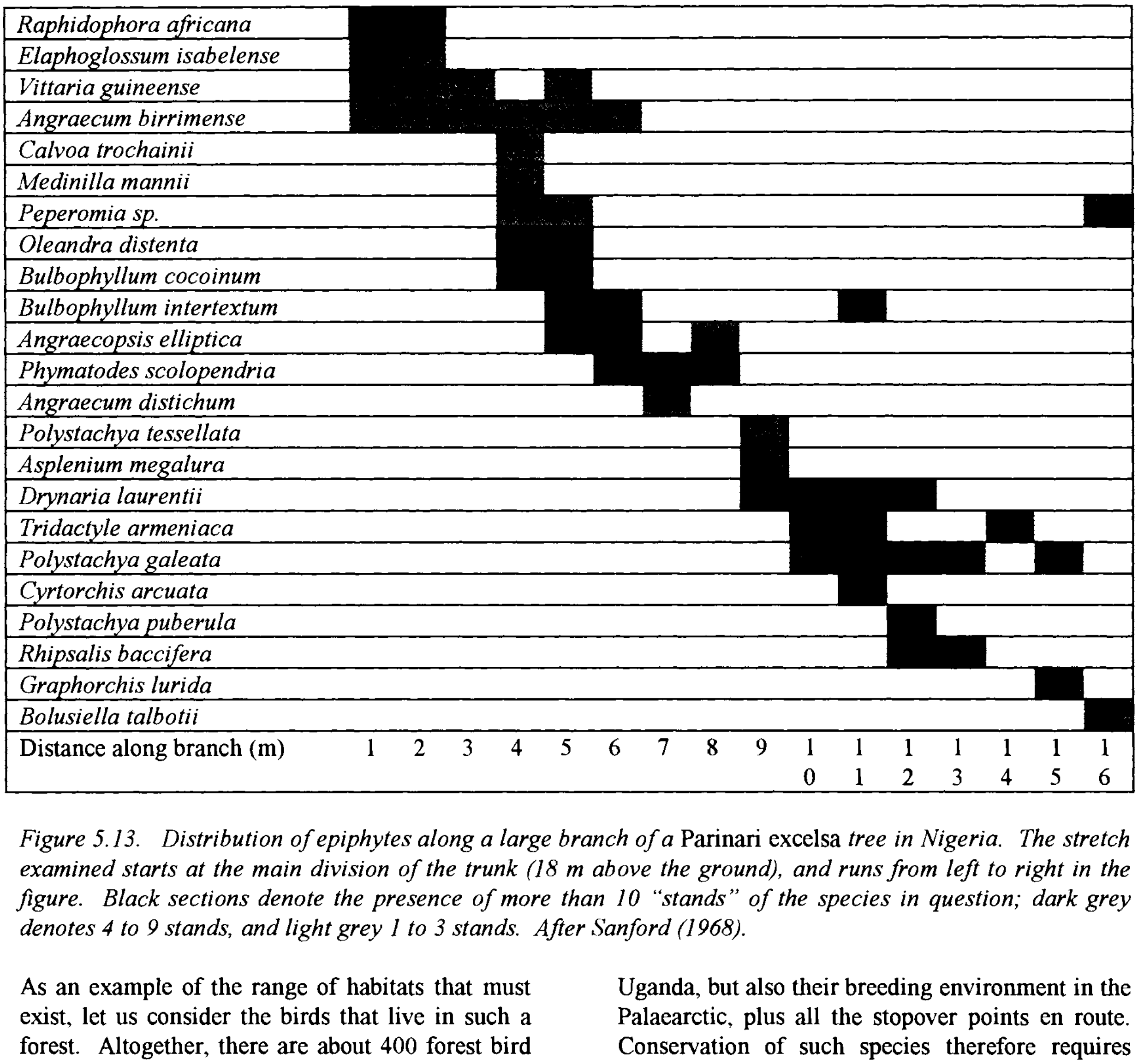
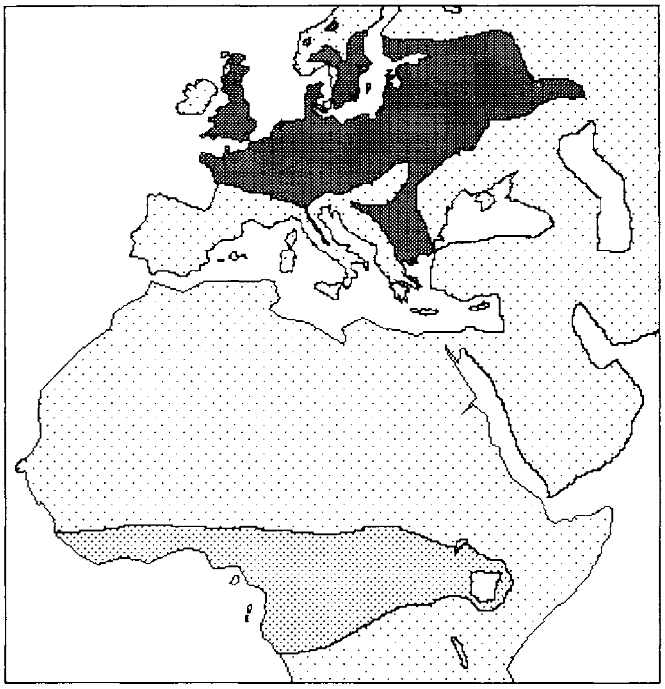


Figure 5.13. Distribution of epiphytes along a large branch of a Parinari excelsa *tree in Nigeria. The stretch examined starts at the main division of the trunk (18 m above the ground), and runs from left to right in the figure. Black sections denote the presence of more than 10 "stands" of the species in question; dark grey denotes 4 to 9 stands, and light grey 1 to 3 stands. After Sanford (1968).*

As an example of the range of habitats that must exist, let us consider the birds that live in such a forest. Altogether, there are about 400 forest bird species in Uganda. As each species exploits the forest in a slightly different way (i.e. each has its own niche), each species has a preference for living and feeding in a certain part of the forest. It is worth noting here that many man-made forests do not have the complex structure of natural forest, so the number of habitats available is much smaller. This is one reason why man-made forests are generally very poor in species (see Section 8.2.2).

5.5.44 The habitats of migrant birds

At the other end of the scale from the microhabitat, some species' habitats can be extremely large. Examples include the many species of bird that migrate annually across continents. About a tenth of all the bird species recorded from Uganda are long-distance migrants that breed in Europe or Asia (the Palaearctic). Their habitats thus include not only their non-breeding environment in Uganda, but also their breeding environment in the Palaearctic, plus all the stopover points en route. Conservation of such species therefore requires international effort. In North America, many migrant species seem to be suffering from tropical deforestation, because the area of Central America where most of these migrants spend the non-breeding season is naturally geographically rather small. The non-breeding range of Palaearctic migrants is fortunately often larger because of the shape of the African continent, so as yet deforestation has not had a noticeable impact. Nevertheless, recent declines in the number of some migrant birds in Europe has been attributed to drought and desertification in Sahelian Africa, through which many migrants must pass twice a year. Although most migrants spend their time in Africa in savannahs and scrubland (Pearson and Lack, 1991), at least 31 species regularly use lowland tropical moist forest, and 32 use tropical montane forest (Curry-Lindahl, 1981). Figure 5.14 shows the breeding and non-breeding range of one species typical of the former.



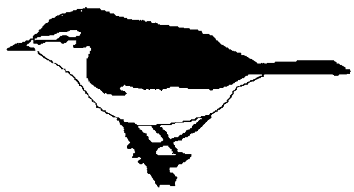


Figure 5.14. Breeding (dark shading) and non-breeding (light shading) range of the wood warbler (above), one of many Palaearctic migrant bird species with such a distribution. Redrawn from Curry-Lindahl (1981).

5.6 SUCCESSION AND TROPICAL FOREST DYNAMICS

Tropical forests, like other ecosystems, are not static. They are constantly changing, in both species composition and extent. Even if we cannot see the change on a human time scale, it is more than likely that change is going on nevertheless, albeit at a pace too slow for us to observe. This means that when we consider management or conservation options for a forest (or other ecosystem) today, we must remember that it may well be different tomorrow. Indeed, the very act of implementing any management may cause change, as we shall see below.

5.6.1 Ecological disturbances

Forests and other ecosystems change of their own accord, but often the event triggering change is some sort of disturbance. Disturbance can be at a variety of scales, from single treefalls to hurricanes or catastrophic fires, and they can be natural or human-induced. Whatever the cause of the disturbance, the event itself initiates an ecological process called **succession**. Succession is defined as *the non-seasonal, directional and continuous pattern of colonisation and extinction on a site*. It results from variation in the ability of species to colonise disturbed areas and from changes in the environment following the establishment of new species. This in turn is a reflection of the ecological niches of the species involved at different stages of the succession. Some species may immediately benefit from a disturbance, and become the first colonisers, while others may only benefit later from the presence of some of those colonisers.

Succession is going on within forests all the time, although normally on a small scale, such as when a tree falls and the subsequent gap is gradually infilled with a succession of colonisers. This is called **gap-phase dynamics**, and will be considered in Section 5.6.3. The local end-point of any succession is a return to the so-called **climax** community. Climax communities are meant to be stable and self-renewing, but often some new disturbance comes along before this state is ever reached. Succession is more obvious when one ecosystem is changing into another, such as when forest colonises savannah, and this is where we will start our examination.

5.6.2 Succession from savannahs to forests

The tropical moist forests of Uganda are mostly outposts of the larger forest block further west in Zaire. Being situated on the fringes of the climatic zone under which tropical moist forest thrives, they are particularly susceptible to slight changes in climate, particularly rainfall. It seems likely that over the millennia and centuries, Uganda's forests have shrunk and expanded according to the prevailing climate - retreating to particularly favourable **refugia** during dry episodes and expanding across the savannahs during wetter episodes (see Sections 4.3 and 5.4.34). For the last few centuries at least (and probably for much longer than this), forests have also had to face disturbance by humans and their livestock. For these reasons the forest boundaries have seldom been static, and even today there are areas in Uganda where we can see that the forest is advancing while in other areas it is retreating. The result of all this change has been the landscape we see in many parts of Uganda today: a **mosaic** of forest and savannah, as shown, for example, in Figure 5.15.

An interesting case of succession is occurring on the western edge of Budongo Forest. Here the forest front has advanced by up to 800 m over the last half century. If all Uganda's forests could expand at this rate without hindrance, then the whole country could be forested within just two thousand years. The reasons for the rapid forest expansion at Budongo probably reflect past human activities rather than any recent change in climate. It is likely that, until this century, burning of the surrounding savannahs for livestock, plus perhaps grazing and browsing pressure from wild game, kept forest expansion in check. This century, with human depopulation following sleeping sickness, and cattle depopulation following trypanosomiasis, plus the enforcement of early burning, and game eradication for tsetse control, the forest was free to expand once again, resuming a trend that some people suggest it might have been following for the last few thousand years (see Paterson, 1991, for details of past management in this area).

It is widely believed that many of the tall-grass savannahs of southern and western Uganda would be quite capable of supporting tropical moist forest if present management were changed. In other words, tall-grass savannah in Uganda is unlikely to be a true **climatic climax**. The same is true of many grasslands throughout the world. Two factors in particular may have lead to the dominance of savannahs at the expense of woodland or forest **fires** and **grazing**.

5.6.21 The influence of fires on forests and savannahs

Fire is a natural feature of grassland ecosystems (through lightning strikes), but seldom has much impact in tropical moist forests. Seasonally dry woodlands may also experience frequent fires. For the last few thousand years, humans have used fire as a tool in managing their environment to suit their own needs, whether to clear land for cultivation or to encourage the spread of grasses suitable for livestock. Because some species of plant (and animal) are better adapted to surviving fires than others, these are the ones that have spread wherever humans have burnt the land. Regular burning over the centuries, possibly every year in the case of many of the tall-grass savannahs in Uganda, has gradually eliminated species that are susceptible to burning and positively encouraged those that thrive on it. Tall grasses such as elephant grass (*Pennisetum purpureum*) and speargrass (*Imperata cylindrica*) burn easily during the dry season, and generate a lot of heat in the process, thereby killing many would-be competitors that may be trying to establish themselves in the grassland. In the following rainy season, these grasses rapidly re-sprout from underground rhizomes, so maintaining their dominance. Such grassland, therefore, is a ***fire-climax*** community.

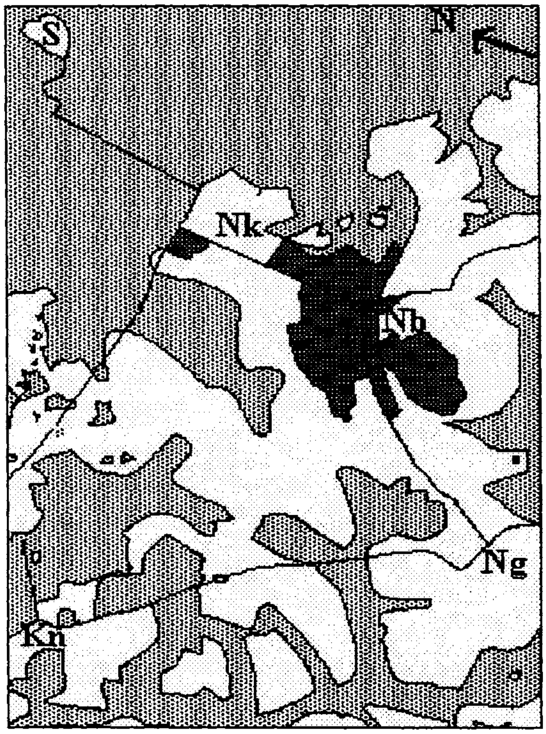


Figure 5.15. Part of the edge of Budongo Forest, Uganda, centred on Nyabyeya, showing a mosaic of natural moist forest (pale shading), savannah (clear) and plantation (dark shading). The mosaic is a result of a mixture of climate, soil, slope, fire, grazing and cultivation, and is now largely "fossilised", as forest expansion is prevented by cultivation of the surrounding savannah. S = Sonso sawmill; Nk = Nyakafunjo; Nb = Nyabyeya; Ng = Nyabugoma, and Kn = Kanyegi. The map represents an area of approximately 50 km^2.

Grasses such as these probably need to be burnt regularly, late in the dry season, to maintain their dominance. They also require full sunlight, so do not prosper under trees. However, if a grassland fire is sufficiently intense, it may spread beyond the grassland into the forest edge, killing some of the fire-sensitive trees in the process. This opens up the ground to colonisation by grasses, which can therefore gradually encroach on the forest. Over the decades and centuries, this could result in forests shrinking to gullies and riverine strips where fires cannot encroach. This process is thought partly to account for the isolation of Rabongo Forest in Murchison Falls National Park (Buechner and Dawkins, 1961).

But what happens if fires are? Early this century in Uganda, a policy of early burning was introduced. Burning early in the dry season means that the resultant fires are less intense because the grass is still moist. This means that some of the more fire-resistant shrubs that are attempting to establish themselves in the grassland will not be killed off, so gradually an open woodland may develop. Meanwhile, the forest edge will not be exposed to such severe fires, and a band of woodland may develop there too, effectively buffering it from grassland beyond, and stopping the forest from shrinking further. In many parts of Uganda this century, grassland has turned to woodland, partly as a result of this policy. For instance, such a trend was reported in *Combretum* woodland in Bunyoro (Turner, 1967), where a policy of late burning from 1914-1924 resulted in "lightly bushed" country, which subsequently progressed to "dense bush" following the introduction of an early burning policy in 1924.

If fire is completely prevented, the build-up of grass litter may eventually reduce the vigour of grass, and may encourage trees and shrubs to establish themselves. Once a few trees are established, conditions become more favourable for other tree species that require shady or moist conditions to germinate or survive as seedlings. Gradually, a forest may grow where once only grass survived. What species colonise depends partly on what seed-sources are around. A tropical moist forest will only develop on the site if there is an area of established moist forest nearby.

Figure 5.16 illustrates the results of a 28-year long experiment on the effects of fire in fire-climax savannah in a forest reserve in Nigeria, which commenced in 1929. As expected, continuing with a late burn regime for 28 years results in a savannah with few trees, all of which are fire-resistant. Early burning results in an increase in trees generally, although very few are fire-sensitive. Complete protection results in a vast increase in the number of trees, including many fire-sensitive ones. Hopkins (1974) reported that after just six years of protection, 35% of the trees in the plot belonged to forest species, while after 28 years the proportion had risen to 64%, at which time only one species of savannah grass was still present. If the experiment had been continued to the present day, the proportion of fire-sensitive trees in the plot completely protected from fire would probably have risen to something like that which exists in tropical moist forest nearby.

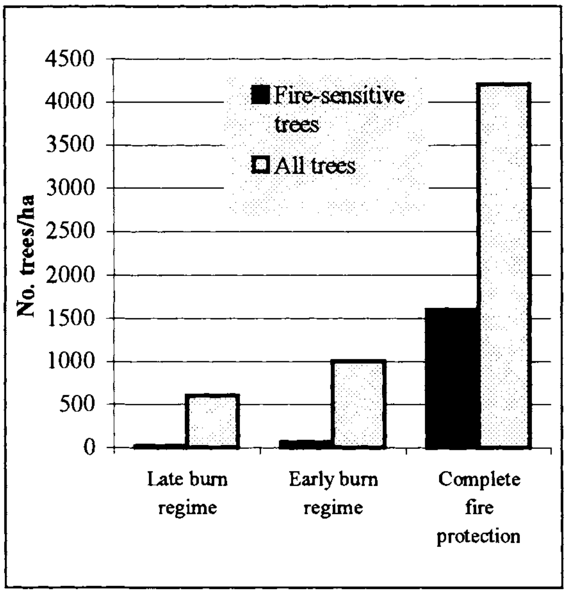


Figure 5.16. The effects of 28 years of management on cleared fire-climax savannah in Olomeji Forest Reserve, Nigeria. After Hopkins (1974) and Charter and Keay (1960).

5.6.22 The influence of grazing on forests and savannahs

Many woodlands and grasslands can make good grazing land for cattle, and humans have used them for this purpose for centuries. Wild game are also important grazers in some areas. Both game and cattle can have a big impact on vegetation structure, and can sometimes shift the balance between woodland and grassland. **Elephants** are particularly important in this respect. In Uganda, elephants were once widespread, but during the twentieth century they were pushed back into smaller and smaller areas, restricting their migrations and forcing them to put more pressure on less land. They also came into increasing conflict with humans. Budongo Forest lies in the path of a traditional elephant migration route down the western side of Uganda.

At times, up to 5000 elephants were thought to be in the forest (Swynnerton, 1924), causing serious problems for silviculture in that they liked to browse regenerating mahoganies in any clearings created by logging ((Langdale-Brown et al., 1964), so much so that there were soon calls for their elimination from the forest (Laws et al., 1975). There are now none left, which may be good for silviculture but this may also be expected to have long-term consequences on forest composition. [By comparison, in western Ghana forest elephants have been recorded browsing on 138 different plant species (Mabberley, 1992)].

Meanwhile, in the southern part of Murchison Falls National Park, elephant densities were rising as they became more and more confined to the park. By 1967, densities in this part of Bunyoro were 2.7 elephants per km^2 (Laws et al., 1975). Even by the early 1960s, there was great concern that the elephants here were destroying large areas of *Terminalia - Combretum* woodland, converting it to grassland (Buechner and Dawkins, 1961), and it was felt that something would have to be done to reduce the problem. The problem went away during Uganda's war years, as nearly all the elephants were shot. The grassland is now rapidly reverting to woodland again, but a legacy of those years is the rarity of elephant-resistant trees in Rabongo Forest, a small tropical moist forest in the middle of the park.

5.6.23 The forest succession sequence

Let us now return to how disturbance such as fire or grazing can trigger a process of succession. We have already seen that if fire or grazing is stopped, then forest can spread. The same thing can happen if cultivation ceases. Whatever the initial disturbance, it is thought that there will usually only be one sort of climatic climax community that will eventually re-establish itself. Figure 5.16 shows various routes to a climax community of moist semi-deciduous tropical moist forest that may exist in western Uganda.

Succession does not stop once forest cover has been restored. The forest may continue to change in species composition for several hundred years. Eggeling's (1947) work on the ecology of Budongo Forest, for example, suggested that in Budongo, the forest succession consists of four distinct forest types, which he called Colonising (Woodland) Forest and Colonising (*Maesopsis*) Forest (both early on in the succession, the former on poorer sites than the latter); followed by Mixed Forest, and finally the climax Ironwood (or *Cynometra*) Forest. Table 5.5 shows the relative abundance of the main tree species in each forest type and in the **ecotones** (intermediate successional stages) between them.

Table 5.5.
Succession of tree species in Budongo Forest, Uganda. Figures refer to total number of individuals which were represented on three or more sample plots by four or more trees exceeding 20 cm dbh. The sequence is from left to right, but the first two types are complementary. From Eggeling (1947)

Species	Woodland Forest	*Maesopsis* Forest	Ecotone	Mixed Forest	Ecotone	Ironwood Forest
Maesopsis eminii	-	74	27	-	-	-
Olea welwitschii	48	54	31	-	-	-
Spathodea campanulata	23	10	4	-	-	-
Sapium ellipticum	14	12	8	-	-	-
Caloncoba schweinfurthii	131	164	6	-	1	-
Phyllanthus discoideus	19	32	32	1	1	-
Erythrophleum suaveolens	15	15	5	2	1	-
Funtumia spp.	1	32	104	20	23	-
Trichilia prieuriana	-	-	2	20	2	-
Alstonia boonei	-	4	2	10	8	1
Mahogany spp.	-	-	2	15	7	1
Chrysophyllum spp.	1	8	6	71	11	1
Celtis spp.	23	61	90	319	141	72
Rinorea ardisiaeflora	-	-	5	13	70	27
Cynometra alexandri	-	-	-	36	55	119
Lasiodiscus mildbraedii	-	-	-	-	118	258

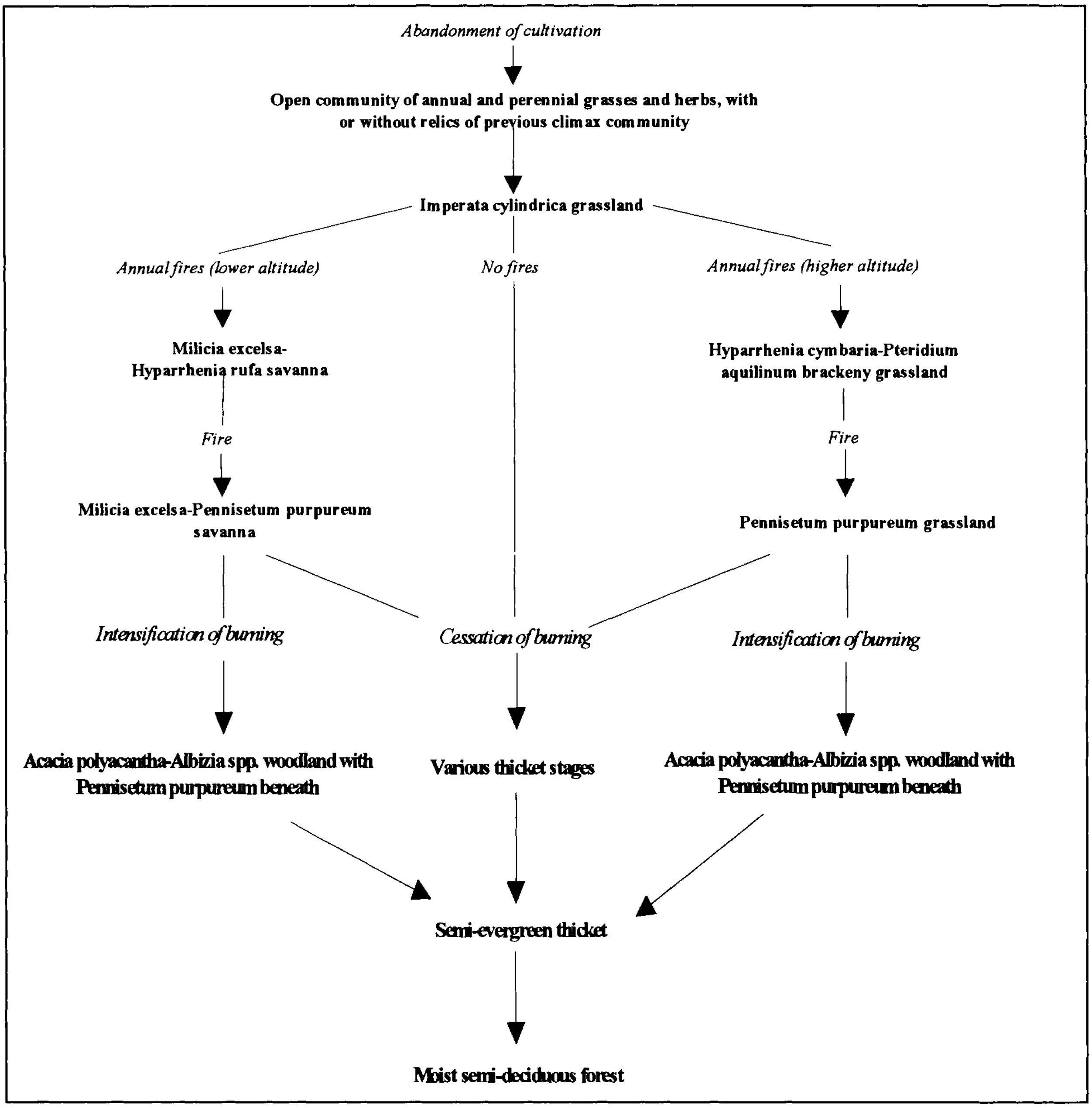


Figure 5.17. Successional routes leading to moist semi-deciduous tropical forest in western Uganda. After Langdale-Brown (1960).

We should remember that succession is not just something that happens to plants. Animals, too, respond to disturbance and to change. So for any succession of plants, there is a corresponding succession in animal species too. Figure 5.18 shows how certain bird species may succeed one another as grassland develops towards forest.

In general, the total number of species living in a given area seems to increase as the succession continues towards the climax. There are exceptions to this, and it is possible that Budongo Forest forms one such exception in that the mixed forest seems, according to some analyses, to be richer in tree species than the ironwood forest. This will be discussed again in Section 6.4.2. But looking at Figure 5.19, which shows the change in number of species of vascular epiphytes along the succession in Budongo, ironwood forest seems to be richer than mixed forest which in turn is richer than either of the colonising types. A further study, this time from Amazonian flood plain forest (Figure 5.20), shows a strong increase in bird, tree and primate richness along the succession towards the climax.

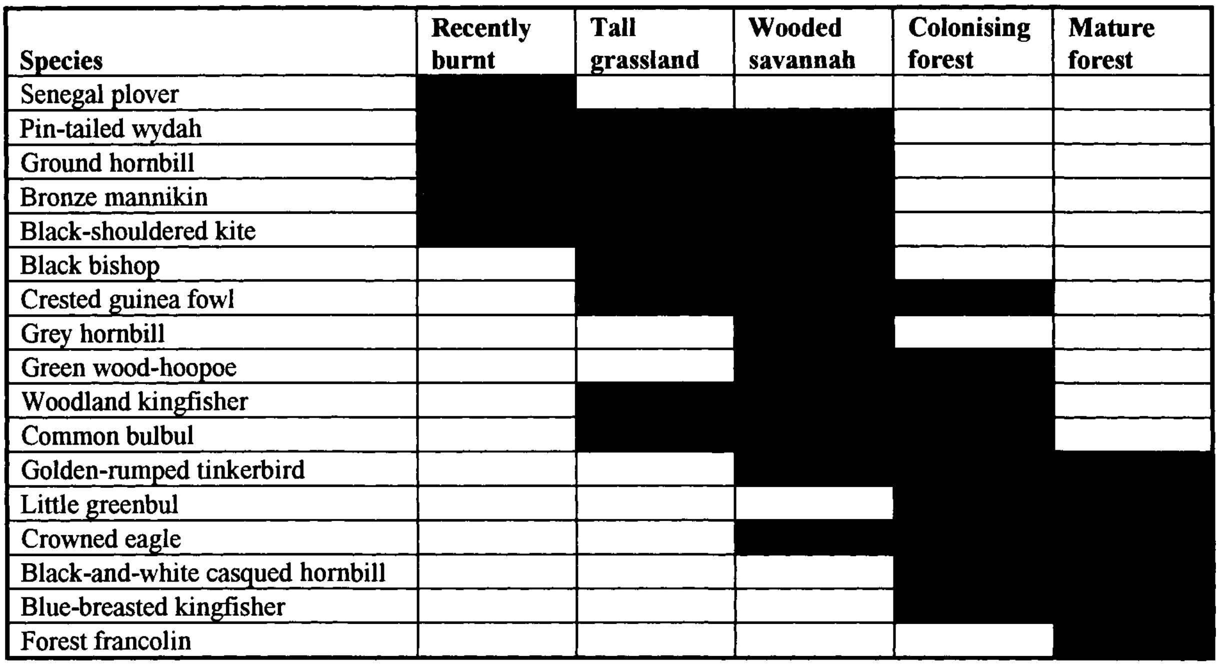


Figure 5.18. Examples of some of the many bird species associated with various stages of forest succession in western Uganda. Black indicates preferred habitat, grey indicates that the species may also be present.

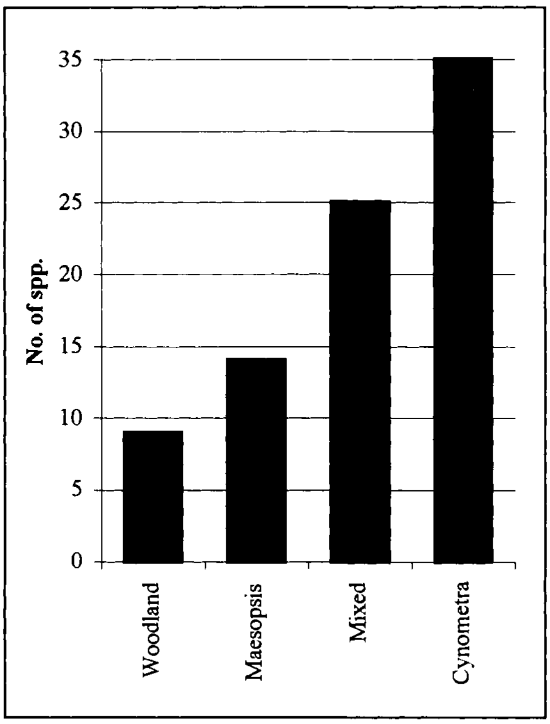


Figure 5.19. The number of species of vascular epiphytes in plots of different forest types in Budongo Forest, Uganda. After Eggeling (1948).

5.6.3 Succession within forests: gap phase dynamics

A forest can be viewed as a mosaic or patchwork of different-aged stands of trees. Some of these stands may cover many hectares, but most are much smaller than this. The reason for this mosaic lies in the way a forest regenerates itself: the so-called forest cycle (Whitmore, 1978). Figure 5.21 shows the four main phases of the forest cycle.

Whenever a tree falls in a forest, whether through old age, a natural disturbance or some human activity, a succession is initiated as plants colonise the gap thereby created. Which tree species are involved in the succession will determine the structure of the future forest for many decades, even centuries. This is why **gap phase dynamics** is considered to be so important in forest ecology, and why it is important for foresters to be aware of it too. The scale of the patchwork is determined by the main gap sizes in a forest, which in turn are determined by what disturbances the forest experiences. Some forests regularly experience severe disturbance, for instance forests on oceanic islands in the path of hurricanes, or forests on steep and unstable slopes prone to landslides, where whole forests may be felled in a single disturbance event. Other forests, probably including most of those in Uganda, naturally experience less severe disturbance. In such forests, most gaps are rather small. Table 5.6 shows a breakdown of gaps and their causes in MPassa Forest in Gabon; a similar breakdown probably applies to many Ugandan forests.

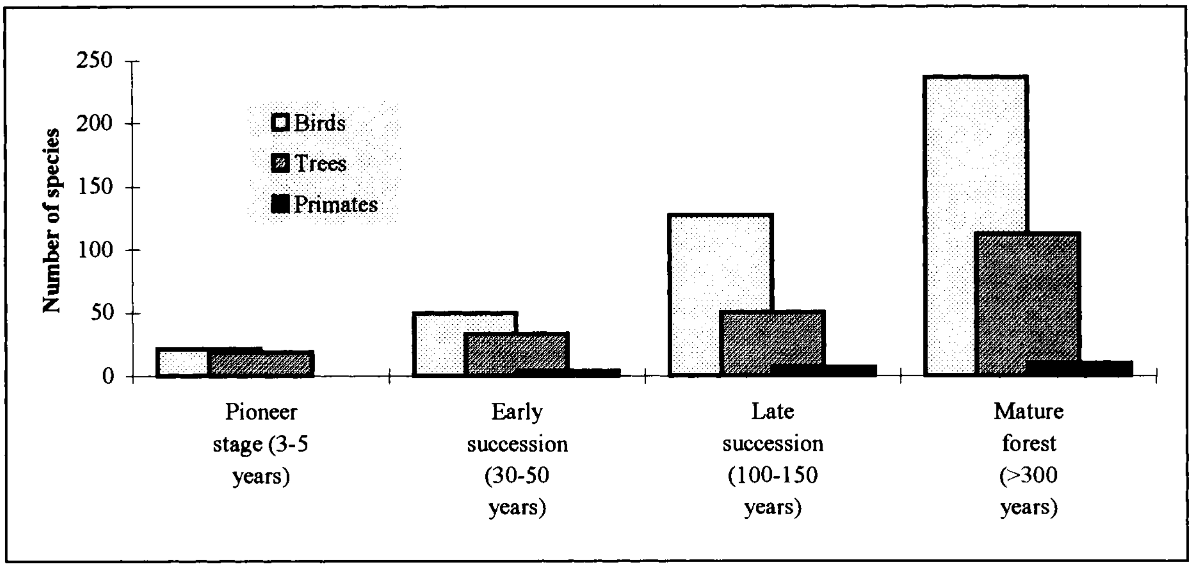


Figure 5.20. The number of species of birds, trees and primates at various stages of primary forest succession in Amazonian flood plain forest. Numbers of trees are >10 cm dbh, in 0.5 ha sample plots. After Terborgh (1986).

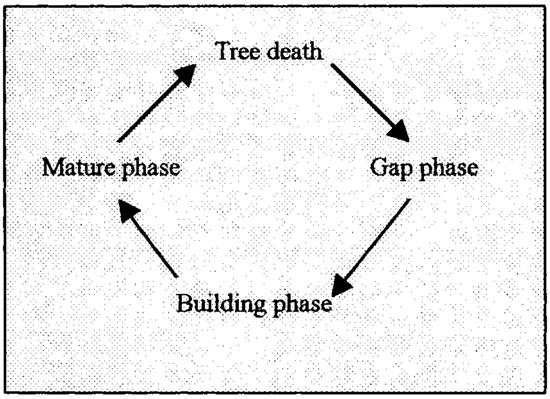


Figure 5.21. The four phases of the forest cycle, according to Whitmore (1978).

But even for a forest that does not naturally experience large-scale disturbance, there may be occasional freak events which have a big impact on the forest. In 1962, for instance, a freak storm hit the northern shore of Lake Victoria, felling many square kilometres of mixed forest in southern Uganda, and initiating succession anew (Mabberley, 1992). Such storms may be regular events to which the forest is adapted, even if they seem very irregular on a human time scale. Just because we may only live for a few decades, many trees live for hundreds of years, and a large natural disturbance once every 300 years may be the main factor in determining the forest's structure and species composition. We should thus be cautious in our conclusions about successional processes based on observations spanning only a few years.

Table 5.6.
Gaps and their causes in MPassa Forest, Gabon (Pickett and White, 1985).

Gap creation process	% of gaps in forest	% of total gap area in forest
Falling tree parts	23	10
Single falling trees	51	38
"Domino" treefalls	14	16
Overlapping or abutting treefalls	13	36

For example, was Eggeling justified in calling Ironwood forest a climax vegetation type in Budongo, or if we waited a few hundred years might we see it swing back to mixed forest or to some other type? As Pickett and White (1985) point out, "*primeval tropical rainforest, undisturbed and stable since the dawn of time, is a myth. Instability of varying extents occurs on several time-scales. The recovery to a steady-state is likely to take several centuries and is perhaps never achieved in many places*". This is one reason why **permanent sample plots** are so valuable, as long as the records are maintained.

In Uganda, the first Forest Department research plots in natural forest were established in 1933; by 1960 there were 267 (Hamilton, 1984). Unfortunately, many of these have since been lost, but those that survive are likely to tell us much about the ecological processes at work in Uganda's forests, and the effects of management on them.

5.6.31 Pioneer and climax tree species

Not all tree species are equally adept at colonising gaps. Indeed, a gap itself is far from uniform, and different tree species will perform differently in different parts of it. Trees are adapted for exploiting different sized gaps, and different stages in the succession. Broadly, they can be divided into **pioneer species** and **climax species**. The main characteristics of these two groups, and how they differ, are shown in Table 5.7.

Some examples of the two groups are given in Box 5.5. The mahoganies are not included because they are somewhat intermediate, in that they can germinate in the shade, but will only survive if there is a canopy opening within a year or two of germination (Synnott, 1975).

Recognising this problem in defining some of the key timber trees, Hawthorne (1993), working in the tropical moist forests of Ghana, identified four main groups or **guilds** of forest trees:

- **Non-cryptic pioneers:** require gaps for germination and only prosper in high light levels
- **Cryptic pioneers:** require gaps for germination, but can prosper later as understorey species in closed forest
- **Non-pioneer light-demanders:** germinate in shade, but require gaps for further development
- **Non-pioneer shade-bearers:** germinate in shade, and can prosper in the absence of gaps

Because of the differences in niches amongst the various tree species, and particularly in their response to light and humidity levels and their dispersal mechanisms, different species will dominate at different stages following gap creation. Broadly speaking, the gap will first become dominated by pioneer species, and later by climax species.

Table 5.7.
The main characteristics of pioneer and climax tree species. After Whitmore (1990)

Characteristic	Pioneer species	Climax species
Synonyms	Shade-intolerants Light-demanders Secondary species	Shade-tolerants Shade-bearers Primary species
Definition	Species whose seeds can only germinate in gaps in which full sunlight impinges at ground level for at least part of the day	Species whose seeds can germinate under forest shade and whose seedlings can establish and survive in shade for at least a year or two
Seed production	Copious, small, produced continually or frequently	Less copious, large, produced annually or less than annually
Dispersal	Wind or animals, often over long distances	Various, including gravity, sometimes only over short distances
Seed dormancy	Normally present; seeds never recalcitrant	Often absent; seeds often recalcitrant
Soil seed-bank	Present	Absent
Growth	Indeterminate, no resting buds	Determinate, with resting buds
Height growth	Fast	Slower
Forking	High	Low
Leaves	Short-lived; high turnover rate	Long-lived; low turnover rate
Roots	Superficial	Some deep
Root/shoot ratio	Low	High
Wood	Usually pale, low density, not siliceous	Often dark, high density, sometimes siliceous
Photosynthesis rate	High	Low
Toxicity of leaves	Low	High
Susceptibility to herbivore damage	High	Low
Geographical range	Wide	Often narrow

Box 5.5
Some examples of pioneer and climax tree species in Ugandan forests

Pioneer species

- *Albizia zygia*
- *Caloncoba schweinfurthii*
- *Chrysophyllum albidum*
- *Croton macrostachyus*
- *Dombeya mukole*
- *Ficus exasperata*
- *Macaranga schweinfurthii*
- *Maesopsis eminii*
- *Milicia excelsa*
- *Musanga cecropioides*
- *Musanga leo-errerae*
- *Pericopsis elata*
- *Rauvolfia vomitoria*
- *Ricinodendron heudelotii*
- *Solanum giganteum*
- *Trema orientalis*
- *Vernonia conferta*

Climax species

- *Celtis durandii*
- *Cynometra alexandri*
- *Funtumia elastica*
- *Lasiodiscus mildbraedii*
- *Microdesmis puberula*
- *Parinari excelsa*
- *Rinorea beniensis*
- *Turraeanthus africanus*
- *Uvariopsis congensis*

5.6.32 *Seed dispersal in forest trees*

So far we have been talking about plants colonising areas, but we have not yet considered how they get there. All plants need to disperse their seeds somehow, so that their offspring stand a chance of finding conditions suitable for germination and growth. Method of seed dispersal is an important aspect of a species' niche, and we find different species employing different dispersal mechanisms. For each mechanism, some are specialists, others generalists. Three main categories of dispersal mechanism occur (Bawa and Hadley, 1990):

- **Self-dispersal** mechanisms include the simple use of gravity and more complex techniques involving "explosive" seed-pods. Both mechanisms only result in short-distance dispersal from the parent tree, so species which use them are usually slow to spread. *Acacia* and *Albizia* species are good examples, as are many tropical forest trees.

- **Wind dispersal** is commonest amongst tree species growing under fairly exposed conditions, whether this be as isolated trees in savannah (such as many species of *Combretum* and *Terminalia*) or as emergent trees in tropical moist forest (such as *Cynometra, Alstonia* and the mahoganies). These trees can use the wind to disperse their seeds over relatively long distances from the parent tree.

- **Animal dispersal** is very widespread in tropical trees. The technique enables trees to disperse their seeds over very long distances from the parent tree, helping them to colonise new areas and encouraging out-breeding. The seeds normally have to be packaged in some way to attract an animal, for instance by being embedded in a tasty fruit or being brightly coloured. Different "packaging" attracts different species of animal.

- A fourth category, **water dispersal,** is also important in some forest types such as riverine forest.

Figure 5.22 shows how the relative proportions of plant species using each mechanism vary according to forest type, from a study in Zaire. Some examples of Ugandan trees that use the three main mechanisms are given in Box 5.6. Although the list is not exhaustive, it gives a fair representation of the proportion of tree species that fall into each category.

It seems, therefore, that most tropical trees use animals to disperse their seeds. In tropical moist forest in Nigeria, 46%-80% of all tree species have fleshy fruit, designed for animal dispersal, whereas only about 10%-25% of temperate American tree species have fleshy fruit (Jones, 1956, Howe and Smallwood, 1982). Interestingly, animals are also the main pollination agents in tropical forests, accounting (in South and Central America) for nearly 100% of lowland tropical forest trees, as opposed to 50% of tree species at a latitude of 20 degrees North, and only 20% at 60 degrees North (Regal, 1982).

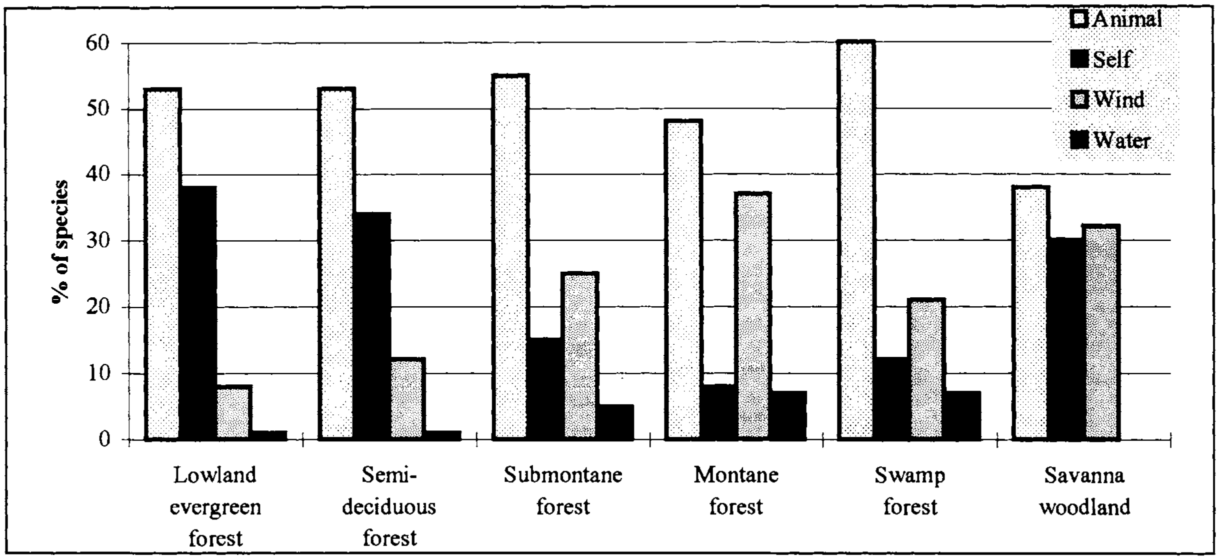


Figure 5.22. Seed dispersal mechanisms amongst Zairean forest plants. After Malaise (1978).

Box 5.6
Examples of Ugandan tree genera using the three main mechanisms of seed dispersal

Self-dispersed trees

- *Acacia*
- *Afzelia*
- *Albizia*
- *Baikiaea*
- *Cassia*
- *Dalbergia*
- *Entada*
- *Erythrina*
- *Erythrophleum*
- *Isoberlinia*
- *Securidaca*

Wind-dispersed trees

- *Alstonia*
- *Bombax*
- *Combretum*
- *Entandrophragma*
- *Funtumia*
- *Hallea*
- *Holoptelea*
- *Khaya*
- *Lovoa*
- *Markhamia*
- *Piptadeniastrum*
- *Pterygota*
- *Salix*
- *Senecio*
- *Spathodea*
- *Terminalia*
- *Vernonia*

Animal-dispersed trees

- *Alangium*
- *Alchornea*
- *Antiaris*
- *Antidesma*
- *Balanites*
- *Beilschmiedia*
- *Blighia*
- *Borassus*
- *Caloncoba*
- *Canarium*
- *Celtis*
- *Chrysophyllum*
- *Coffea*
- *Cola*
- *Cordia*
- *Croton*
- *Desplatzia*
- *Discoglypremna*
- *Dracaena*
- *Drypetes*
- *Elaeis*
- *Erythroxylum*
- *Ficus*
- *Grewia*
- *Guarea*
- *Ilex*
- *Isolona*
- *Juniperus*
- *Kigelia*
- *Klainedoxa*
- *Lindackeria*
- *Macaranga*
- *Maesopsis*
- *Mammea*
- *Microdesmis*
- *Milbraediodendron*
- *Milicia*
- *Musanga*
- *Myrianthus*
- *Nauclea*
- *Olea*
- *Parinari*
- *Parkia*
- *Phoenix*
- *Phyllanthus*
- *Podocarpus*
- *Prunus*
- *Pseudospondias*
- *Rauvolfia*
- *Ricinodendron*
- *Salvadora*
- *Solanum*
- *Sterculia*
- *Strombosia*
- *Strychnos*
- *Symphonia*
- *Mabernaemontana*
- *Tapura*
- *Tetrapleura*
- *Treculia*
- *Trema*
- *Trichilia*
- *Turraeanthus*
- *Uvariopsis*

Animals act as dispersal agents either as a by-product of their own feeding behaviour, or, less frequently, through picking up seeds that get tangled in their fur or feathers. Different animals have preferences for different sorts of fruit and seeds; for instance some specialise in certain size-classes of fruit or seed. Many hornbills prefer small fruit, or fruit with small seeds, or seeds with red or purple arils, whereas many monkeys prefer fruit with a succulent pulp, containing many seeds, or that are orange, while duikers prefer fruit with succulent fibrous pulp, or nuts with a kernel, or large fruit generally (Gautier-Hion, 1990). This means that some animals are responsible for dispersing the seeds of many trees, while others are only important for one or a few species. Figure 5.23 shows the relative importance of different animals for dispersal of forest plants in Gabon.

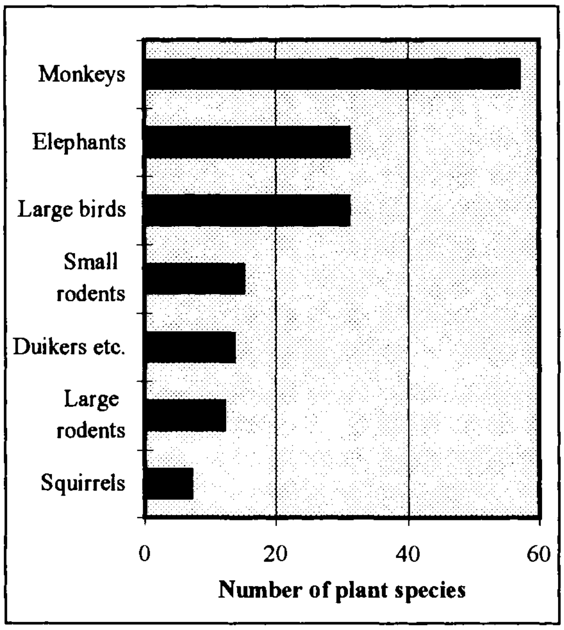


Figure 5.23. The relative importance of different animals for dispersal of forest plants, from a study in Gabon (Gautier-Hion, 1990).

Primates, large birds and elephants seem to be the most important dispersers of tree seeds. Elephants seem to be particularly important, because, of the tree species whose seeds they disperse, they are often the only animal large enough to eat the seeds and thereby disperse them. For example, in a study in Côte d'Ivoire, seeds from one year's worth of elephant droppings were found to have come from 37 tree species, only 7 of which are known to be dispersed by monkeys or birds as well as elephants (Alexandre, 1978). This has important implications for conservation and forest management, because it indicates that it is not enough to protect just the trees themselves. Without the dispersers, many of the trees would not be able to survive in the long term. Thus the long-term future in Uganda for elephant-dispersed trees such as *Balanites wilsoniana, Warburgia ugandensis,* and even *Borassus aethiopum* is now in doubt, even though adult trees are still common in many areas. Likewise, the animals would not be able to survive without the range of trees producing fruits and seeds. For example, in Gabon, fruits and seeds make up the staple diet of 45% of all the mammal species found in the tropical forest there (Gautier-Hion, 1990).

Dispersal of tree seeds by primates has been investigated in Budongo Forest by Plumptre et al. (1994). Table 5.8 lists the species that have been found as intact seeds in the faeces of primates. Many important timber trees are included in the list, although the authors point out that more research would be necessary to determine just how important these primates are for the survival of these trees. Note, too, that some exotics are also on the list.

Table 5.8.
Tree species in Budongo Forest, Uganda, for which intact seeds have been found in the faeces of primates. After Plumptre et al. (1994).

Tree species	Blue monkey	Chimpanzee
Broussonetia papyrifera		✓
Caloncoba schweinfurthii		✓
Celtis durandii	✓	✓
Celtis mildbraedii		✓
Celtis zenkeri	✓	✓
Chrysophyllum albidum	✓	✓
Cleistopholis patens		✓
Cordia milleni		✓
Ficus spp.	✓	✓
Klainedoxa gabonensis		✓
Maesopsis eminii	✓	✓
Margaritaria discoidea	✓	
Mildbraediodendron excelsum		✓
Milicia excelsa		✓
Morus lactea	✓	✓
Myrianthus arboreus	✓	✓
Pseudospondias microcarpa		✓
Psidium guajava		✓
Ricinodendron heudelotii		✓
Uvariopsis congensis		✓

5.7 SUMMARY

This chapter has been particularly detailed and wide-ranging, to emphasise that ecology touches so many areas of forest management and conservation. Nevertheless, it has not really been possible to do the subject full justice here, and anyone wanting to take their reading further should look at the reading list below.

Particularly valuable lessons from ecology are that:

- Different areas support different communities, partly because of differences in the physical environment.
- Species interact in often complex ways which result in communities of species living together and depending to varying degrees on each other. Interspecific relationships are at their most complex in tropical forests.
- Changes that affect one species will almost certainly affect the network of other species living in the same area. The more species-rich an area, the more such species will potentially be affected.
- Some species are very susceptible to change, while others thrive on it.
- Some species have very precise requirements for life (specialists) while others are more tolerant of a range of conditions (generalists). Tropical forests are particularly rich in specialist species.
- Communities are often naturally dynamic in their species composition, and are prone to change over a variety of time-scales and distances.

5.8 FURTHER READING

Atlas of Uganda. 1967. Government of Uganda.

Buechner, H.K. and Dawkins, H.C. 1961. Vegetation change induced by elephants and fire in Murchison Falls National Park, Uganda. *Journal of Ecology*, Vol. 42 (4): 752-766.

Deshmukh, I. 1986. *Ecology and tropical biology*. Blackwell, Palo Alto.

Eggeling, W.J. 1947. Observations on the ecology of the Budongo rainforest, Uganda. *Journal of Ecology* 34 (1), 20-87.

Langdale-Brown, I., Osmaston, H.A., and Wilson, J.G. 1964. *The vegetation of Uganda and its bearing on land-use*. Government of Uganda.

Pomeroy, D.E. and Service, M.W. 1986. *Tropical ecology*. Longman, Harlow.

Whitmore, T.C. 1990. *An introduction to tropical rainforests*. Clarendon, Oxford.

CHAPTER 6

NATURAL FOREST MANAGEMENT AND NATURE CONSERVATION

CHAPTER OUTLINE

6.1 INTRODUCTION

Despite growing awareness that tropical forests are priorities for nature conservation because of all the species they support, it is clear that few countries in the tropics will be able to afford to designate more than a small proportion of those forests as preservation areas (National Parks, Strict Nature Reserves etc.). Much of the remainder of the permanent forest estate is likely to be put under some sort of management, and timber production is likely to be one of the main activities. One of the objectives of conservation, therefore, must be to try and ensure that natural forest management for timber production is carried out in such a way that most of the wildlife survives.

Natural forest management for timber production has a relatively long and successful history in Uganda compared to many other tropical forest countries. Silvicultural operations began in Budongo, Mpigi and Mabira forests as early as the 1930s (Dawkins, 1958). The emphasis of management has been the maintenance and enhancement of the natural forests' timber production potential; different silvicultural "treatments" have been tried and at least some of these have proved successful in meeting this objective. But here we address two questions:

- What has been the effect of natural forest management on wildlife?

- How can adverse effects be minimised and positive effects maximised, so that production forests can also act as conservation areas?

This second point is also addressed in Chapter 7.

6.2 WHAT DOES NATURAL FOREST MANAGEMENT INVOLVE?

Natural forest management has usually been based on *selection* systems, in which selected timber trees are felled and the forest treated in various ways to ensure a future yield of the same timber trees. The first felling (*salvage*) yields many large-diameter trees, many of them commercially overmature. This felling is also intended to remove *undesirables*. Subsequent treatments include the use of *arboricides* to poison further undesirables (an example of *refining*), and, in some cases, *enrichment planting* of desirable species. Subsequent fellings yield more uniform but smaller size-classes of selected timber trees. Both monocyclic silvicultural systems (i.e. returning to log once during the time it takes a commercial tree to reach commercial maturity from having been a seedling or sapling) and polycyclic ones (i.e. returning to log more than once during the same growth cycle, so that trees that were immature on one visit will have reached maturity by the next) have been tried in Uganda. Many forests were to have been converted from polycyclic to monocyclic under a plan initiated in the 1960s (Philip, 1962), to reduce wastage and residual damage.

6.3 IMPACTS ON THE FOREST ENVIRONMENT AND MICROCLIMATE

Wildlife may be affected either directly or indirectly by logging or other natural forest management operations. Box 6.1 highlights some of the more readily discernible impacts that may affect the forest environment in general.

Tree-felling creates artificial gaps in the canopy, allowing light to penetrate to the forest floor. This is little different from a natural treefall, but in managed forest the proportion of gaps can be greater, as can the average gap size (see Section 6.4.2). This affects various aspects of the forest microclimate, which in turn affect which species can live in the gap, since the niches of different species encompass different preferences for humidity, temperature, light levels and so on (see Section 5.4.1). Figures 6.1 and 6.2 come from a study in south-west Ghana, and compare air temperature and relative humidity near ground-level in closed forest and in a large clearing.

These figures illustrate that, whereas night-time conditions of microclimate are similar, in the daytime a clearing can become far warmer and less humid than an equivalent area under forest. This affects the kind of tree species that can become established there, and thus the composition of the forest in the years to come. The larger the clearing (up to a point) the more the resultant forest composition will differ from the original. If we decide that the species that establish in humid, shady conditions are particularly important for nature conservation, then we should make sure that they are catered for in management plans so that some areas remain unlogged.

Box 6.1
Some of the impacts of logging on the natural forest environment

- Compaction of soil by machinery and skidding, making it unfavourable for seedling establishment
- Creation of large gaps in the canopy, favouring regeneration of pioneers and climbers, altering the microclimate and increasing the chance of wind throws, erosion and fires
- Damage to non-target trees by machinery and falling trees, leading to long-term mortality of damaged trees
- Loss of trees in the way of skidder tracks and loading bays
- Soil erosion and siltation of water-courses due to exposure of soil
- Hydrological changes due to blocked water-courses during road construction
- Disturbance to wildlife by noise and general activity
- Increased hunting pressure and risk of encroachment along logging and skidding tracks
- Decrease in abundance of timber trees above minimum diameters, with knock-on effects on other species and an overall change in forest tree species composition
- Changes in abundance and distribution of animals according to how their habitats are affected by logging

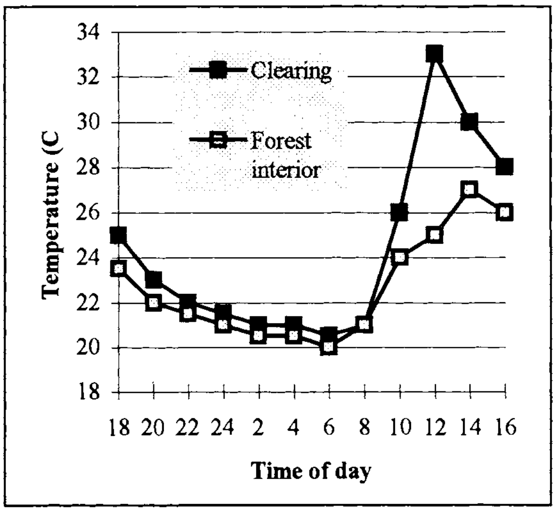


Figure 6.1. Daily cycle of air temperature in a rainforest in south-west Ghana. After Longmann and Jenik (1974).

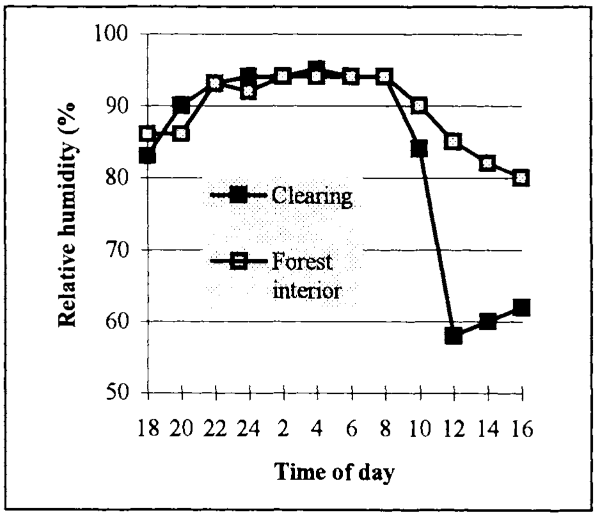


Figure 6.2. Daily cycle of humidity in a rainforest in south-west Ghana, on an unusually dry day. After Longmann and Jenik (1974).

6.4 IMPACTS ON TREES AND VEGETATION

Although Uganda's natural forests contain several hundred tree species, relatively few have been favoured as timber trees. For instance, those that are listed in the top two timber grades and which occur in Budongo Forest are given in Box 6.2. In practice, even fewer species are in regular use. In Budongo, for instance, despite attempts by the Forest Department to force sawmills to diversify, the proportion of mahogany removed compared to other tree species has remained more or less constant since the 1930s (Plumptre et al., 1994).

6.4.1 Impacts on the target tree species

In some cases, management has resulted in the depletion of stocks of timber species, such that a few are now becoming rare. Internationally, many tropical timber species are threatened by over-exploitation, (FAO, 1986) although as yet only a few (such as the mahoganies, *Cordia milleni* and *Milicia excelsa*) are threatened in Uganda (see Section 3.3.5 for more details).

Many timber species will regenerate successfully in logged forest, but only if seed trees are left to ensure an adequate source of seeds. In Budongo Forest, for instance, most *Entandrophragma* spp. trees do not start producing seeds until they are over 80-100 cm dbh; for *Khaya anthotheca* the figure is about 70 cm dbh (Plumptre et al., 1994). Thus if all such trees are harvested as soon as they reach a diameter of 70 cm dbh, there may not be sufficient seeding trees remaining to ensure that the species regenerates, and enrichment planting may be necessary. In other cases, however, management has ensured that stocks of timber trees are maintained, or even enhanced. In Budongo, *Maesopsis eminii* not only seeds profusely well before reaching 70 cm dbh, but it also regenerates well in gaps. Unlike mahoganies, enrichment planting is seldom necessary. Of course enrichment planting of timber species can, if taken to extremes, eventually result in a forest structure that is almost as uniform and even-aged as a plantation.

6.4.2 Impacts on non-target tree species and vegetation

During felling, whether by mechanised logging or pit sawing, it is not just the target tree that is affected. Many other trees and shrubs in the vicinity, comprising future timber trees and many other species, may also be damaged or destroyed. How much of the surrounding vegetation is affected depends on the intensity of harvesting, but also on the care taken (for instance, climber cutting, directional felling and careful planning of skidding tracks and roads). Figure 6.3 compares tree mortality in three African production forests with similar intensities of harvesting. In these particular cases, up to 65% of trees are damaged during the removal of just 1% of the trees. It may be assumed that higher levels of damage correspond with greater subsequent domination of the regeneration by pioneers. The Ugandan study (in Kibale Forest) shows the highest rate of damage, at over six times the rate of the Gabon study. This emphasises the importance of good planning and management of harvesting operations (see Chapter 7).

Table 6.1 takes a closer look at the Kibale study area, and compares various aspects of vegetation in unlogged, lightly logged and heavily logged forest. From this study, it is clear that the immediate impacts of logging here include a reduction in basal area and stem density (hardly surprising), an opening up of the canopy, an increase in the average gap size, and a drop in the number of tree species present. Seedling regeneration may be suppressed, and heavy logging produces larger impacts than light logging.

Box 6.2
The top two grades of timber trees in Budongo Forest, Uganda (Plumptre et al., 1994)

- *Albizia* spp.
- *Alstonia boonei*
- *Aningeria altissima*
- *Entandrophragma* spp.
- *Antiaris toxicaria*
- *Celtis durandii*
- *Celtis mildbraedii*
- *Celtis zenkeri*
- *Chrysophyllum* spp.
- *Cordia milleni*
- *Cynometra alexandri*
- *Diospyros abyssinica*
- *Dombeya mukole*
- *Funtumia* spp.
- *Guarea cedrata*
- *Hallea stipulosa*
- *Holoptelea grandis*
- *Khaya anthotheca*
- *Lovoa trichilioides*
- *Maesopsis eminii*
- *Milicia excelsa*
- *Morus lactea*
- *Myrianthus arboreus*
- *Olea welwitschii*
- *Trichilia dregeana*
- *Zanthoxylum* spp.

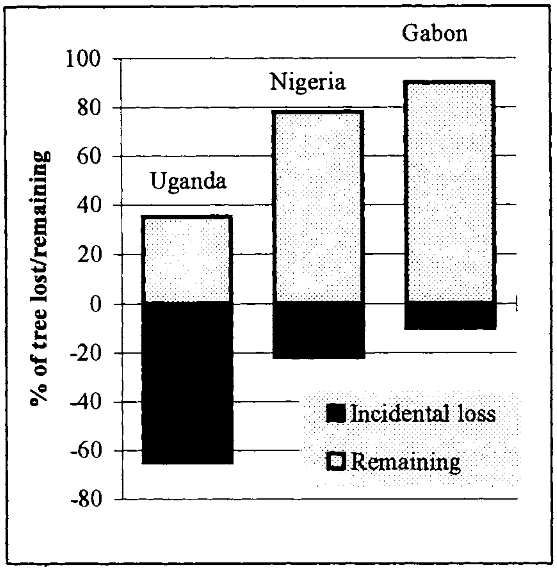


Figure 6.3. The proportion of trees >30 cm dbh remaining or damaged, following logging at an intensity of 1% in three African production forests. Data are from Johns (1985) for Uganda, from Redhead (1960) for Nigeria, and from White (1992) for Gabon.

Studies elsewhere suggest that a certain amount of canopy opening, whether by logging or other silvicultural treatments, can increase productivity and tree species diversity.

Thus the aim of good management need not necessarily be to minimise canopy opening, rather to optimise it. This is the theoretical basis behind many silvicultural operations in Ugandan natural forests. Figure 6.4 examines this phenomenon more closely, by looking at changes in productivity of forest recovering from differing intensities of logging in Indonesia.

The figure suggests that, whereas intensive logging results in forest degeneration (negative growth) (due to the growth of climbers, herbs and shrubs that suppress tree seedlings), light logging can indeed enhance growth. In this example, a logging intensity that destroyed 9% of the trees (a level similar to that recorded in the Gabon study above) resulted in a higher growth rate than one that only destroyed 4% of the trees (a level of disturbance perhaps more typical of many natural unlogged forests). But at logging intensities where 23%-76% of the trees were destroyed (similar to the Ugandan study above), forest degeneration resulted. In Kibale Forest, it was suggested by Skorupa and Kasenene (1983) that a logging intensity that resulted in a basal area reduction of 25% was about the maximum that would allow the forest to recover to its natural turnover rate within a few years. Above this, treefalls were found to continue well after logging at a rate several times the background rate for neighbouring unlogged forest. In other words, **high rates of logging precipitate long-term changes in forest dynamics.**

Table 6.1.
Effects of logging on vegetation in Kibale Forest, Uganda.
Data from Skorupa (1986) and Tabor, Johns and Kasenene (1990)

Variable	Unlogged	Lightly logged	Heavily logged
Total basal area (m^2/ha)	36	27	19
Total stem density (no./ha)	256	267	125
Large stem density (no./ha)	25	12	8
% canopy cover> 9 m	87	65	45
% canopy cover> 15 m	72	50	32
Average gap size (m^2)	256	467	1307
Tree species richness (av. no./100 stem sample)	26	23	18
Tree species density (av. no. in 20 5x50 m plots)	25	23	14
Seedling regeneration	Good	Good to fair	Poor

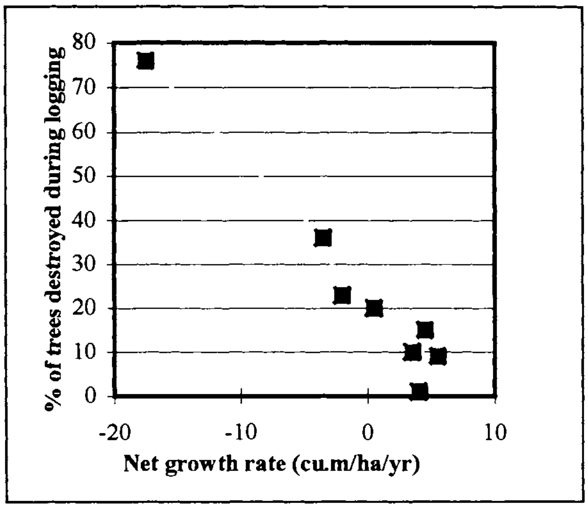


Figure 6.4. The effects of different levels of felling damage on subsequent growth of tropical forest, from a study in Indonesia. All points to the left of the zero on the horizontal axis indicate that forest degeneration is occurring. After Miller (1981).

Even if felling damage is not so great as to cause forest degeneration, the species composition of the forest may change greatly following logging or silvicultural treatments. In general, pioneer tree species (see Section 5.6.31) will be favoured in the resulting regeneration, while non-pioneer species will be disfavoured, at least for the first few years. This is demonstrated for a study of regeneration following logging in Ghana in Figure 6.5. In Budongo Forest, the "mixed forest" type has increased at the expense of "ironwood forest" over the past four decades, probably as a result of arboricide treatment and logging in the latter forest type (Plumptre et al., 1994). This was the main aim of silviculture in Budongo, although ironically it does not seem to have resulted in better mahogany regeneration.

Figure 6.6 compares the tree species composition of logged and unlogged areas in Kalinzu forest. The data-set suggests that logging can be good for some species but bad for others. In particular:

- Pioneer and "weed" species become more frequent; some of these are seemingly absent from unlogged plots.
- Climax species become less frequent, sometimes seemingly to the point of local extinction. Extinction seems particularly likely for species which are already rare in unlogged forest.
- The number of species or species-groups may change (e.g. a decrease from 48 to 42 at Kalinzu).

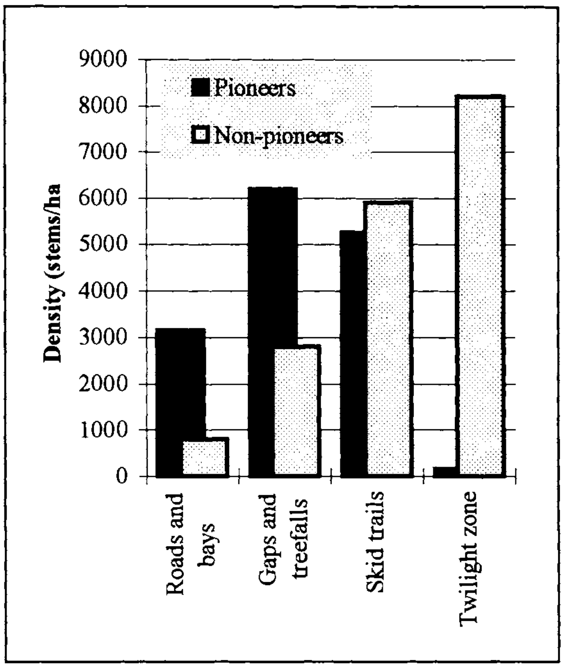


Figure 6.5. Density of regenerating pioneer and non-pioneer trees in different categories of forest in a logged area of Bia South Game Production Reserve, Ghana. After Hawthorne (1993) "Twilight zone" refers to the area of unlogged forest beyond the immediate influence of any of the preceding three categories. Regeneration of pioneers is greatly increased in categories affected by logging, and regeneration of non-pioneers suppressed.

When interpreting data such as these, it must be remembered that they are derived from plots rather than whole forests. This means that all the "extra" species that appear in logged forest have not appeared from nowhere, but must have always been present at low levels in the forest but were so rare (perhaps only occurring in occasional gaps or along the forest edge) that they were missed by the sampling process. This means that they are not of great conservation concern, as they can probably survive in a forest whether it is managed or not. The only situation in which they might risk being lost is if the forest reserve was unmanaged and very small, in which case there may not be sufficient gaps at any one time to support all the gap species (Johns, 1985).

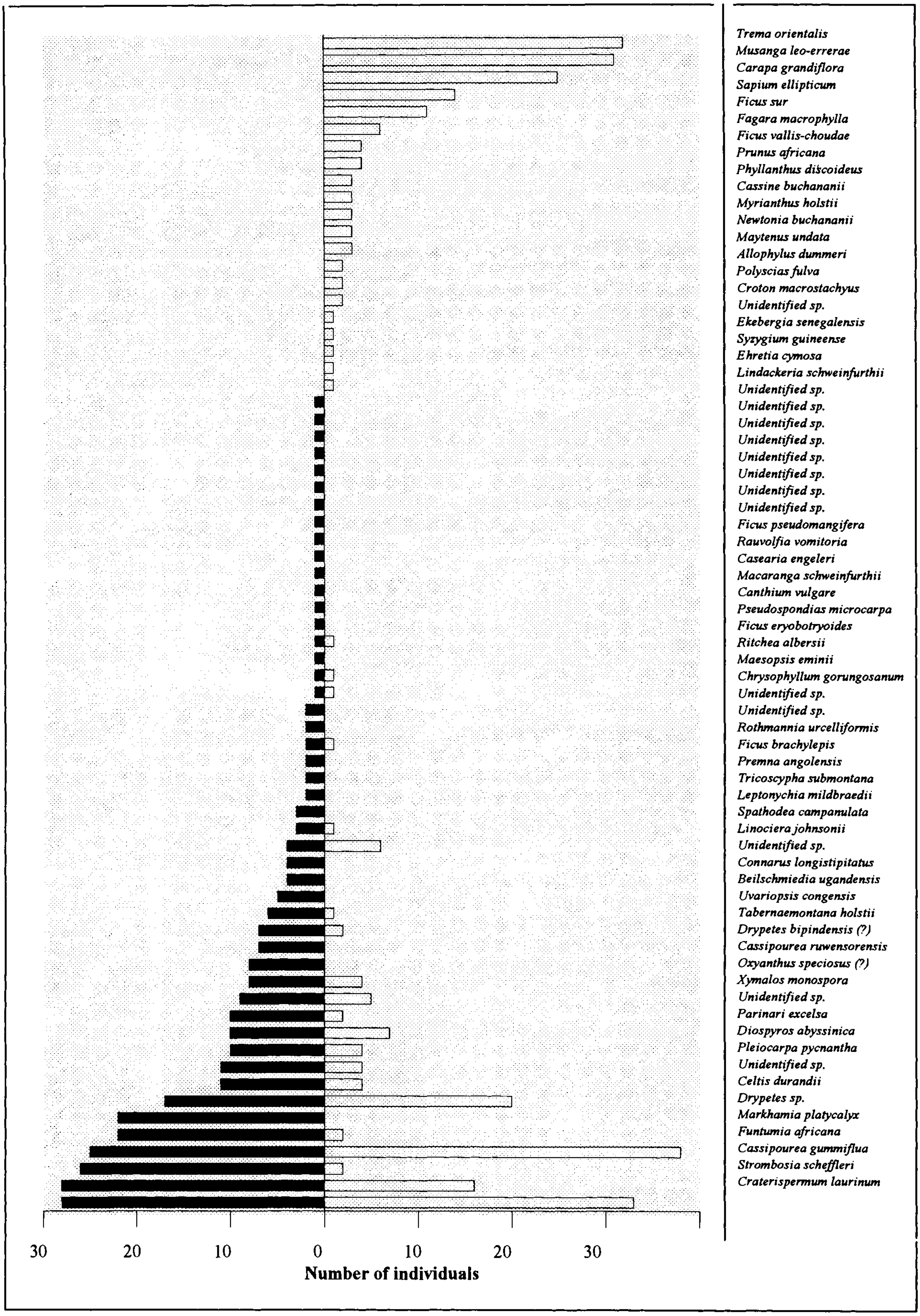


Figure 6.6. The number of trees of 69 species in 1 ha plots in adjacent areas of relatively undisturbed (left) and mechanically logged (right) Parinari *forest in Kalinzu Forest, Uganda. Data from Kisubi (1991).*

In a logged or otherwise disturbed forest, any truly additional species are likely to be either non-forest species that find temporary homes in clearings, or more worryingly, invasive exotic species (see Section 8.4), which benefit from the disturbance and may, in the long term, cause the extinction of many native species. In the forests of the East Usambaras, for example, Sheil (1994) notes that whereas undisturbed forest now harbours 19 species of naturalised exotic plants, disturbed forest and forest edge harbours almost double that number (36). He concludes that *"timber harvesting options that might [otherwise] be compatible with sound conservation are likely to be severely diminished by the presence of aggressive exotics"*. It is likely that the spread of the invasive exotic *Broussonetia papyrifera* in Budongo is enabled by forest disturbance associated with logging and pit sawing.

Regarding species that seem to disappear following logging, whilst it is possible that they may still exist at low densities in logged forest, they are still of greater conservation concern. It may be that, even if they can survive in logged forest for a generation or two, they may not persist for longer than this. For such species, many of which are likely to be slow-growing shade-tolerators, their main chances of survival are in undisturbed nature reserves.

The "***intermediate disturbance hypothesis***" (Connell, 1978), that states that species diversity within a given patch should be highest at intermediate frequencies or intensities of disturbance. But what is meant by "intermediate" varies from ecosystem to ecosystem, and from forest type to forest type. Natural forest management has most chance of being compatible with conservation of tree species if it is carried out at such a rate that gap creation mimics the natural disturbance regime of the forest in question, and does not exceed that rate too much (Denslow, 1980). If it does exceed the natural rate, then the forest will probably change in structure and composition: there will be some winners, but also losers. However, as Hobbs and Huenneke (1992) note, it is worth remembering that in most reserves, the "natural" disturbance regime is now unlikely to persist because reserves have become isolated or have lost certain species (such as elephants) that used to cause natural disturbance; thus a management decision that must be made is what disturbance level to maintain and how.

6.5 IMPACTS ON MAMMALS

6.5.1 Impacts on primates

Primates (monkeys, chimpanzees, gorillas, pottos and bush-babies) are important members of tropical forest ecosystems in Uganda. As well as forming a large and very visible biomass, many are also important as dispersers of tree seeds because of their often frugivorous diet. For many people, they are the very essence of a tropical forest. Partly for these reasons, primates have been well studied in many tropical forests, and there is a large amount of information concerning their conservation status and the impacts of forest management on their populations. In Uganda, long-term studies have been carried out at Budongo and Kibale Forests.

At Budongo, studies by Plumptre et al. (1994) have demonstrated that three out of the five species of diurnal (daytime-active) primates exist at statistically significantly higher densities in logged forest than in unlogged forest, as Figure 6.7 shows. The remaining two species occur at roughly similar densities in logged and unlogged forest. In Kibale forest, however, where there are seven native species of diurnal primates, studies (Skorupa, 1986; Johns and Skorupa, 1987) suggest that five species show a statistically significant decrease with logging, one (black-and-white colobus) shows a significant increase and one (blue monkey) seems relatively unaffected (Figure 6.8).

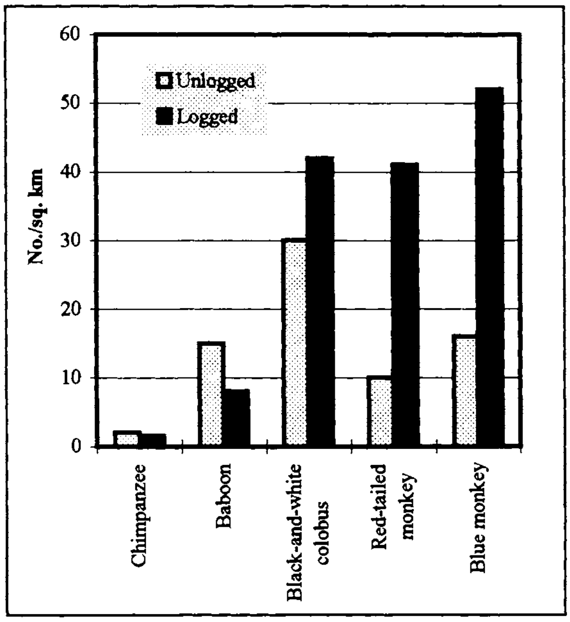


Figure 6.7. The impacts of logging on primates in Budongo Forest, Uganda. After Plumptre (1994).

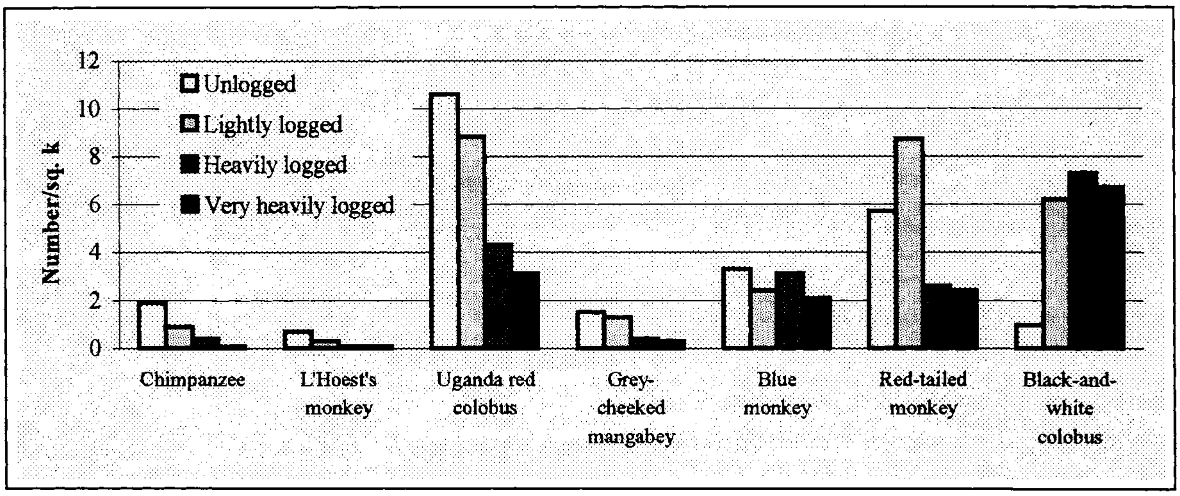


Figure 6.8. The impacts of different logging intensities on primates in Parinari-*dominated areas of Kibale Forest, Uganda. Lightly logged forest implies 25% loss of basal area and 20% loss of canopy cover. Heavily logged implies 45% loss of basal area. Very heavily logged implies 50% loss of basal area and >40% loss of canopy cover. All surveys were conducted 9 to 16 years after logging. After Skorupa (1986).*

Circumstantial evidence from Kalinzu Forest (Howard, 1991) suggests that all diurnal forest primates there are three to five times commoner in logged forest than in unlogged. It has been suggested that the main reason for the differences between Kalinzu and Kibale Forests is that one of the main colonising tree species in gaps created by logging in Kalinzu is *Musanga leo-errerae*, a species which has fruits that are much favoured by primates. This tree is not such a feature of gaps in Kibale Forest, where its place is taken by *Trema orientalis* (see Figure 6.7), a species that does not produce sought-after fruits.

In Budongo Forest, logging and silvicultural operations have tended to increase the area of mixed forest at the expense of ironwood forest. Mixed forest seems to be able to support higher densities of some primates than ironwood forest (Plumptre and Reynolds, 1994), because there are more fruiting trees of more species available year-round, especially figs (a common pattern in logged forest, Earl, 1992), and because production of young leaves (on which black-and-white colobus feed) is higher.

Looking further afield to other parts of Africa, recent studies in Gabon (White, 1992) suggest that whereas western lowland gorillas increase following logging (because they feed on herbaceous vegetation which also increases), chimpanzees decrease significantly, probably because the main fruiting trees that provide them with most of their food decrease. Lowland gorillas were also found to increase in logged forest in Cameroon (Blockhus et al., 1992), while mountain gorillas in Zaire also seem to benefit from limited tree-felling in their montane forest habitat (Murnyak, 1981). Meanwhile, Thomas (1991) showed that in the Ituri forest of eastern Zaire most primates occurred at higher densities in secondary forests; a similar pattern occurs on Tiwai island, Côte d'Ivoire (Oates et al., 1990). The main conclusions to be drawn from these studies are:

- Logging benefits some species (if increased population density can be said to be a benefit), while other species suffer.
- Whether a species benefits or not depends in part on its food preferences and whether these increase or decrease as a result of logging.
- The same management can have different impacts on primates in different forests.

It is worth noting, however, that the species in Budongo that seem to benefit from logging are all widespread primates under no threat of extinction. It may be that they are widespread for the very reason that they are tolerant of disturbances. In Kibale, however, the species that are adversely affected include several (L'hoest's monkey, Uganda red colobus and chimpanzee) that are rare or threatened (see Section 3.3).

6.5.2 Impacts on other mammals

Few other mammals have been as well studied as the primates. In Budongo Forest, preliminary findings suggest that ground-living rodent species richness is greater in unlogged forest than in logged forest (Musamali, pers. comm. 1994), while data for squirrels shows no clear pattern (Plumptre et al., 1994). In Kibale, heavily logged forest was found to contain more rodents and more rodent species than unlogged forest (Kasenene, 1980), and this was thought to be having harmful effects on tree seed and seedling survival. Bongos (a forest antelope) were found to increase in logged forest in Ghana (Blockhus, et al., 1992), and probably many other grazers and browsers will do likewise, assuming hunting pressure does not increase.

The case of elephants has been rather better documented in Uganda, because they were an unwelcome beneficiary of the Forest Department's silvicultural operations in Budongo. Earlier this century, Budongo was said to be the headquarters of a herd of elephants estimated at 5000 head (Swynnerton, 1924), of which perhaps 500 may have been a resident herd of the forest-dwelling subspecies (Langdale-Brown et al., 1964). Langdale-Brown et al. (1964) wrote that "*elephants are particularly fond of the succulent herbaceous tangle that springs up in accidental or man-made gaps, and will visit such places repeatedly, each time breaking off the tips of any young saplings, trampling down any seedlings, and assuring the perpetuation of this 'elephant climax tangle'* ". It is thus not surprising that the Forest Department sought to eliminate elephants from Budongo, as illustrated by this quotation from the second revision of the Budongo working plan (Trenaman, 1955), which had as one objective "*to nurture, **with the exception of the larger game**, specimens of the characteristic living communities in Budongo in their natural state*". Even in 1970, elimination was still seen as the goal, as this quotation from Laws, et al. (1970) illustrates: "*the presence of elephant is incompatible with timber production...the only solution is the elimination and exclusion of elephants from the forest*". Between 1925 and 1965, at least 15,000 elephants were shot in Bunyoro by the Game Department (Laws, et al., 1970), and by the 1980s they were effectively extinct in Budongo. Thus, although elephants could theoretically benefit from natural forest management, in practice in Budongo they certainly did not. In parts of West Africa, elephants could similarly benefit from logging, but are prevented from doing so by hunters that follow the logging roads deep into the forest.

6.6 IMPACTS ON BIRDS

Studies on birds are not as common as for trees or primates, and most studies have been carried out outside Africa. Preliminary findings in Budongo suggest that hornbills are significantly commoner in unlogged forest, and that forest recovering from logging in the 1950s or 60s is more favourable for hornbills than forest logged more recently (Plumptre et al., 1994). Other studies in Budongo (Owiunji, pers. comm. 1993) suggest that most, but not all, species of birds found in unlogged forest also occur in logged forest.

Figure 6.9 presents more comprehensive data from a study of forest in Amazonian French Guyana (Thiollay, 1992). In this study, many more species show a decline in abundance following logging rather than an increase, and this decline seems to persist at least ten years after the logging event. Species that were most severely affected were mostly those associated with the understorey of tall mature forest; less severely affected were species associated with the forest canopy or with small gaps and vine tangles. Small frugivorous birds, and birds associated with clearings or edges, generally increased.

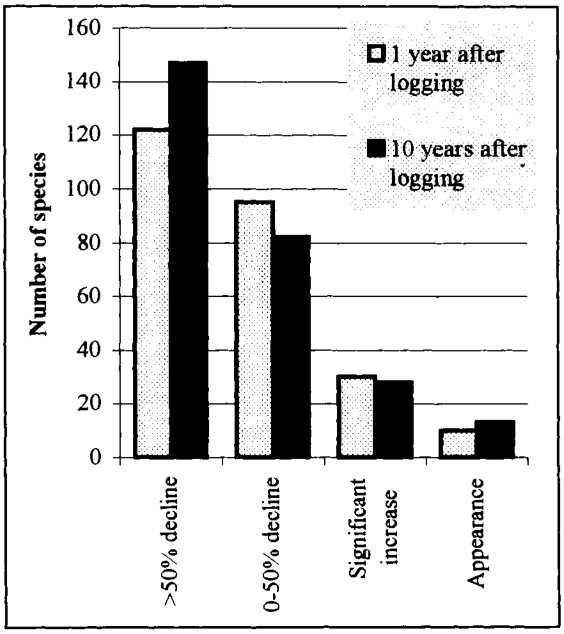


Figure 6.9. The impacts of logging on population density of forest birds in French Guyana, one year and ten years after logging. After Thiollay (1992).

Unfortunately the study has not been going on long enough to determine whether the declines are eventually reversed.

Two further studies that recorded declines in bird species richness are from West Malaysia (Johns, 1985) and Sabah (Payne and Davies, 1982). In the former, primary rainforest was found to support 195 species of bird while logged forest supported 122; in the latter the corresponding figures are 161 and 137.

As with other groups of organisms, the results of studies on birds show that it is not easy to generalise about the impacts of natural forest management. Some species may benefit, while others may lose out. From a conservation point of view, we need to be particularly concerned about any species that decline, particularly if this decline seems to be permanent or long-term. At the moment we do not have the data to show which species are affected this way in Uganda.

6.7 IMPACTS ON INVERTEBRATES

If studies on birds are scarce, then studies on invertebrates are positively rare. This rather undermines any conclusions that we may want to draw from the studies that exist for other groups, and is all the more alarming when it is remembered that about two out of every three species on the planet are insects and an even higher proportion are invertebrates (including insects). If we want to generalise about the effects of natural forest management on wildlife, we should not ignore the invertebrates (Johns, 1992).

Invertebrates number many millions of species, and it is impossible to generalise about the effects of any human activity on them. In tropical forest, many invertebrates may be indifferent to management, and many may benefit in a similar way to pioneer tree species or the more generalist primates. Moderate levels of forest disturbance seemed to have no effect on dung beetle assemblages in Kibale Forest, Uganda (Nummelin and Hanski, 1989) nor in forest in Sabah, Malaysia (Holloway et al., 1992). Similarly, species richness in leaf-litter ants in Ghana showed no significant differences between primary forest, secondary forest and cocoa farms (Belshaw and Bolton, 1993). However, in a study in Cameroon (Watt, unpubl. 1995.), leaf-litter ant species richness was higher in disturbed forest than in undisturbed, while butterflies showed the opposite trend, albeit weakly (Figure 6.10).

There is one guild of invertebrates that is most likely to be adversely affected by natural forest management, and this is the wood-feeding guild (saproxylics), which is probably the numerically most dominant guild in natural forest, at least in temperate zones. Saproxylic species (i.e. those associated with dead wood, see Section 5.5.41) are likely to suffer particularly if management progressively eliminates large old trees. Such trees are often termed "overmature" by foresters. A typical commercial forester's definition of an overmature tree is that given by Keay (1961):

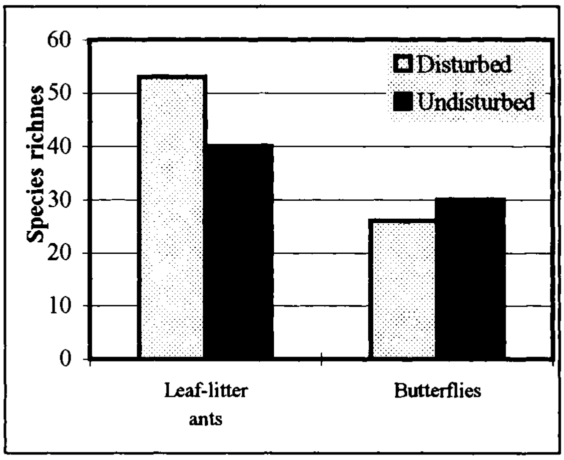


Figure 6.10. Species richness of leaf-litter ants and butterflies in experimentally disturbed and undisturbed forest in Ebogo, Mbalmayo Forest, Cameroon. From Watt (unpubl. 1995).

- *trees which have become too large to be conveniently handled by the exploiter*
- *trees which are becoming more and more unsound*
- *trees which are no longer growing fast enough to earn an economic return*

This very negative view of overmature trees needs to be balanced by their immense importance for nature conservation, and a fourth definition might read:

- ***trees which, though old, are in their prime as habitat for a wide range of specialised species, particularly insects, other invertebrates, fungi and epiphytes***

Studies in the temperate forests consistently show that managed forests support far fewer species of saproxylics than unmanaged ones (Speight, 1989). Indeed, in Britain, where nearly all the forests are managed or have been in the past, at least 20 species of saproxylic beetles have become extinct since prehistoric times, and a further eight species are known to have become extinct in the last 200 years. At least 27 species of saproxylic insects have not been seen in Britain this century, including 13 not seen since 1950 (Warren and Key, 1989). Of the 150 woodland invertebrate species officially listed as threatened in Britain, 65% are thought to be threatened primarily by the removal of dead wood or old trees from forests (Hambler and Speight, 1995).

For the cool temperate boreal forests, where the usual management procedure is clear-felling followed by replanting or natural regeneration, the impacts on invertebrates are undoubtedly profound. In Finland, for example, it is estimated that 692 species of animal and plant are currently faced with extinction as a result of that country's forestry practices, which are theoretically among the best anywhere in this forest zone (Wright, 1995). Most of these species are likely to be invertebrates, many of them saproxylics. A similar situation exists in adjacent Sweden, where logging of old-growth forest threatens 200 forest-dwelling species of plants and animals with extinction, and a further 800 with decline. Again, most of these will be saproxylics (Taiga Rescue Network, 1992).

Given that for most groups studied, tropical forests are naturally far richer in species than temperate ones (see Section 2.3), it seems likely that long-term management of natural tropical forests for timber or firewood production could lead to the decline and perhaps extinction of hundreds or even thousands of species of saproxylic invertebrates. However, since there have been scarcely any studies on saproxylics, this conclusion remains conjectural. Support for it comes from a preliminary study by Collins (1980) who looked at termites (an important group including many saproxylic species) in Sarawak, and recorded over twice as many species in unlogged as in selectively logged forest, which itself was twice as rich in species as clear-felled forest (Figure 6.11).

However, a more recent experimental study in Cameroon (Eggleton et al., 1995) showed no consistent difference in termite species richness between essentially unlogged and old secondary (selectively cleared) tropical rainforest: if anything, the secondary forest supported more species. Even forest that had been heavily enriched thirty years previously through planting of *Terminalia ivorensis* was not significantly poorer in termite species. It was only once the forest was completely cleared (to make way for a plantation) that species richness dropped significantly, from around sixty species to around thirty.

Species diversity amongst the specifically wood-feeding guild actually seemed to be higher in old secondary forest compared to primary forest (figure 6.12). The authors speculate that this might be due to a superabundance of dead wood in disturbed forest, and further suggest that many termite species benefit from the gap-like conditions found in old secondary forest.

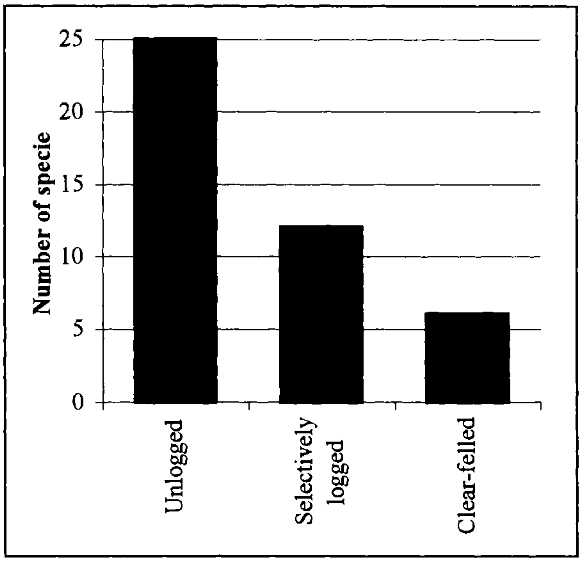


Figure 6.11. The number of termite species recorded in a day's collecting in unlogged, selectively logged and clear-felled forest in Malaysia. After Collins (1980).

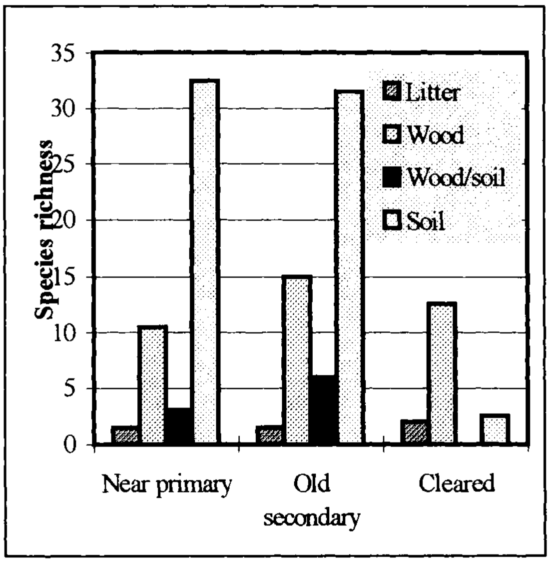


Figure 6.12. Differences in species richness amongst different feeding guilds of termites in undisturbed, disturbed and cleared forest in Mbalmayo Forest, Cameroon. After Eggleton et al. (1995).

What this or other short-term studies cannot show, however, is the **long-term** implications of forest management/disturbance. What would happen to the secondary forest if it was managed in such a way that it never regained the structure of primary forest? Will it always have a superabundance of dead wood, and a structure similar to the gaps found in primary forest, or will there be times when these conditions are not present? Would secondary or enriched forest still be able to support a full complement of species if there was no primary forest adjacent to it for colonisation? Would enriched forest continue to support so many species into the second, third and subsequent cycles of planting and harvesting?

Conclusions that can be drawn from insect studies to date are:

- As with other groups, some species will benefit while others will lose out, but the proportion of losers may well be higher than in better-studied groups.
- Declines and extinctions may be imperceptible over a single logging cycle, but may accumulate over many cycles and eventually lead to mass extinctions.
- Because of the degree of uncertainty due to lack of study, we should be cautious in extending findings from studies on other groups of animals or plants to invertebrates.

6.8 FOREST MANAGEMENT PRINCIPLES

Boxes 6.3 and 6.4 are guidelines that were drawn up by the International Tropical Timber Organisation (ITTO) and the World Conservation Union (IUCN) in 1982 to address biodiversity conservation issues in forests managed for timber production (Blockhus et al., 1992).

6.9 SUMMARY

- Natural forest management is based on the premise that manipulation of the forest can enhance its productivity for timber.
- In manipulating the forest, we alter its ecology in ways which may seem subtle to us as humans but which can be profound for some other species that depend on the forest.
- Some species are affected directly, and immediately, while others are affected indirectly and over a longer period.
- Some species benefit from natural forest management. Timber trees are meant to be the main beneficiary, but other species that favour the conditions created by natural forest management can also benefit. These species can normally continue to survive in managed forest.
- We know that other species do not benefit from natural forest management; many decline significantly and some may be driven to extinction. For this reason, we will always need protected areas where there is no human intervention.
- What we know about natural forest management so far enables us to be cautiously optimistic about its impacts on wildlife generally. However, it will only be successful if carried out carefully and if the results are monitored, and we should err on the side of caution because we still know very little about its effects on most species, especially in the long-term.

6.10 FURTHER READING

Blockhus, J.M., Dillenbeck, M., Sayer, J.A. and Wegge, P. 1992. *Conserving biological diversity in managed tropical forests.* IUCN, Gland.

Johns, A.D. 1992. Species conservation in managed tropical forests. In: Whitmore, T.C. and Sayer, J.A. *Tropical deforestation and species extinction.* Chapman and Hall, London.

Plumptre, A.J. and Reynolds, V. 1994. The effect of selective logging on the primate populations in the Budongo Forest Reserve, Uganda. *Journal of Applied Ecology*, Vol. 31: 631-641.

Box 6.3
Basic principles governing the relationship between natural forest management and the conservation of forest wildlife (Blockhus et al., 1992)

1. Any disturbance of a forest, natural or man-induced, will alter it as a habitat for animal and plant species. Small-scale disturbances may enhance structural, floristic and faunistic diversity. Large-scale disturbances tend to simplify the ecosystem and result in loss of biological diversity.

2. The management of forests for timber production requires modification of the natural ecosystem to increase the yield of commercial species. Inevitably, some of the original forest species are then lost. Total aerial biodiversity may remain similar as other species colonise but because the colonisers are common and widespread and the displaced species are old-growth specialists, many with restricted ranges, the net result is a qualitative change in diversity favouring generalist species at the expense of old-growth specialists.

3. Detailed information on the ecology of all forest species and on their response to disturbance is not available. The safest strategy for conserving biological diversity is therefore to establish large undisturbed protected areas covering representative samples of all forest types.

4. Few countries are able to allocate sufficient areas to total protection to guarantee the preservation of all animal and plant species and their intraspecific genetic variation. In most countries, totally protected areas do not exceed 4%-8% of national territory and individual areas are generally small. When species exist only in small isolated populations, they are susceptible to extinction caused by random environmental events and genetic deterioration. If natural forests are only retained in small isolated protected areas, then many species will inevitably be lost.

5. Forests managed for timber and/or non-timber products do provide habitats for many, in some cases the majority, of the plant and animal species found in pristine, unmanaged forests. The number of species persisting is dependent on a variety of factors, predominantly on the degree of intervention and modification of the original ecosystem. In some cases of low-intensity utilisation, forests may, at least in the short term, have greater diversity than undisturbed ecosystems. Species composition will have changed, however, and some rare or specialised species may be lost.

6. Even though managed forests do not provide the requirements of all pristine forest species, they have a particularly important role in providing a buffering function around protected areas. This will especially benefit wide-ranging species, that are often able to persist in large production forests while they cannot persist solely in small isolated national parks and reserves. Because production forests are an extension of total forest area, although of a modified form, they will allow the existence of larger population sizes of such species than would be expected in protected areas alone. Production forests as buffer zones around natural forests will further act to minimise a severe problem in small protected areas.

Box 6.4
Natural forest management principles for the conservation of forest wildlife (Blockhus et al., 1992)

1. Certain forestry practices maintain the biodiversity conservation value of managed forests. These include the use of selective systems which take out small numbers of trees per unit area on a regular basis. These are often, though not always, more conducive to biological diversity conservation and to sustaining the functioning of the ecosystem than systems under which a larger proportion of trees are removed simultaneously during logging. Minimum intervention systems are more likely to sustain both timber yields and biodiversity values.

2. Animal and plant species will recolonise logged forest much more rapidly if small areas of all forest types are protected as biological resource reserves or refugia (strict nature reserves). These should be in addition to forest areas that are inoperable for physical reasons, as these will usually represent different forest types.

3. Many animal and plant species are adapted to old-growth forests. The survival of these species is favoured if some areas of forest are managed on very long logging cycles. The value of areas of forest managed on long rotations will be greater if they are located so as to act as sources of colonists for intervening areas managed on shorter rotations.

4. Animal and plant species cannot survive for long in isolated fragments of forest. Small, isolated production forests and protected areas will have little value for biological diversity. The value for biological diversity of both categories of land will be greatly enhanced if they are located in large contiguous blocks. Internal zoning can be used to achieve the optimum balance between production and conservation objectives.

CHAPTER 7

PROMOTING WISE MANAGEMENT OF FORESTS

CHAPTER OUTLINE

7.1 SUSTAINABLE FORESTRY: AN INTRODUCTION

In Chapter 6 we saw how natural forest management can have important consequences for nature conservation: if it is done badly, then it can be very damaging, but if it is done well, then it can be fairly benign. In this chapter, we want to consider how to make sure that management of the natural forest estate is carried out in as "wise" a way as possible, so that it fits in with the overall aim of sustainable development. In doing so, we will need to bear in mind the ten principles that should be common to all forms of environmental management (Box 7.1).

By using the word "wise", we are implying that we are using the forest resources sustainably. **Sustainable use** is defined by IUCN/UNEP/WWF (1991) as ***using renewable resources at rates within their capacity for renewal***. For forestry, this implies that we must pursue **integrated forest management**, defined in the above document as ***management which maintains indefinitely, without unacceptable impairment, the productive and renewal capacities as well as the species and ecological diversity of forest ecosystems***. Wyatt-Smith (1987) put it this way: *"Sustainable forestry means to harvest forest in such a way that provides a regular yield of forest produce without destroying or radically altering the composition and structure of the forest as a whole."* Sustainable forestry, according to Vanclay (unpubl.) is *"rather like a major civil engineering undertaking: we need land use plans, community consultation, the timely involvement of many individuals from many different disciplines, quality control in all operations, and efficient accounting and revenue collection."*

The need to address these issues is now urgent almost wherever the world's natural forests are being managed. This is made very clear in the conclusions to a recent survey conducted for the International Tropical Timber Organisation (Poore, 1989) (Box 7.2).

7.2 ENVIRONMENTAL IMPACT ASSESSMENT (EIA)

7.2.1 What is EIA?

EIA is the process of systematically acquiring and analysing information in order to assess the impact a specific development will have on the environment. The rationale is that such an assessment will enable one to better judge whether the development should go ahead, and if so, whether any modifications need to be made to the original plan to minimise environmental damage and maximise benefits. Although it is normally used when major projects such as dam-building or other civil engineering works are being considered, the techniques employed are equally useful for assessing smaller or more diffuse activities, such as forestry operations.

Box 7.1
The ten principles of environmental management (Rhodes, 1994)

- **The duty of care**. All consequences of an action should be examined carefully, before undertaking the action.
- **The precautionary principle**. Due to the large amount of uncertainty, risk and irreversibility involved in environmental processes and relationships, actions should err on the safe side.
- **Empowerment**. Decisions and actions should, where possible, be from the ground level upwards: the users should have the power to decide how to use their environment.
- **Subsidiarity**. The scale of management used should be appropriate to the problem and at the lowest effective level.
- **Social learning**. All members of a community should have an equal chance to participate and managers should listen to and respect their views.
- **Sustainability**. Any actions should be able to maintain, indefinitely, the environmental systems and processes.
- **Areal equity**. Each area should be treated with respect to the endowments it possesses and not over-utilised.
- **Intergenerational equity**. The environment passed on to future generations should be of the same quality or better than it is today.
- **Procedural equity**. All actions undertaken should be transparent and accountable.
- **The polluter pays principle**. Any pollution events are the full responsibility of the polluter to clean up.

Box 7.2
The main findings of a recent international survey of the state of natural forest management (Poore, 1989)

- The amount of tropical moist forest worldwide being managed for the sustainable production of timber is negligible (< 1 million ha), compared with the area nominally being managed for timber (828 million ha).
- Many countries have the intention, expressed in their legislation, to manage forests sustainably. In a number of countries, partial forms of sustainable management are being practised either deliberately or by default.
- There seems to be some awareness in most of the producer countries, particularly among their foresters, that action is needed.
- Nevertheless, progress in establishing stable sustainable systems is so slow that the general decline in quality and quantity of forests continues.
- Comprehensive and urgent measures are necessary if the tropical timber trade is to continue in the long term to handle material which even approaches the quantity and quality to which it has become accustomed.
- The future existence of large areas of tropical forest, perhaps even the majority, depends on the establishment of sustainable systems of management, many of which must have timber production as their basis.

Carrying out an EIA of natural forest management, for instance, clarifies which operations are likely to have greatest impact, and enables us to think more clearly about how adverse impacts can be minimised. These ideas can then be fed into the management planning and monitoring process.

7.2.2 How is an EIA carried out?

The unique nature of each project means that it is not possible to prepare definitive guidelines for EIA procedures. However, most systems operating throughout the world contain a number of common stages, which together add up to a reasoned and agreed body of knowledge. Typically the following stages are included:

- **Project description.** At the outset a clear description of the project and its location may suffice; intricate detail is unnecessary.
- **Scoping and baseline studies.** *Scoping* is the term used to describe the focusing of the assessment process into areas of importance. Three blocks of information are needed to focus an assessment programme accurately:

  - Full project description, including construction and operational procedures.
  - Definition of the receiving environment. An understanding of the environment as a continuum is vital in targeting areas of study and prediction of impacts.
  - Definition of the human populations affected by the project. This not only includes people on or close to the development site but also transitory populations, such as tourists.

  The first two categories define the scope of an EIA programme. Correlation of one category against the other will focus research efforts and avoid unnecessary coverage. A commonly used method for achieving this is the **matrix.** In its simplest form this consists of plotting project attributes on one axis (a), against the environmental components on the other (b). This minimises the risks of environmental impacts being overlooked and, equally importantly, demonstrates the logic behind their identification. An example of a matrix is given in Table 7.1.

  Introducing the third (social) dimension to the scoping process can be done by ranking the areas of concern identified by the biophysical matrix according to the impact they will have on the local community.

- **Detailed studies, analysis and impact prediction.** Once the matrix has been generated by the scoping procedure the impact on the environment of every element involved in all stages of the project is assessed. This is done by describing the impact a specific element will have on each of the components of the receiving environment. Time spent establishing the agreed scope of a programme should save effort and expenditure at the detailed investigation stage. The significance of this impact will be the extent to which it affects humans and the environment. However, it is impossible to forecast the significance of changes with precision as by nature predictions involve uncertainty.

- **Development of mitigation measures.** There are no hard and fast guidelines for the drafting of mitigation measures. At this stage attention is focused on development processes and any which indicate a negative impact should be altered or excluded.

- **Production of non-technical summary, including decision to permit or refuse development.** This should contain the findings of the assessment, including details of whether the proposed development should go ahead or not, and if so in what form.

- **Monitoring programme.** The impact of the development, if it goes ahead, should be constantly monitored so that any deviation from predicted impacts can be detected at an early stage and management practices developed to accommodate such changes. This will also help improve forecasting accuracy in the future.

Table 7.1.
An example of an Environmental Impact Assessment matrix for assessing impact of logging activities. Based on Zimmermann (1982)

	Logging	Forest clearing with fire	Forest roads, skid trails & yarding areas	Log hauling by road	Logging camps	Sawmilling & other transform-ations	Demograph-ic and economic expansion
Land forms and soils							
Water resources							
Climate and air quality							
Vegetation							
Wildlife and fisheries							
Traditional cultures /subsistence							
Cash economy & demography							
Epidemiology							
Conservation & amenity areas							
Other							

7.2.3 EIA and natural forest management

Let us imagine that there is a proposal to open up an undisturbed part of Budongo Forest to logging and pit sawing. It is clear that this will have environmental implications, since we know that Budongo Forest is important for nature conservation. It may also have sociological consequences. We now want to investigate these in more detail. One way to do this would be by visiting areas where pit sawing and logging are currently being carried out, so that the impacts these activities are having there can be identified, along with any mitigating measures that could be taken to reduce any adverse impacts.

The first stage is to design a matrix in which to record all the information on impacts and mitigation measures. Down the left-hand side we list various aspects of the forest or human environment that might possibly be affected, while along the top we list the possible activities associated with the logging (or pit sawing), broken up into logical groups if possible. Note that each of these boxes is a summary only: a memory-jogger. For instance, sub-categories of the "vegetation" category could include forest clearance, loss of species (rare, commercial and others), species diversity, genetic resources, forest regeneration, influx of weeds, persistence of weeds, unknown species, phytopathology, slash and other debris, fire hazard, adjacent uncut forest, exotic species, herbicides and so on.

The matrix is then taken into the field, and a cross put in any box where it is felt that there may be some environmental impact, even if in practice the impact could be avoided. For instance, if one of the possible activities along the top of the matrix were log hauling, then aspects of the forest environment listed down the left-hand side that might be affected by this could be land forms and soils, vegetation and wildlife and fisheries, and so on. After the field visit, the filled-in matrix can be examined, looking particularly at those boxes containing crosses.

Now is the time to use this information to decide (1) whether the whole project is too environmentally damaging to go ahead, or (2) if it is going to go ahead, what mitigating measures can be taken to minimise damage? For instance, the management or development plan could specify minimum standards for road construction, installation of drainage ditches and tunnels, and maximum road widths, if it is felt that these could help reduce damage to environmentally acceptable levels. It is possible that the result of the analysis is that we do not yet have enough information to decide whether the development should be permitted, in which case we could recommend delaying implementation until sufficient information (for instance on presence of rare species) has been gathered.

7.3 WISE MANAGEMENT OF NATURAL FORESTS

Many forests in Uganda have been managed for timber production, and it is likely that some will continue to be managed primarily for this purpose in the future. It is important, therefore, to be aware of the management decisions that can be taken to help minimise adverse impacts. These make good sense not only for the conservation of nature, but also for the long-term sustainability of timber production. It therefore also makes good long-term economic sense.

7.3.1 Minimising impacts on the ground

The Environmental Impact Assessment outlined above points to a number of areas where potentially damaging impacts may arise from normal forestry operations. Many of these impacts can be minimised relatively simply by taking a few precautions. Box 7.3 lists some of the more essential precautions that should be taken.

7.3.2 Logging or pit sawing?

The issue of whether logging or pit sawing is a better form of harvesting in natural forest is complex. There are good arguments for and against each activity, and which method wins probably depends very much on the location of the forest and its surroundings. In theory, pit sawing should have much less environmental impact on the forest than logging, with all its associated roads, skidder tracks and loading bays. However, in practice this is not necessarily the case: well-planned and controlled logging is preferable to unplanned and uncontrolled pit sawing. Some of the points to bear in mind when considering which method would be most appropriate for a given area are given below:

- **Ecological effects:** regeneration, species composition, knock-on effects etc. Pit sawing normally preferable, but if uncontrolled then timber stands can easily be over-exploited.
- **Ease of monitoring**. Logging normally easier, because operations are centralised rather than dispersed.
- **Ease of changing course if necessary**. Pit sawing normally easier, because once a sawmill is established, there are financial reasons for making sure that it keeps running even if to do so exceeds the renewal capacity of the forest.
- **Harvesting efficiency** (proportion of each tree harvested and its value once processed). Logging normally more efficient, harvesting a higher proportion of each target tree and often producing a more valuable product.
- **Financial efficiency** (capital, loans, overheads etc.) Pit sawing requires much less investment, so does not usually face the problems of running into debt that can be faced by logging operations, especially when imported spare parts are costly or unavailable. A study in Rwanda (Rohner, 1978) found that high-quality pit sawing earned the country \$28 per m^3 , whereas mechanical logging lost \$13 per m^3. Furthermore, logging normally requires large forest areas to be financially viable, whereas pit sawing does not.
- **Social acceptability:** employment, wage labour, immigration, haves and have-nots etc. A complex issue. Sawmilling probably creates a smaller but better paid workforce; workers more likely to be from outside the area.

In countries such as Uganda, where forests are normally small, surrounding populations are high, and illegal activities difficult to control, the question of ease of monitoring is crucial to deciding whether pit sawing or logging is preferable. In Budongo Forest, which has sawmills and (illegal) pit sawyers, it has proved very difficult to keep pit sawing under control. Box 7.4 lists some of the reasons for this suggested by participants of the conservation training courses recently held at Nyabyeya Forestry College.

The list suggests that pit sawing has become the main method of timber extraction, whether we like it or not. Possibly the best course of action for the future would be to find a way of controlling pit sawing, rather than seeking to stop it altogether. One recent suggestion is that pit sawyers should be responsible for felling of marked trees and initial processing of logs, which they should then take to the sawmills for further processing. That way, pit sawyers could continue to make a living, while the operation would be easier to control (and tax), and the timber products would be of a better quality and higher value.

Box 7.3
Some of the precautions that can be taken to minimise ecological damage during logging operations in natural forest (Jonsson and Lindgren, 1990)

- Survey of timber trees and saplings and seedlings of commercial species
- Thorough road planning and mapping
- Planning and marking of extraction trails
- Climber cutting
- Marking and mapping of trees to be harvested and recommended felling directions
- Marking of seed trees to be saved and left standing
- Marking of areas with valuable regrowth to be retained
- Marking of areas which must not be logged over for other reasons
- Scouting with representatives of the forest department together with the concessionaire or operators

In addition, loggers should be issued with written instructions, specifying:

- Boundaries of the logging tract
- Species allowed for harvest
- Volume allowed for harvest
- Minimum girth diameter
- Silvicultural considerations, e.g. damage to residual stand
- Silvicultural obligations, e.g. replanting
- Weather conditions when operations should cease due to risks of soil damage and erosion
- Machinery to be used/not to be used
- Maximum allowable open ground area
- Penalties if agreements are violated

Box 7.4
Some possible reasons for the difficulty of controlling illegal pit sawing in Ugandan forests, as suggested by practising Ugandan foresters at recent training courses

- Most people living around the forest are very poor. They look at the forest reserve as a source of employment and survival.
- There is no alternative local source of income which is as quick and easy.
- There are no alternative local sources of affordable building materials and furniture.
- Local people view the forest as God-given, and therefore available for them to use as necessary.
- Local people may view sawmillers as exploiters who came to take away their riches.
- Rich men and politicians are also involved, making control very difficult.
- Forest Department staff often work far away from their homes on very low and irregular salaries and allowances. The temptation to get involved in earning some extra money is high.
- Those who have invested in the timber business will fight to retain their investments rather than abandon them.
- The methods used in tackling illegal pit sawing are rigid and inflexible.
- Some pit sawyers are armed, making it difficult to confiscate tools from them.
- District security staff are also involved in the business, so support from them is hard to come by.
- Hard evidence of involvement is not easy to find, making it easy for accusations to be levelled at innocent people, or for people to deny that others are involved, either for money or favours.
- Few financial resources are available to combat illegal pit sawing, and the forest is very large making it difficult to patrol.
- Much of the transport of timber from the forest to the road and beyond occurs at night.
- The demand for mahogany is high, making illegal trade lucrative. Nearly all mahogany on sale in Uganda comes from Budongo.
- There are no marketable trees left on public land which pit sawyers could cut legitimately.
- Many pit sawyers know no other livelihood than pit sawing.

7.3.3 Monitoring operations and the use of indicators

Whatever precautions are taken to ensure that logging or pit sawing is carried out sustainably, there is always a need for **monitoring**, to determine the success or otherwise of the precautions. Monitoring is made easier if use is made of a set of ***indicators*** which, when taken together, point to the success or otherwise of management. Indicators can be geared to particular levels of management, for instance whether institutional/managerial or operational.

Table 7.2 gives an example of an internationally recognised list of criteria and indicators for sustainable natural forest management. The list is not exhaustive, but gives an idea of the range of indicators that could be used. The idea is that an institution involved in forest management and conservation (such as the Forest Department) could use such a set of indicators to assess its own performance, and to look at ways of improving the situation if found to be deficient in any particular area.

Table 7.3 gives a more simplified set of indicators that could be used at the operational level, in this case, based on the logging situation in Sabah, Malaysia. It is a very simple system: for example, it does not require the manager to have detailed knowledge of rare species. This may be a weakness in some cases, but in most instances a system like this would have more chance of acceptance than one that required detailed monitoring of rare plants and animals, particularly if the really important areas for biodiversity conservation were already excluded from timber concessions anyway.

Many may find that the indicators selected for this particular example would not be suitable in their own situation. If this were the case, then a more appropriate set could be devised: the very act of drawing up a list of indicators is useful. The most valuable thing about the system is that it enables the manager to check that things are going according to plan at every stage. If they are not, it enables the manager to identify clearly where things are going wrong, and to make amends accordingly.

Table 7.2.
Criteria and indicators that could be used to assess the sustainability of natural forest management at the level of the individual forest (ITTO, 1992)

Criterion	Examples of indicators
Resource security	• The legal establishment of forest areas or management units
	• Existence of a management plan
	• Clear demarcation of boundaries in the field
	• The presence or absence of illegal exploitation and encroachment
	• The duration of concession agreements
The continuity of timber production	• The presence of clear, official harvesting rules • Long-term soil productivity
	• A pre-logging stand inventory
	• The number of trees and/or volume of timber per hectare harvested
	• Provision for monitoring the residual growing stock after logging
	• Records of annual product outputs over time
	• Net productive area
	• Records of annual areas cut over time
The conservation of flora and fauna	• Protection of ecosystems in the concession or management unit • The extent of vegetation disturbance after logging
An acceptable level of environmental impact	• Extent of soil disturbance • Extent and spatial distribution of riparian and other watershed protection areas
	• The extent and severity of soil erosion
	Provision for protection of bodies of water
Socio-economic benefits	• The number of people employed • The nature and extent of benefits from forestry activities
Planning and adjustment to experience	• Community consultation • Arrangements for forest management to take into account traditional forest utilisation

Table 7.3.
Some operational criteria for assessing sustainability in logging operations. After Udarbe et al. (1994)

Criterion	Indicator	Specification	Mitigating measures
Ensure natural regeneration capacity of the timber stand is maintained	Size-class of tree harvested	Harvest only trees >60 cm dbh and <120 cm dbh	• Tree marking
	Number of trees retained per hectare	Protected species (e.g. rare trees, figs) >5 trees >60 cm dbh as seed source if regeneration is insufficient Potential crop trees in next cycle (10-40 cm dbh)	• Tree marking
	Proportion of damaged trees in the residual stand	<35% of total stem number	• Tree marking • Directional felling • Low impact yarding • No felling on slopes >25 ^{o}
Ensure that the impact of the felling operation is limited	Felling damage	<20% of the residual stem number	• Directional felling • No felling on slopes >25 ^{o}
Ensure that the impact of the yarding operation is limited	Area of bare soil exposure	<15%	• Restricted tractor yarding on slopes <15^{o} • Skyline systems on steeper slopes
	Yarding damage	<15% of the residual stem number	• Felling in herring-bone pattern according to yarding infrastructure • Bucking of logs to length <8 m

7.4 THE FOREST MANAGEMENT SYSTEM

7.4.1 Major components of the forest management system

For effective management of natural forests, wise management is required at three main levels: at the level of the institution (such as Forest Department or Ministry), at the level of the forest management unit (such as Forest Reserve or Working Plan Area), and at the level of forest compartment. Each of these levels will tend to have a different planning horizon, and each will require different sorts of management input. Table 7.4 attempts to illustrate the main components of such a management system. Although this system was developed for the forest estate of Sabah, Malaysia, the principles should also be useful for a country like Uganda.

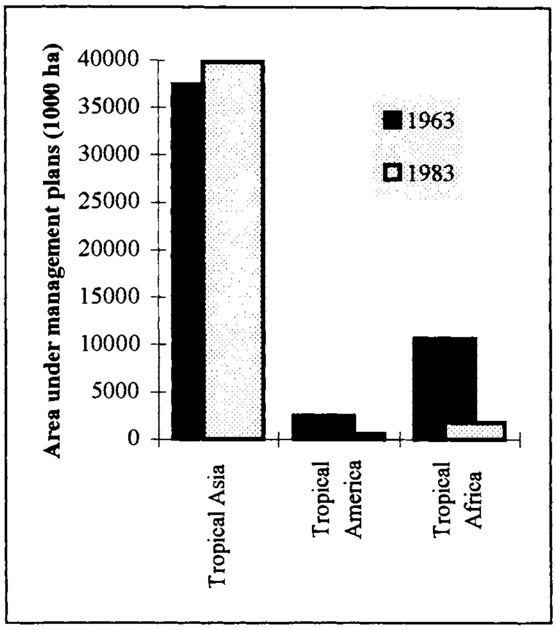


Figure 7.1. The area of tropical moist forest under management plans in the three main tropical regions, 1963 and 1983. After Mather (1991).

7.4.2 Forest management planning

7.4.21 The role of forest management plans

A well-designed **management plan** is vital for sustainable natural forest management, although it is not the only plan that is necessary, as Table 7.4 demonstrates. In recent years, the area of tropical forest that actually has a management plan has fallen sharply, except in Asia. The fall has been particularly severe in Africa, as Figure 7.1 shows. The 1983 figure for Africa is mostly composed of managed forest in Ghana and Uganda (Mather, 1991), since few other countries in Africa have any functional management plans at all. So although Uganda is ahead of some other countries, there is still a great deal of work to be done to bring long-expired plans up to date. Although in this chapter we have been concentrating on timber operations, we should remember that a forest management plan will almost always have to meet other objectives too. Figure 7.2 is a reminder of some of these.

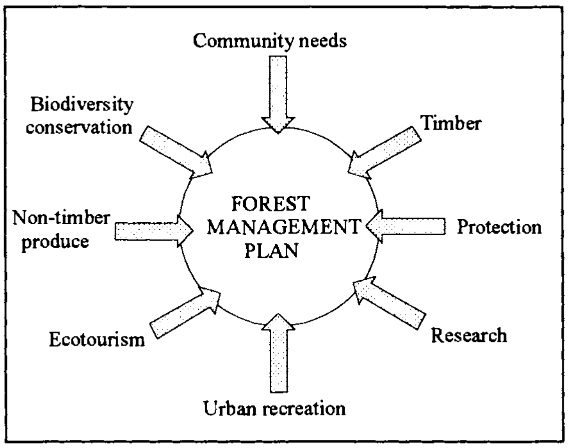


Figure 7.2. Some of the objectives of natural forest management. After Udarbe et al. (1994).

Table 7.4.
Suggested major components of a forest management system (Udarbe et al., 1994)

Management level	Planning horizon	Major components
Institution	10-20 years	Forest Sector Plan Forest Policy Forestry and related Legislation
Forest management unit	5-10 years	Management Planning Monitoring and Evaluation Environmental Impact Assessment
Forest compartment	Annual	Implementation Resource Accounting

7.4.22 Structure of a management plan

A management plan is basically a statement of *goals* and measurable *objectives* that guide the management of a given forest area. Goals are the basis for determining what actions to take, where they should be taken, and the budget and personnel needed for their implementation. A plan covers a specific period, such as five or ten years, and is used as a basis for developing annual operational plans. A good management plan should be dynamic and subject to modification as new information becomes available; there should be a feedback loop through monitoring the effectiveness of activities carried out in the operational plans.

A management plan should not be overburdened with biological information and scientific descriptions of the area. Such information is important, but its place is in a separate report, or perhaps in an appendix to the plan. The intended users of a management plan (planners, managers and local government officials, for instance) are likely to be confused by too much scientific information.

The content and organisation of a management plan may vary from place to place. Every plan for which conservation is one objective (including most natural forest reserves), would benefit from inclusion of the main points listed in Box 7.5.

7.4.3 Drawing up a management plan

Management plans are intended to be useful documents. All too often, plans are written and then never consulted; as often as not, this is because the plan is too detached from reality to be useful. It is useful to think of the process of drawing up a management plan in terms of the following points:

1. Where are you now? *(assessment stage)*
2. Where would you like to be? *(identifying objectives and constraints)*
3. How could you get there? *(exploring and choosing options)*
4. Decide on and plan your route *(finalising the management plan)*
5. How will you know when you have arrived? *(setting measures of performance)*
6. Go! *(implementation)*

Box 7.6 looks at how these points can be translated into more formal stages.

Drawing up a good management plan is not easy. To help in its preparation, it is useful to compile a list beforehand, covering the available information on current management. This encourages the writer to think about the area's role and to what use existing information could be put in compiling the plan (MacKinnon et al., 1986).

Box 7.5
The main components of a management plan for a protected area. After MacKinnon et al. (1986)

1. **National and regional background**. This sets the stage, providing an overview of the area within the national and regional context, from the perspective of national forestry and conservation objectives. Also included is a review of the regional economy, land uses in adjacent areas and communications networks.
2. **Description and inventory of the reserve**. Land forms, geology and soils, climate, biological aspects, and the socio-economic and historical background of the area described. This description should be interpreted in the context of forestry and conservation, for example, how soils affect native flora and timber species, drainage and erosion. Other data are filed as appendices.
3. **Management considerations**. Consist of evaluation and projection, as well as a clear definition of objectives. Special limitations and constraints are identified, and the significance of the area is evaluated. It is under this component that the zoning plan for the area is given.
4. **Management programmes**. This component practically addresses resource management, human use, research and monitoring, as well as the administrative requirements of the reserve.
5. **Development programmes**. This component includes all requirements of buildings and equipment, with the financial and personnel implications of the plan, including a development schedule indicating priorities and critical paths.
6. **Appendices**. These should summarise data used as the basis for the plan, including:
   - Details of the legal establishment of the reserve
   - A complete reference list of all relevant publications
   - Species check-lists
   - Pertinent climatic and socio-economic data
   - Supporting maps and air photos

Box 7.6
A process for preparing a management plan for a protected area. After MacKinnon et al. (1986)

1. **Form a planning team.** This team should include all those who are involved in the management of the resources. It is now advocated that this means that local people must also be consulted.
2. **Collect background material.** This should include legislation, cultural resources, socio-economic data, geology and geomorphology, climate etc.
3. **Carry out a field inventory.** This is usually necessary to assess the nature of the resource.
4. **Carry out an analysis of limitations in available materials.** What you would like to see in the plan, and what is achievable given limited resources.
5. **Draw up a statement of objectives.** What you would like the plan to achieve and by when.
6. **Examine the implications of any zoning and boundary demarcation.** These are basic considerations for any protected area, and need to be examined early in the planning process.
7. **Action planning.** Consider how each objective is to be managed and by whom.
8. **Consider financial implications.** There is no point making grandiose plans if they are too expensive.
9. **Prepare a draft version of the plan.** The plan's implementation will affect many people. The ideas of the planning team should form the backbone of the plan, but do not assume that everyone will agree with it.
10. **Circulate the draft.** All interested parties should have an opportunity to comment and respond.
11. **Prepare the final version of the plan.** Consider responses of all interested parties.
12. **Implement the plan.** Do not deviate from it unless circumstances change.
13. **Monitor implementation, evaluate regularly and revise if necessary.** Plans are made to be adhered to, but not unquestioningly so: they are a guide rather than a set of laws. If they need revision, do not be afraid to do so, but follow the same steps as in the initial preparation.

7.4.4 Guidelines for sustainable forest management

Recently, there has been an upsurge of interest in developing guidelines for sustainable forest management. This interest has come not only from conservation organisations, but also from the timber industry itself, in recognition of the fact that if the industry does not support sustainable forest management, then its own future is in jeopardy. Box 7.7 contains a series of guidelines drawn up jointly by ITTO and IUCN (Poore and Sayer, 1991), based on an earlier report by ITTO (1990). The first twelve objectives are rather general, but the remainder are particularly relevant to this chapter, and all have a bearing on nature conservation.

7.5 NATURAL FOREST MANAGEMENT AND TIMBER CERTIFICATION

Because of the widespread concern about poor management of tropical forests, and the consequences for conservation and human rights, there have recently been several independent moves in consumer countries to encourage sustainable management of those tropical forests from which timber is exported. The idea is to produce a certification system for timber on sale in consumer countries, so that consumers can choose to buy timber which they know has come from a sustainably-managed tropical forest. Such timber will almost certainly be more expensive than timber extracted unsustainably, partly because sustainable management costs money, and partly because suppliers will be able to charge a premium simply because consumers will want to buy sustainably-produced timber. Although there is no official export of natural forest timber from Uganda at present, it is possible that the situation may change in the future. Even if this does not happen, it makes sense to aim to manage forests up to the standard of the certifiers, and so it is worth looking at these certification schemes in some detail.

The scheme gaining most widespread acceptance at the moment is that of the Forest Stewardship Council (FSC), an independent group of conservationists, foresters and timber companies with a secretariat based in Mexico. The FSC is a "certifier of certifiers", in that it gives its seal of approval to other, smaller organisations that are themselves certifying timber trade operations. The Council is still rather new, and its ideas may change in the coming years, but its principles and criteria at the time of writing are given in Box 7.8.

Box 7.7
Guidelines for sustainable forest management (Poore and Sayer, 1991)

1. A strong political commitment at the highest level is indispensable for management to succeed.
2. An agreed forest policy should be supported by appropriate legislation which should, in turn, be in harmony with laws concerning related sectors.
3. There should be a mechanism for regular revision of policy in the light of new circumstances.
4. A national forest inventory should establish the importance of all forests, independent of their ownership status, for the purposes of both conservation and production.
5. There should be flexible provisions for such inventories to be broadened to include information not previously covered, if and when the need and opportunity for such additional information arises.
6. Certain categories of land, whether public or private, need to be kept under permanent forest cover to secure their optimal contribution to national development.
7. The different categories of land to be kept under permanent forest are: land to be protected; land for nature conservation; land for production of timber and other forest products; land intended to fulfil combinations of these objectives.
8. Land destined for conversion to other uses (agriculture, mines etc.), and any land for which the final use is uncertain, should be kept under managed forest until the need for clearing arises.
9. The principles and recommendations for implementation of these guidelines apply equally strictly to national forests and privately-owned or customarily-held forests.
10. There should be a national agency capable of managing the government forest estate, and assisting in the management of private and customarily-held forests, according to the objectives laid down in the national forest policy.
11. Forests set aside for timber production are able to fulfil other important objectives, such as environmental protection and, to a varying extent, conservation of species and ecosystems. These multiple uses should be safeguarded by the application of environmental standards to all forest operations.
12. Proper planning, at national, forest management unit and operational levels reduces economic and environmental costs and is therefore an essential component of long-term sustainable forest management.
13. The forest set aside for timber production should be the subject of a more detailed inventory to allow for planning of forest management and timber harvesting operations. The question of type and quantity of data to be gathered should be the subject of cost-benefit analysis.
14. Management objectives should be set rationally for each forest management unit. Formulation of objectives should allow the forest manager to respond flexibly to present and future variations in physical, biological and socio-economic circumstances, keeping in mind the overall objectives of sustainability.
15. The size of each production forest management unit should preferably be a function of felling cycle, the average harvested volume per hectare and annual timber out-turn target of the operating agency (state forest agency, concessionaire, etc.).
16. The choice of silvicultural concept should be aimed at sustained yield at minimum cost, enabling harvesting now and in the future, while respecting recognised secondary objectives.
17. In order to ensure sustained production of timber from each forest management unit, a reliable method for controlling timber yield should be adopted.
18. A management inventory supported by a detailed map is indispensable to the preparation of working plans for each forest management unit.
19. Working plans should guarantee the respect of environmental standards in field operations.
20. Forest management operations can have important positive or negative environmental consequences, both in the forest itself and outside (transboundary effects). These consequences should be assessed in advance of operations to ensure overall sustainability.
21. Harvesting operations should fit into the silvicultural concept, and may, if they are well planned and executed, help to provide conditions for increased increment and for successful regeneration.
22. Efficiency and sustainability of forest management depend to a large extent on the quality of harvesting operations. Inadequately executed harvesting operations can have far-reaching negative impacts on the environment, such as erosion, pollution, habitat disruption and reduction of biological diversity, and may jeopardise the implementation of the silvicultural concept.

Box 7.7 (continued)

23. Pre-harvest prescriptions are important to minimise logging damage to the residual stand, to increase safety for logging personnel and to attune harvesting with the silvicultural concept.
24. Planning, location, design and construction of roads, bridges, causeways and fords should be done19 Working plans should guarantee the respect of environmental standards in field operations.
25. Extraction frequently involves the use of heavy machinery and, therefore, precautions must be taken to avoid damage to residual vegetation, soils and watercourses.
26. Post-harvest operations are necessary to assess logging damage, the state of forest regeneration, and the need for silvicultural operations to assure the future timber crop.
27. Permanent production forest should be protected from activities that are incompatible with sustainable timber production, such as the encroachment of shifting cultivators often associated with the opening up of the forest.
28. Fire is a serious threat to future productivity and environmental quality of the forest. Increased fire risk during logging, and even more so following logging, demands stringent safety measures.
29. Chemicals, such as those used in silvicultural treatment, constitute risks both in terms of personnel safety and environmental pollution.
30. There should be incentives to support long-term sustainable forest management for all parties involved. Concessionaires should have the long-term viability of their concession provided for (mainly by government controlling access to the forest); local populations should benefit from forest management (see below); government forest departments should receive sufficient revenue to continue their forest management operations.
31. For private or customarily-held forests the basic approach to sustainability is the same as for government forests.
32. The national forest service should provide assistance to customary rights holders and private forest owners to manage their forests sustainably.
33. Timber from forest land to be converted to other uses, and from forests damaged by hurricanes and other disasters, should be optimally utilised. At the same time, disruption of management of the permanent production forest should be avoided.
34. Monitoring and research should provide feedback about the compatibility of forest management operations with the objectives of sustainable timber production and other forest uses.
35. Sustained timber production depends upon an equitable distribution of incentives, costs and benefits, associated with forest management, between the principal participants, namely the forest authority, forest owners, concessionaires and local communities.
36. The success of forest management for sustained timber production depends to a considerable degree on its compatibility with the interests of local populations.
37. Timber permits for areas inhabited by indigenous peoples should take into consideration the conditions recommended by the World Bank and the International Labour Office for work in such areas.
38. Management for timber production can only be sustained in the long-term if it is economically viable (taking full account in the economic value of all costs and benefits from the conservation of the forest and its ecological and environmental influences).
39. A share of the financial benefits accruing from timber harvesting should be considered and used for maintaining the productive capacity of the forest resource.
40. Forest fees and taxes should be considered as incentives to encourage more rational and less wasteful forest utilisation and the establishment of an efficient processing industry, and to discourage logging of forests which are marginal for timber production. They should be and remain directly related to the real cost of forest management. Taxation procedures should be as simple as possible and clear to all parties involved.
41. In order to achieve the main principle of good and sustainable management, forest fees and taxes may need to be revised at relatively short notice, due to circumstances outside the control of loggers and the forest agency (e.g.. fluctuations in international timber markets and currency values). The national forest agency should be granted the authority to carry out such revisions.
42. Continuity of operations is essential for sustainable forest management.

Box 7.8
Forest stewardship principles, as defined by the Forest Stewardship Council (Jackson, 1994)

Principle 1: Compliance with Laws and FSC Principles. Forest management shall respect all applicable laws of the country in which they occur, and international treaties and agreements to which the country is a signatory, and comply with all FSC Principles and Criteria.
Principle 2: Tenure and Use Rights and Responsibilities. Long-term tenure and use rights to the land and forest resources shall be clearly defined, documented and legally established.
Principle 3: Indigenous Peoples' Rights. The legal and customary rights of indigenous peoples to own, use and manage their lands, territories and resources shall be recognised and respected.
Principle 4: Community Relations and Workers' Rights. Forest management operations shall maintain or enhance the long-term social and economic well-being of forest workers and local communities.
Principle 5: Benefits from the Forest. Forest management operations shall encourage the efficient use of the forest's multiple products and services to ensure economic viability and a wide range of environmental and social benefits.
Principle 6: Environmental Impact. Forest management shall conserve biological diversity and its associated values, water resources, soils, and unique and fragile ecosystems and landscapes, and, by so doing, maintain the ecological functions and integrity of the forest.
Principle 7: Management Plan. A management plan, appropriate to the scale and intensity of the operations, shall be written, implemented and kept up to date. The long-term objectives of management, and the means of achieving it, shall be clearly stated.
Principle 8: Monitoring and Assessment. Monitoring shall be conducted, appropriate to the scale and intensity of forest management, to assess the condition of the forest, yields of forest products, chain of custody, management activities and their social and environmental impacts
Principle 9: Maintenance of Natural Forests. Primary forests, well-developed secondary forests and sites of major environmental, social or cultural significance shall be conserved. Such areas shall not be replaced by tree plantations or other land uses.
Principle 10: Plantations. Plantations shall complement, not replace, natural forests. Plantations should reduce pressures on natural forests.

7.6 SUMMARY

Getting management of natural tropical forest right is no easy matter, especially since our ideas of what is "correct" management are going through a period of change in favour of conservation. This chapter has shown some of the actions that can be taken to aid management. They can be summarised as follows:

- Make efforts, from the planning stages onwards, to ensure that all activities are environmentally sustainable.
- Continually assess the environmental impact of all activities and modify them to minimise impacts; use indicators at all levels to aid judgement.
- Maintain and use plans, especially management plans, to direct all activities; use checklists to help preparation of plans.
- Remember that forests serve multiple functions, so consult widely, and involve other people in planning and decision-making.

7.7 FURTHER READING

ITTO. 1991. *ITTO guidelines on the conservation of biological diversity in tropical production forests.* ITTO, Yokohama.
ITTO. 1992. *Criteria for the measurement of sustainable tropical forest management.* ITTO, Yokohama.
MacKinnon, J., MacKinnon, K., Child, G. and Thorsell, J. 1986. *Managing protected areas in the tropics.* IUCN, Gland.
Poore, D. 1989. *No timber without trees.* Earthscan, London.
Poore, D. and Sayer, J.A. 1991. *The management of tropical moist forest lands: ecological guidelines.* IUCN, Gland.
Zimmermann, R.C. 1982. *Environmental impact of forestry: guidelines for its assessment in developing countries.* FAO, Rome.

CHAPTER 8

TREE PLANTING AND NATURE CONSERVATION

CHAPTER OUTLINE

8.1 INTRODUCTION

This chapter looks at the implications of tree planting, whether on farms or in plantations, for nature conservation. We have already seen that deforestation and poor management of natural forests is generally very harmful for nature conservation. But what role does tree planting have in nature conservation? Are plantations good substitutes for natural forests? To what extent does tree planting help environmental conservation generally, and nature conservation in particular?

8.2 BIODIVERSITY IN PLANTATIONS

8.2.1 Environmental impact of plantations

In many parts of the world, natural forests are being replaced by plantations. How will this affect nature conservation and the environment generally? The main point to note is that plantations are undoubtedly far less important for nature conservation than natural forests. The degree to which they differ in their importance depends on a number of factors. In each of the following factors, the first option is likely to have more adverse impacts, or fewer positive impacts, on nature conservation than the second:

- Whether plantations are established (a) directly on land cleared of natural forest for the purpose, or (b) on land from which natural forest was cleared some time before, such as farmland or degraded forest.
- Whether plantations replace (a) all natural forest or (b) only a proportion of it.
- Whether plantations are of (a) single or (b) many species.
- Whether plantations are (a) managed on short or (b) long rotations.
- Whether plantations are composed of (a) exotic or (b) native species.
- Whether plantations are (a) heavily weeded to exclude competing vegetation or (b) not.
- Whether the plantation is in its (a) first or (b) subsequent cycle of planting.

The greatest harm that plantations can do is if they replace natural forest. About 15% of tropical plantations have been established at the expense of natural forest (Postel and Heise, 1988). More general adverse environmental effects of plantation establishment are many. Some that apply particularly to afforestation of formerly open land are given in Box 8.1. Note, however, that there can also be many beneficial effects, discussed later in this chapter.

There are many ways in which plantations can be enhanced so that they are better places for wildlife. Some of these are listed in Box 8.2. The issue of whether to plant exotics or native species is not as contentious, from a nature conservation point of view, as some environmentalists have made out, since a plantation will nearly always have low intrinsic nature conservation value whether it is composed of native species or exotics.

Box 8.1
Some possible adverse environmental impacts of plantation establishment, especially on previously open land. From ODA (1992b)

- Depletion of ground water. Trees intercept rainfall and have a large appetite for ground water which disappears in evapotranspiration. They can lower the surrounding water-table, which might be to the detriment of other species, wells and agriculture, although species vary widely in this respect.
- Trees provide a habitat for pests, predators and disease vectors, as well as for beneficent animals.
- Forests may increase the risk of fire.
- The introduction of new tree species, or changing the balance between existing ones, will alter the ecosystem.
- Fast-growing pioneer species whose valuable attributes, such as ability to colonise deforested and degraded land, may be offset by less desirable traits. These include reduction of soil moisture/soil fertility, suppression of other vegetation, and invasiveness (i.e. tendency to invade farmlands or replace natural vegetation).

There is justifiable concern, however, about invasive exotics (see Section 8.4), but this is more an issue of where the plantation is located rather than whether exotics should be used *per se.* Finally, there is also justifiable concern that exotics will one day be vulnerable to pests or diseases introduced accidentally or deliberately. This is a valid concern, but it is not really a conservation argument.

In areas where it is considered important to use native species in plantations, the following species are just a few of many native to Uganda which may prove useful (from Struhsaker, 1987 and Hamilton, 1984):

- *Sesbania sesban:* for firewood and as a nitrogen-fixer;
- *Markhamia platycalyx:* especially for poles;
- *Maesopsis eminii:* for timber;
- *Cordia millenii:* for timber;
- *Khaya anthotheca:* for timber, but can suffer from shoot borer (*Hypsipila* spp.) in plantations, and not native along Lake-shore;
- *Milicia excelsa:* for timber, but can suffer from gall-fly (*Phytolema lato*) in plantations in southern Uganda, although not in the north.

8.2.2 Plantations versus natural forests

If natural forest is replaced by plantation, this is a great loss to nature conservation. But if plantations are developed on land formerly under some other use, then the implications for nature conservation may be positive, neutral or negative. In practice, plantations are only really of any value for nature conservation if there is no natural forest with which to compare them. In any studies that have compared plantations with natural forests, the latter always emerge as being far more important.

Box 8.2
Some methods for enhancing the nature conservation value of plantations. After Sawyer (1993)

- Extend rotation periods on specified areas to allow "old growth" to develop and to encourage the growth of natural vegetation.
- Retain corridors of the original natural vegetation throughout and alongside plantations, and linked to reserves (unless the planted species is potentially invasive).
- Leave ground near to water-courses unplanted: areas which are of marginal production value, such as gullies, stream buffers and steep slopes, are often of high conservation value.
- Allow an understorey to develop, so that cover and a continuous source of food for birds and mammals are provided.
- Manage harvesting and tending operations in such a way that minimises habitat disturbance.

For instance, during courses held at Nyabyeya Forestry College in 1993 and 1994, participants were asked to survey a pine plantation growing near Budongo Forest and assess its value for biodiversity conservation. Although the techniques employed were rather basic, during all the courses no more than about fifty plant species were recorded from the plantation. This compares very unfavourably with the 855 or so recorded from Budongo Forest by Synnott (1985). On the other hand, a study of moth diversity in a eucalyptus plantation in Sabah, Malaysia, reported recently by Tickell (1995), concluded that the plantation under investigation had nearly as many species (800) as nearby selectively logged secondary forest (1000).

The difference between this finding and that quoted above is probably due to the species-group investigated (perhaps moths are more mobile than plants), to the differences between pine and eucalyptus in the amount of natural vegetation that survives beneath the canopy, and probably also due to the different histories of the plantations - that at Nyabyeya was planted on open land, whereas that in Sabah was almost certainly planted directly on purposely-cleared natural forest.

Figure 8.1 shows the numbers of bird species recorded during a study of native montane forest and exotic coniferous forest in the Kenya highlands.

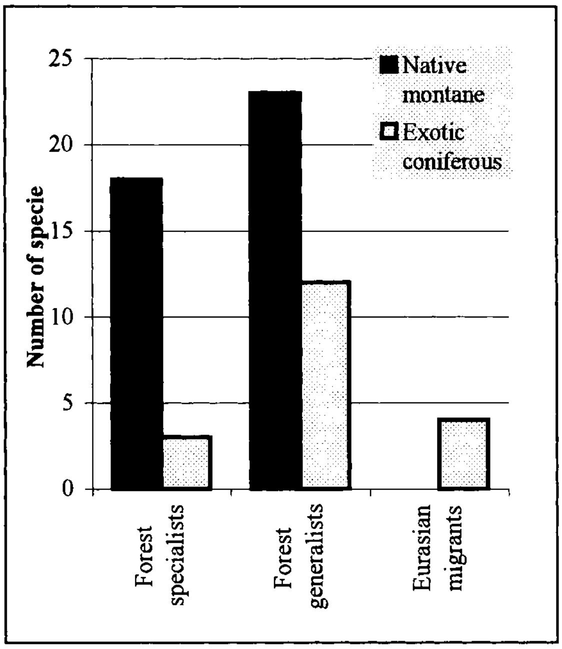


Figure 8.1. Bird species found in two areas of forest, one native and the other exotic, in the Kenya highlands. After Carlson (1986).

The birds are divided into three groups: forest specialists, forest generalists and Eurasian migrants. Native forest is shown to support far more species in the first two groups (five times the number and double the number respectively). Coniferous forest appears to support more species of European migrant birds, however, although presumably these species are not dependent on this forest type being present in the tropics, because it has only been around for a few decades and yet the birds have been migrating for millennia.

A further study, this time from Uganda, looks at the number of bird species recorded from different categories of land around Kibale Forest (Figure 8.2). Again, natural forest is seen to support far more species, particularly forest specialists, than any other land use category; indeed, even cultivated land seems to support more species than any form of plantation in the area. Interestingly, eucalyptus plantation seems to be far more valuable for forest birds than pine plantation, which has fewer species even than tea plantation. The original study (Pomeroy and Dranzoa, unpubl.) also investigates bird density, and concludes that densities of birds in plantations are normally far lower than in natural forest, particularly for forest specialist species.

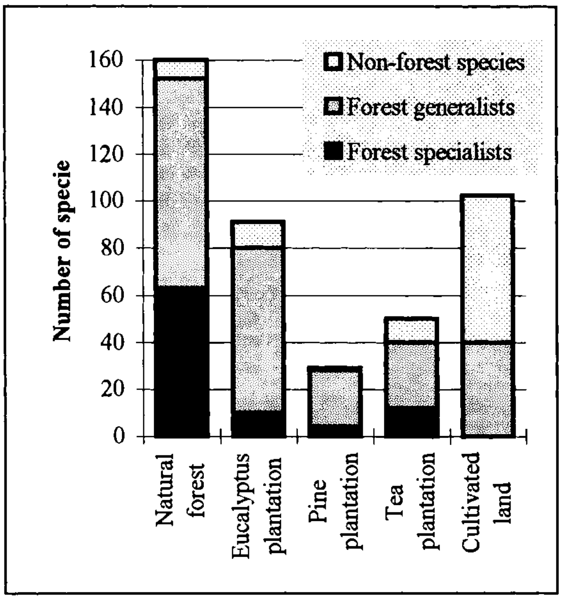


Figure 8.2. The numbers of bird species recorded from various land-use types around Kibale Forest, Uganda. After Pomeroy and Dranzoa (unpubl.).

8.3 REDUCING PRESSURE ON NATURAL FORESTS BY PLANTING TREES

Plantations have low intrinsic value for nature conservation. But this does not make them irrelevant to conservation. The main conservation argument in their favour is that, as human consumption levels escalate, they can help to take pressure off the exploitation of natural forests. Trees planted on farmland could also do the same.

Let us look at this argument in a little more detail.

8.3.1 Plantations and biomass yields

To understand the value of plantations as sources of fuelwood, we must first compare them with other potential sources, including natural forest.

Figure 8.3 shows the standing stock of woody biomass thought to be present in various types of woody vegetation. From this it seems that coniferous plantations have more woody biomass than deciduous plantations, but slightly less than intact tropical moist forest. At first sight, this suggests that tropical moist forest is a better source of woody biomass, but the chart also suggests that, once depleted, tropical moist forest has relatively low value compared to coniferous plantations (see Section 6.5.2 for why this might be so). Other woody vegetation types, including woodland, scrub and grassland, have much lower standing stocks. Note, however, that the figure shows **standing stock**, not **productivity**: coniferous plantations have a twenty-to-thirty year turnover period, whereas crop residues from farmland, for instance, could be harvested twice a year. On the other hand, perhaps 80% of a plantation tree's woody biomass could be used as fuelwood, whereas only 25% of crop residue could be (Turyahikayo, 1994).

8.3.2 Supply and demand for timber and other wood products

8.3.21 Supply

Plantations and trees planted on farmland cannot provide all the products of a natural forest, but they can provide some of them, for instance fuelwood and sawn timber. Demand for both these products is rising. At the same time, the supply of them from natural forest is falling, since the area of natural production forest is falling (either because of deforestation (see Chapter 1) or because forest is taken out of production).

Figure 8.4 shows predictions of the annual yield of timber available from Uganda's natural forests and plantations for the period 1985-2000. Note that the yields from plantations are almost as large as the yields from natural forest, despite the much smaller area of plantation. This is because plantations have much higher mean annual increments: in Uganda, something in the order of $15 m^3$/ha/yr. (Plumptre and Carvalho, 1991), as opposed to 1 or 2 m^3/ha/yr. for natural forest. [Note that some hybrid eucalyptus plantations in Brazil even yield 70 m^3/ha/yr. (FAO, 1994)]. Even so, it is clear that the amount of timber available has been declining, and this decline looks set to continue unless planting rates increase.

8.3.22 Demand

On the other hand, demand looks set to increase. Figure 8.5 is based on predictions made in the 1970s, and suggests that Uganda's consumption of wood products is growing rapidly. At the time, it was predicted that the only wood product whose consumption would decrease would be that of firewood in the monetary sector, since it was felt that, over time, people would adopt other means of cooking and heating; but so far, this has scarcely happened. The booming housing construction sector is consuming an increasing proportion of sawn timber and poles. By the year 2000, it is estimated that Uganda will need nearly 4 million new homes (Ministry of Energy, Minerals and Environment Protection, 1991). As Figure 8.6 shows, the predictions for Uganda are broadly in line with reported levels of consumption in Africa as a whole.

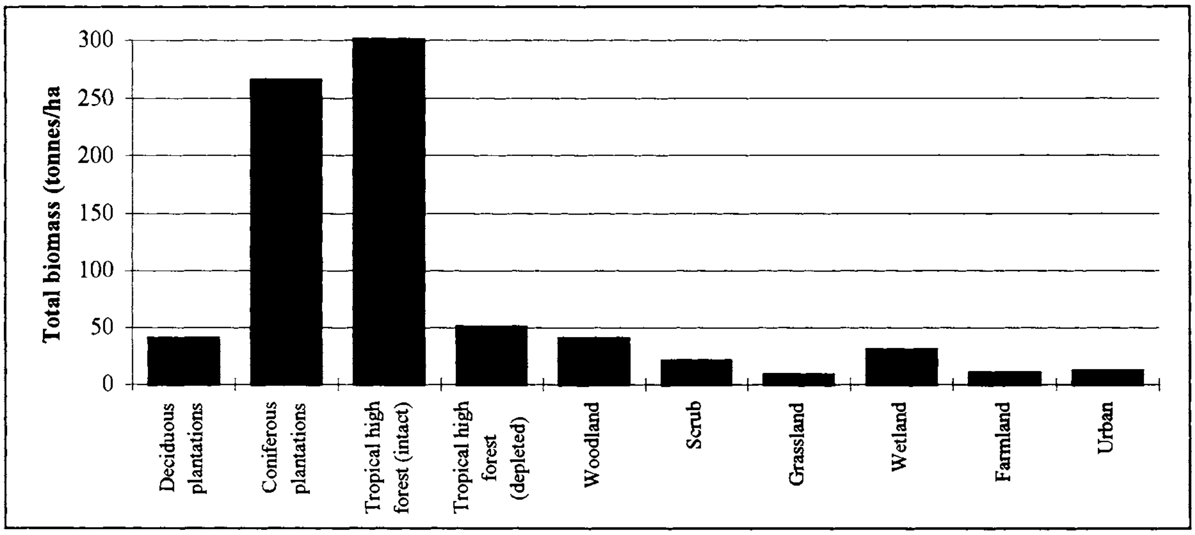


Figure 8.3. The standing stock of biomass for main types of land cover in Uganda. After Turyahikayo (1994).

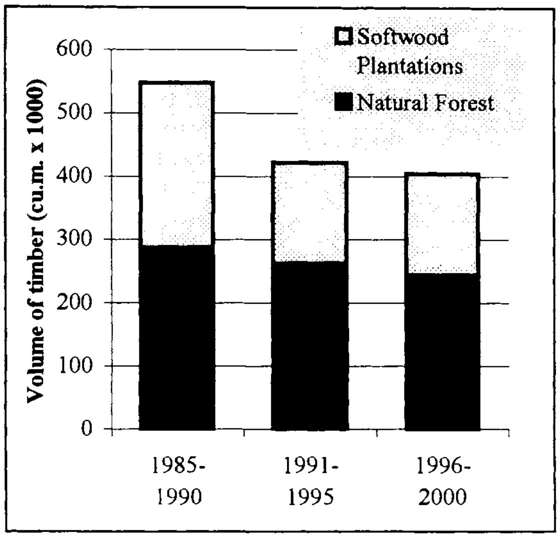


Figure 8.4. 1985 predictions of annual yields available from Ugandan forests.

8.3.23 The gap between supply and demand

There is an increasing gap between demand for wood products and their supply. This is as true for timber as it is for fuelwood: several former major timber exporting countries (such as Nigeria) have now become net importers, as domestic supplies have been exhausted. Will Uganda, once an exporter of timber, go the same way? Mahogany is already imported from Zaire. Even in the 1950s, Dawkins (1958) wrote that "*...to reach [the necessary level of production of sawn timber in Uganda] within fifty years is extremely ambitious, and is probably beyond the capacity of the tropical moist forest however skilfully managed...*", implying that, unless many more plantations were established, Uganda would have to import timber. Similarly, Lockwood (1973) recommended that either the natural forests would have to be harvested a lot more intensively (and therefore unsustainably) to meet the short-term needs of the country, or the area of tree plantations would have to be expanded tenfold if Uganda was to satisfy its requirements for wood products in the year 2000. [The first recommendation was taken up during the Amin years, but, fortunately from a conservation point of view, the sawmills deteriorated faster than the natural forests (Karani, 1994)]. The gap between coniferous sawn-wood and paper/board production and consumption seems to be widening throughout the tropics (Brooks, 1993). Globally, the world's tree plantations provide only 7%-10% of the world's commercial wood consumption (FAO, 1994).

About 58% of all energy consumption in Africa is met by fuelwood: by far the highest proportion in the world (the global average is only 5%) (FAO, 1994). Fuelwood supplies in many African countries are now thought to be inadequate to meet this demand (see Figure 8.7). The rate of consumption of fuelwood in Uganda is 40 times that of sawnwood (FAO, 1989a). Although talk of a "fuelwood crisis" seems to be moving off the political and environmental agenda, Kenya already imports charcoal from Uganda, much of it collected illegally from natural forest reserves; meanwhile, people in Tororo district, near the Kenya border, have had to change their eating habits to cope with fuelwood scarcity, as have people in Kabale district, where many families now only cook once a day.

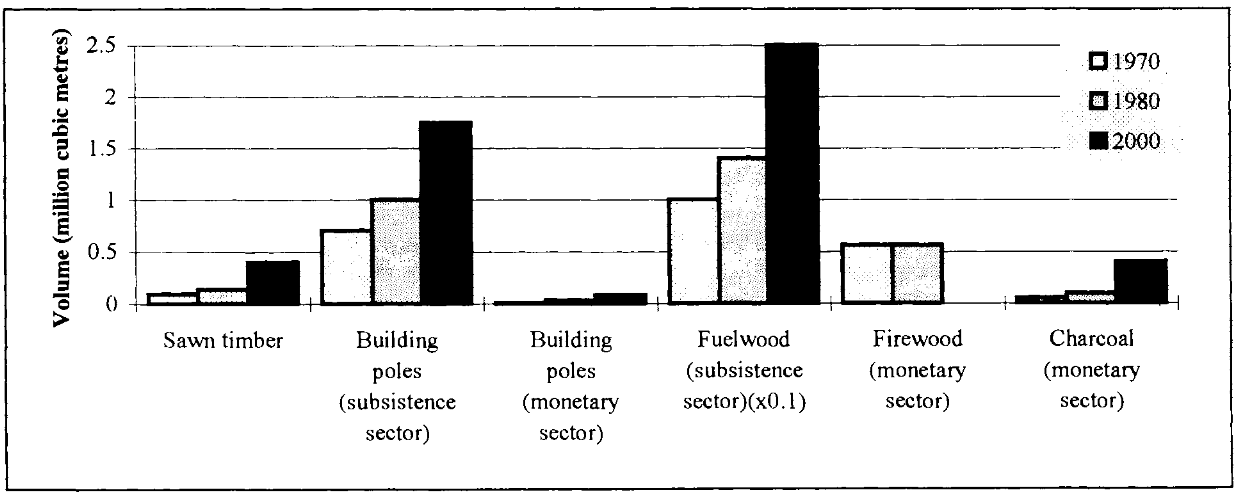


Figure 8.5. Production in 1970 and projections to 2000 for consumption of various wood products in Uganda. After Lockwood (1973) and Hamilton (1984). Note that the charts for fuelwood (subsistence sector) have been shortened by a factor of ten so that they can be presented on the same graph as the other wood products, while the charts for charcoal refer to million tonnes, not million cubic metres.

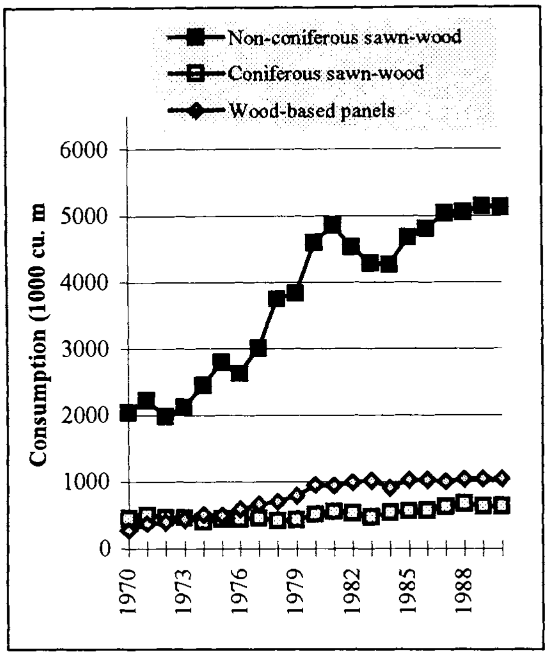


Figure 8.6. Apparent consumption levels of three types of wood products in Africa, 1970-1990. From FAO AGROSTAT statistics, in Brooks (1993).

8.3.24 Closing the gap

The gap between supply and demand could theoretically be closed in two ways:

- by increasing supply (for instance, more plantations, woodlots and trees on farmland); and
- by reducing demand (for instance, improved fuel efficiency).

Increasing supply

Globally, the area of planted forest has increased greatly in recent years, but most of this has been in temperate countries. In the tropics, there have been substantial increases in Latin America and the Asia/Pacific region, although much of the increase in the latter area has been on land cleared of natural forest specifically to establish plantations. In Africa, by contrast, there has been hardly any growth. Figure 8.8 shows the trend for the humid tropics; the situation in drier areas is probably not that different. Overall, there are about 30 million hectares of forest plantations in the tropics, an area which is rising by about 2.6 million hectares annually (FAO, 1994), of which only 90,000 hectares (5%) is planted in Africa (ITTO, 1993). Although 30 million hectares sounds a lot, far more natural forest is being lost: the current ratio of natural forest loss to plantation establishment in the humid tropics is about 5:1 in Asia, 15:1 in Latin America, and 30:1 in Africa (Whitmore, 1990). Africa currently has just 7% of the tropic's plantations (ITTO, 1993).

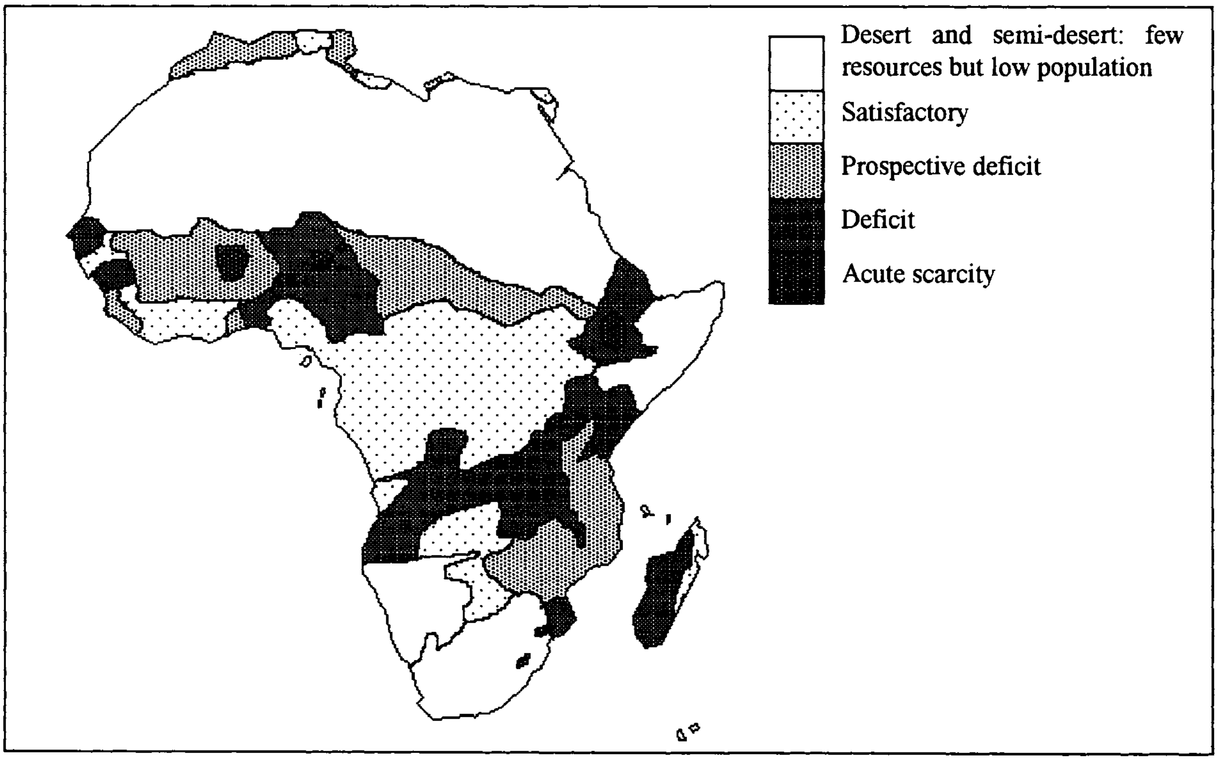


Figure 8.7. The state of fuelwood supplies in Africa. FAO data, after Mather (1991).

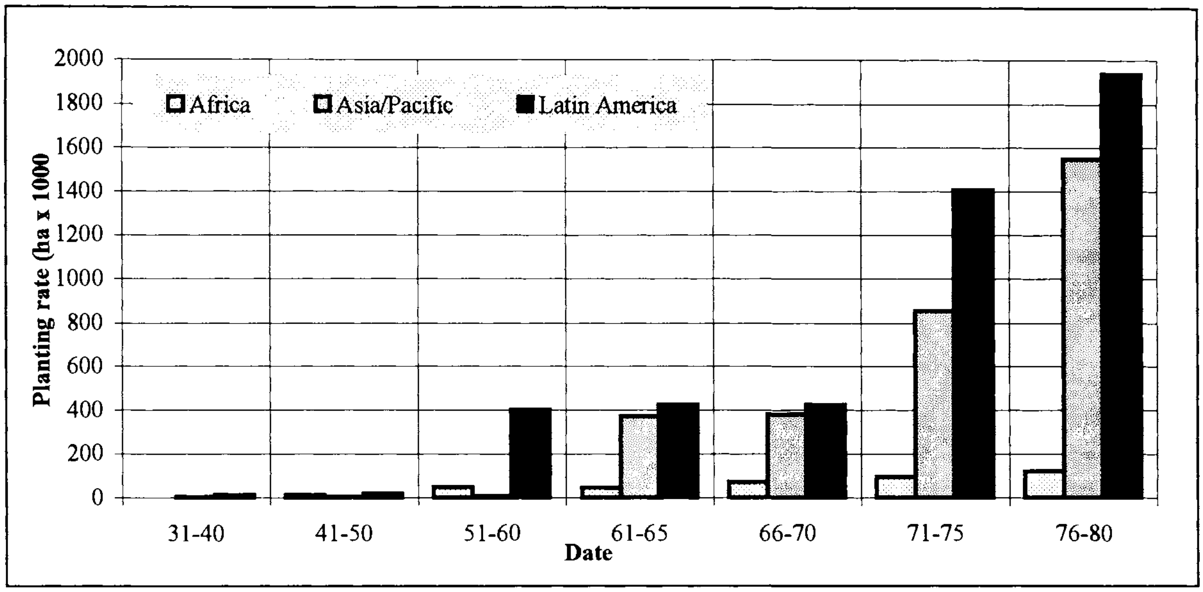


Figure 8.8. Trends in planting rates of plantations in the humid tropics. After Grainger (1986).

So at present, the increase in plantations is probably not even keeping pace with increase in demand in Africa, let alone closing the gap. This implies that natural forests continue to provide much of the produce instead, which is potentially very harmful for nature conservation if it goes beyond what the forests can supply sustainably. On the other hand, tree-planting on farmland seems to be increasing, at least in some areas, as more and more farmers become aware of the benefits of trees to them. The classic example of this is in Machakos district, Kenya, where there are now more trees on farmland than at any time in the last fifty years, even though human populations are now much higher (Lundgren 1993). In fact, in the 10 million hectares of high-potential land in Kenya, woody biomass on farmland increased by 4.7% per year, and the volume planted was found to be strongly positively correlated with human population density (Figure 8.9)(Holmgren et al., 1994). The authors of this study conclude that secure land tenure has been the key to this growth in planted trees. It is unfortunate for nature conservation, however, that in most areas farmers first clear natural forest (20,000 ha per year in Kenya), and then have to go through a period of tree scarcity before beginning to plant their own trees.

Already in Uganda a third of the standing stock of trees is on farms (Millington, 1994). However, there are very many reasons why Ugandan farmers do not plant trees, as Figure 8.10 illustrates. Most claim that they do not have enough land, a situation that is likely to get worse as populations increase.

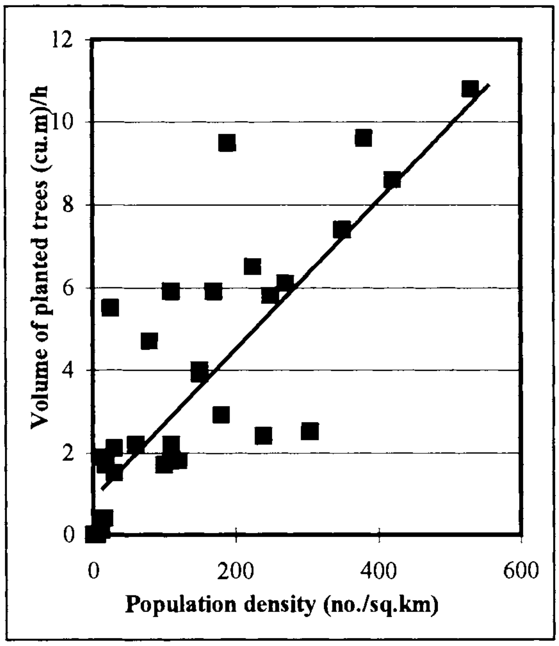


Figure 8.9. Planted biomass volume versus human population density for districts in the high-potential areas of Kenya. Redrawn from Holmgren, Masakha and Sjoholm (1994).

Reducing demand

Reducing demand is potentially a more sustainable option (since sooner or later increasing consumption levels will exceed what the land can supply anyway). There is gross discrepancy in levels of consumption between countries of the developed and developing world. Whereas developing countries tend to use more fuelwood, developed countries use more timber.

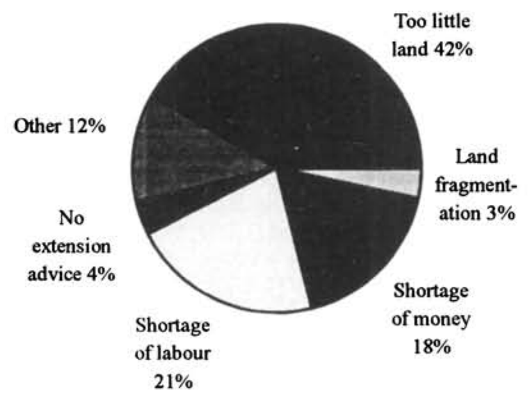


Figure 8.10. Farmers' constraints to implementing policies on tree-planting, erosion control, and swamp and forest conservation, based on seven study areas in various parts of Uganda. After Tukahirwa (1992). The total of 88% suggests that only 12% of farmers are free from any of these constraints.

According to Hurtado (1994), if everyone used as much wood as people in the Netherlands, then 11,000,000,000 m^3/yr. would be needed by the year 2010, a volume that could simply not be met by the world's forests, natural or plantation. Developed countries are only now beginning to wake up to this by starting to recycle wood and consume less. Fifty-five per cent of the global consumption of wood products is for fuel (Whitmore, 1990). In Uganda, 96% of the population cooks with firewood or charcoal (Karani, 1994), so theoretically the potential for making savings here by increasing efficiency of stoves and charcoal manufacture is vast. According to Struhsaker (1987), fuel conservation measures could be 2-25 times more effective at closing the gap between supply and demand than current levels of tree-planting, although much would depend on the level of uptake. Measures include the following (after Struhsaker (1987), and HBEW (1994)):

- Drying wood before burning it. This increases heat output, and could reduce consumption by over 20% (Struhsaker).
- Using improved fuel-efficient wood cooking stoves (Struhsaker). Some models can reduce consumption 5-10-fold; a "multipot" stove uses 7 trees per family per year, whereas a traditional 3-stone fire may use 12. If fuel-efficient stoves were widely promoted and uptake was twice what it has been in Kenya, then about 2.5% of current fuelwood consumption could be saved (HBEW).
- Using more efficient charcoal kilns. 50%-70% of wood's energy is lost in converting it to charcoal. Efficiency of conversion can be increased by 50% by using only dense, dry wood in uniformly sized pieces, and by packing the wood tightly and giving a thick earth covering to the kiln to prevent complete combustion (Struhsaker). If improved earth kilns such as the Casamance kiln were promoted widely, then about 2.5% of current fuelwood consumption could be saved (HBEW).

8.4 INVASIVE EXOTIC SPECIES AND CONSERVATION

8.4.1 What are invasive exotics?

The term ***exotic*** is widely understood by foresters to mean a species of tree that is not indigenous to the area where it is being grown. Many have been deliberately introduced because they have valuable characteristics that local species may lack; hence many of the most important plantation tree species are exotics. Examples in Uganda include the pines (mostly from Central America) and eucalypts (from Australia). Other plants and animals can also be described as exotics. Animal examples include chickens (from tropical Asia), turkeys (from North America) and goats (from the Middle East).

Many other exotics have been spread around the world by humans, either deliberately or accidentally. Most of them could not survive in their new home without the continued presence of humans either deliberately nurturing them (such as many crop plants) or maintaining the conditions necessary to their survival (such as agricultural weeds). But just a few species find the conditions in their new home good enough for survival without the help of humans, and establish ***naturalised*** or ***feral*** populations in the wild. Of these, a small proportion find conditions so suitable that they become more common in their new home than they ever were in their native home. When they start replacing indigenous species, we refer to them as ***invasive exotics***. There are now numerous examples of invasive exotic plants and animals throughout the world. Their spread causes economic as well as ecological problems.

8.4.2 Economic importance of invasive exotics

In the United States, for example, 4500 species of exotic plants and animals have established feral populations, of which about 15% can be classed as invasive exotics. Just 79 of the worst offenders are estimated to have cost the nation $97 billion this century (Kiernan, 1993). The introduction of Nile perch (*Lates niloticus*) to Lake Victoria has caused major changes in the fisheries there, and has been particularly damaging for traditional fishing communities. Recently, the spread of water hyacinth (*Eichornia crassipes*) has been causing further hardship for lake-shore communities. The leucaena psyllid (*Heteropsylla cubana*) has been decimating stands of leucaena (*Leucaena leucocephala*) throughout Asia and is now spreading through Africa; likewise the aphid *Cinara cupressi* on cypress in East and Central Africa.

8.4.3 Ecological importance of invasive exotics

Invasive exotics can radically alter the entire ecosystem and threaten many species with extinction. Bibby et al. (1992) estimated that 8% of all the world's threatened restricted range birds are threatened by exotics, while WCMC (1992) estimated that 21% of all the world's threatened mammals are threatened by exotics (see Section 3.3.3). There is no figure available for threatened plants, but invasive exotics are likely to be one of the largest threats. The way they do so will depend on what niche they occupy.

An invasive exotic **predator** may outcompete a native predator, causing it to go extinct. It may start to prey on species that have not evolved to cope with the new predator, causing extinction of those prey species too. As they disappear, so there may be further knock-on effects throughout the food web. A classic example is the case of Nile perch in Lake Victoria, introduced in the 1950s. The native fishes, including over 100 endemic tilapia species, were soon decimated by the new predator, and the whole ecology of the lake is now very different from before the introduction. Changes are still going on, and many extinctions are likely. FAO (1992) estimates that of the 300 or so species of fish that existed in the lake before the introduction of Nile Perch, about 200 have either disappeared or are threatened with extinction.

If the invasive exotic is a **herbivore**, the effects can be equally profound. Goats, rabbits and deer, introduced to islands around the world where no similar herbivores existed, have managed to convert forests to scrub and desert within a few centuries.

Invasive exotic **plants** have probably been responsible for most ecological damage, and this is the group that concerns us most in this chapter. Many have been introduced by foresters as potential timber, firewood, pulp or fodder trees, or as boundary markers. Sheil (1994) has listed 48 plant species which have become naturalised in the East Usambara mountains of Tanzania, some of which are causing major changes to the forest. Most were introduced by the Forest Department. Chief among these is *Maesopsis eminii*, which, although native in western Tanzania (as in western Uganda), is not native in the Usambaras. In the Usambaras, it is gradually replacing many of the native species (many of them endemic) because it is better at colonising gaps than they are. Binggeli (1989) estimates that within 200 years, *Maesopsis* could make up 50% of the forest canopy.

Other examples of invasive exotic plants include *Cecropia* sp., a South American tree that is ecologically very similar to *Musanga* and which is beginning to replace it in logged forest in Côte d'Ivoire; the trailing shrub *Chromolaena ochroleuca*, common in forest edges throughout West Africa, *Psidium guajava* and *P. cattleianum* (guavas), which are major causes of species extinction on many tropical and sub-tropical islands and are spreading in Ugandan forests too, *Spathodea campanulata*, a native of Uganda that is invasive in semideciduous forests in Sri Lanka, and the Asian *Azadirachta indica* (neem), is spreading in many parts of tropical Africa (Davidson, 1987).

8.4.4 Invasive exotic plants in Uganda

It is possible that *Maesopsis*, the main problem species in the Usambaras, may prove equally invasive in forests in Eastern Uganda, such as Elgon and West Bugwe, where it is also not native. Many other plants are causing concern in Uganda, although most are proving to be problems in plantations (such as *Toona ciliata*, *Cassia spectabilis* and *Cedrela mexicana*), grazing land (such as *Lantana camara*) or waterways (such as *Eichornia crassipes*, the water hyacinth). Fortunately, relatively few are causing problems in natural forest so far.

Three that are now causing concern in Budongo Forest are *Broussonetia papyrifera* (paper mulberry), *Psidium guajava* (guava) and *Cassia spectabilis*. Paper mulberry was brought to Budongo in 1953, when it was planted in Research Plot 41 near the Sonso sawmill (Dawkins, 1956). The experiment was designed to investigate the potential of paper mulberry for pulp production from its fibrous bark. Within a year, the trees had increased in height from 1.3 m to 7 m; a year later they had reached 12 m. The study concluded that paper mulberry "*...has shown the fastest growth recorded by any trees in Uganda...*", and recommended that "*...it should be tried further wherever there is any possibility of paper making near any rainforest blocks...*". It was also noted that the plot "*...will continue to be carefully watched...*", but unfortunately this did not happen. Paper mulberry has since started to spread, firstly into disturbed areas around the sawmill, but increasingly in gaps and along logging roads throughout the forest. In areas nearest to its original introduction, it is almost the only tree species present, and it is possible (but not proven) that it may eventually come to dominate large areas of Budongo.

In the case of guava, the species can now be found in many parts of the forest, and is sufficiently common for its fruits to be valued by local communities as a "wild" food (Johnson, 1993). Given its performance in forests in other parts of the world, it too could become a major nuisance. *Cassia spectabilis* was introduced by the Forest Department as a boundary marker (its crown shows up well in aerial surveys because of the yellow flowers), but has since spread along forest roads and into gaps. This same species has already proved highly invasive in Semliki Forest.

8.4.5 What makes some exotic plants invasive?

Of the many thousands of plant species that have been carried around the world by humans, few have become invasive. Whether they do so or not depends on a number of factors. An understanding of these should help foresters to avoid encouraging further invasive exotics in the future, and may help us to understand how best to tackle problem species. Box 8.2 lists some of the factors that make some species invasive and others not.

8.4.6 What should we do about invasive exotics?

We know that invasive exotics pose serious ecological and economic threats, and that historically we have not recognised the threats until it is too late. Many species have become invasive after their introduction by well-meaning foresters. With an understanding of what makes some species potentially invasive, we should be able to evaluate species with this in mind before deciding whether to introduce them or not. If we decide to introduce them, we may decide to keep them well away from any natural forest that might be invaded, or to ban their use as boundary markers around natural forest. Furthermore, armed with an ecological understanding of invasive exotics, we should be able to predict the best methods of limiting their spread (such as altering logging practices) and perhaps even suggest practical ways to eliminate them once they have become established. The costs of not doing anything can be high indeed.

8.5 SUMMARY

We have seen that, whereas plantations do not tend to have much intrinsic nature conservation value, planting trees is nevertheless important as one mechanism for helping to meet the increasing demand for wood products. In so doing, tree-planting takes pressure off the natural forests, which could otherwise not meet the demand without being grossly overexploited. Promoting efficiency in the use of woodfuel also has a role to play.

In some cases, it is true that tree planting also has broader environmental advantages, but there are often also disadvantages. We should be particularly aware of promoting the planting of any tree species that might become invasive in natural forest. Box 8.3 outlines some of the strategies that are likely to prove most successful, and environmentally sustainable.

Conditions under which establishing plantations would be inappropriate include where they are established on land of higher value for other social, environmental or economic purposes, especially where this is done by clearing natural forests (incurring high environmental costs) or by compulsory acquisition (incurring high social costs) (Kanowski and Savill, 1992).

Box 8.2
Some characteristics that make some exotic species invasive and others not

- **They are usually early successional species rather than climax species.** Thus disturbance increases the invasibility of plant communities (Hobbs and Huenneke, 1992). For instance, paper mulberry is a coloniser of forest gaps in its native habitat on the islands of the South Pacific. The forests there are naturally prone to high levels of disturbance by tropical storms, and paper mulberry is well adapted to responding to this disturbance. Logged forest in tropical Africa may mimic this natural disturbance, making successful colonisation by paper mulberry more likely. Likewise, in the East Usambaras, undisturbed natural forest now harbours 19 species of naturalised exotics, whereas disturbed (logged) forest and forest edge supports nearly twice as many (36) (Sheil, 1994).
- **They usually grow quickly.** Paper mulberry was described as the fastest growing tree in Uganda. Thus, once it colonises an area, it is good at out-competing potential rivals for space and light. This characteristic also means that invasive exotics can spread faster than we can control them.
- **They usually have abundant seed production.** Paper mulberry can flower more or less continuously throughout its adult life. Each "flower" is actually a group of flowers, and the "fruit" therefore contains many seeds.
- **They usually have short generation time.** Paper mulberry starts flowering within two years.
- **They usually have good long-distance seed dispersal mechanisms, such as wind or popular fruit.** The fruits of paper mulberry are highly favoured by monkeys and hornbills, maybe more so than many native species that would otherwise form their diet. For example, paper mulberry fruit can make up about 20% of the diet of chimps around Sonso in Budongo Forest (Bakuneeta, pers. comm. 1994), and the seeds found in chimp dung are viable (Plumptre et al., 1994). Since chimps have large home ranges, they may disperse the seeds widely. Hornbills, too, may travel miles between feeding and roosting sites. **An invasive exotic may therefore increase exponentially**, but by the time we notice that it has become well and truly established it may be too late to do anything about it.
- **They can often reproduce vegetatively, for instance by suckering.** Even if paper mulberry is cut down, it soon regenerates from suckers. These suckers can gradually extend through the forest from a parent tree, and will be there ready to grow if a gap should appear.
- **They often have generalised pollination systems not dependent on specific pollinators.** Paper mulberry has flowers that are attractive to a wide range of insects, so its pollination is not dependent on the presence of one pollinator. If it had a specific pollinator, the chances are that it would not set seed outside the normal range of that pollinator, unless the pollinator had also been introduced.
- **They often have a competitive advantage due to lack of specific pests or diseases.** This is one of the main reasons that invasive exotics can perform better in their new homes than in their native areas. The growth of most species of plants (and animals) is often suppressed by other pests or diseases, for example viruses, fungi or herbivorous insects. When a plant is introduced outside its natural range, normally these pests and diseases are left behind. Thus they can grow unchecked in their new home, unlike the native plants around them. Sometimes, this advantage is short-lived if the pest eventually manages to arrive as well, as in the case of leucaena and its psyllid or cypress and its aphid. So far, it seems that nothing has come along to suppress the growth of paper mulberry.

Box 8.3
Four strategies for sustainable plantation forestry (ITTO, 1993)

- **Plantations of pioneer species**, which do not displace important ecosystems or rich agricultural land, for national industrial timber requirements and possible export.
- **Planting of multi-purpose and/or nitrogen-fixing species**, as an integral part of rural development and incorporated into land use strategy at village level, where the villager controls what, where and how planting is done.
- **Planting to augment farming systems**, to add diversity, increase robustness and multiply benefits which flow from more complex systems.
- **Planting to harness environmental services**, to reduce erosion or rehabilitate waste ground.

FURTHER READING

FAO. 1994. Forest development and policy dilemmas. In: *The state of food and agriculture 1994*. FAO, Rome.

Holmgren, P., Masakha, E.J. and Sjoholm, H. 1994. Not all African land is being degraded: a recent survey of trees on farms in Kenya reveals rapidly increasing forest resources. *Ambio*, Vol. 23 (7): 390-395.

Plumptre, R. and Carvalho. 1991. *The marketing of Ugandan Hardwoods*. CMF Forst-Consult report.

Sawyer, J. 1993. *Plantations in the tropics: environmental concerns*. IUCN/UNEP/WWF, Gland. 83pp.

Sheil, D. 1994. Naturalised and invasive plant species in the evergreen forests of the East Usambara Mountains, Tanzania. *African Journal of Ecology* 32: 66-71.

Tukahirwa, E.M. 1992. *Uganda: environmental and natural resource management policy and law: issues and options*. Makerere University, Kampala.

WCMC. 1992. *Global biodiversity: status of the earth's living resources*. World Conservation Monitoring Centre/Chapman and Hall.

CHAPTER 9

ECONOMICS AND NATURE CONSERVATION

CHAPTER OUTLINE

9.1 INTRODUCTION

Economics is traditionally viewed as a method for understanding how best to make money from what are known as the "three factors of production": land, labour and capital. The objective of most enterprises, whether by individuals, companies or governments, is to maximise profits.

This view of economics suggests that it should have no role to play in promoting conservation. It all sounds very 'unsustainable', in that only a single product (money) is seen as having any value, and the more of it and the quicker it can be made the better. Increasingly, the world seems to be becoming more and more monetarised, and development is only seen as being important if it is *economic* development, or making money. Conservation is often seen as standing in the way of making money, and in economic terms is often considered to be a cost, something that reduces or obstructs profitability.

However, economics need not be like this. Economics should only ever be considered a tool, and wise use of tools depends on wise users. In the right hands, economics can be a powerful tool for supporting conservation. If we want to promote conservation amongst economists and politicians, many conservationists now argue that we will have to start speaking their language, and manipulate its use so that it provides us with good economic arguments for conservation.

9.2 TRADITIONAL ECONOMICS

9.2.1 Traditional economics and conservation

There are many examples of environmentally harmful developments that have been sanctioned by traditional economic analyses. In each case, the analyses assume that the economic value of the land will be enhanced by the development. Examples include:

- converting primary natural forest to timber production forest, often resulting in the "mining" of the forest for timber with no thought for long-term sustainability;
- converting natural production forest to short-rotation plantations of exotic species;
- converting forest to agricultural land; and
- submerging forest under reservoirs for hydroelectric power generation.

One reason for this is that, in a traditional economic model, the measure of success of any intervention or enterprise is considered in monetary terms: how much money can be produced, and at what expense to the producer. The aim is to **maximise monetary profits for the individual, company or government**. Costs to the producer borne in converting or exploiting the natural forest will be compared with the profits to be made from conversion or exploitation. By these standards, conversion and exploitation is normally seen to be profitable.

9.2.2 Discount rates and externalities

Profitability depends not just on the overall long-term financial value, but also on how quickly that financial value is realised. A quick return on investment is seen as desirable, so converting to crops with shorter rotations also becomes desirable, as does "mining" the forest's timber in as short a time as possible. This is because most people do not want to see their money "tied up" for years and years: they would rather have it sooner, even if overall they do not get as much money this way as they would if they waited for it all to arrive at once after many decades. This is human nature in most societies: in an uncertain world, we want to make quick profits and prefer to ignore the long-term consequences of this decision either for ourselves, our descendants or society at large. In other words, we value the present over the future. In the language of economists, we have high personal **discount rates**. Money-lenders (such as banks) often exacerbate this natural tendency because they too have high interest rates (which reflect the personal discount rates of the bank's investors), so the sooner the loan can be paid back the better. This means that when potential supporters of projects are looking at the likely commercial profitability of a project, or investigating how a project's performance would compare with a commercial venture, they often use quite a high discount rate in their calculations. A final drawback is that quick profits from the unsustainable use of resources can be ploughed back into further investments, so multiplying profits further. As long as there are still resources to exploit, this often remains the most profitable option.

This illustrates a serious problem with traditional economics: it is selfish. The only costs that are considered are those borne by the individual, company or government investing in the enterprise. All other costs are **externalised**. Box 9.1 summarises this apparent paradox, according to some leading environmental economists. For conservation to succeed, then, we need something different from traditional economics.

Box 9.1
The paradox of economics and biodiversity loss (Pearce and Moran, 1994).

1. Economic forces drive much of the extinction of the world's biological resources and biodiversity.
2. Yet biodiversity has economic value. If the world's economies are rationally organised, this suggests that biodiversity must have less economic value than the economic activities giving rise to its loss.
3. Yet we also know that many biological resources do have significant economic value. And we know that many of the destructive activities themselves have very low economic value.
4. Therefore, something is wrong with the way actual economic decisions are made; for some reason they fail to "capture" the economic values that can be identified.
5. These "economic failures" lie at the heart of any explanation for the loss of biological diversity. If we can address them, there is a chance of reducing biodiversity loss.

9.3 WELFARE AND ENVIRONMENTAL ECONOMICS

9.3.1 Introduction

Welfare and environmental economics are extensions of the traditional economic model. But instead of seeking to maximise profits for individuals, companies or governments, they seek to **maximise economic welfare for the whole of society**. The welfare of a society is the sum of the well-being of every individual member of that society. Thus for an intervention or enterprise to appear profitable under welfare and environmental economics, the benefits to society must be shown to outweigh all the costs to society. In other words, welfare economics **internalises the externalities** that traditional economics ignores. Since conservation in the modern sense of the word is so closely linked to sustainable development, promoting the wise use of resources for society as a whole, this is a very useful tool for conservationists.

Many different techniques are available to support these new economic ideas. Most aim to come up with a figure for the **total economic value** of a resource or project. Some are taken directly from traditional economics, while others have been devised more recently and are called "new" economics.

One of the main methods used is **cost-benefit analysis** (CBA). CBA is a method that is used widely in many branches of economics. The main difference is that, in welfare economics, CBA covers a much wider scope, to encompass as many of the costs and benefits as possible rather than sticking to those that affect only the individual, company or government.

Typically, whatever methods are used, welfare and environmental economics are useful to conservationists in six main ways (Pearce et al., 1988):

- in demonstrating the national importance of environmental goods and services;
- in calculating the benefits of projects and programmes designed to improve the environment;
- in estimating the true (normally externalised) costs of non-environmentally sustainable projects or programmes;
- in calculating a basis for compensation for environmental damage;
- in determining the extent to which regulatory policy should be implemented; and
- in determining the extent to which past policies have been socially beneficial.

9.3.2 Cost-benefit analysis (CBA)

9.3.21 The CBA process

Conducting a cost-benefit analysis of a conservation project, such as establishing a protected area or zoning a forest reserve, involves three steps (Ruitenbeek, 1990):

1. **identifying** what would happen in the absence of a conservation project (e.g. deforestation, loss of soils, water shortages, depletion of resources generally).
2. **quantifying** the timing and amount of the economic costs and benefits of these physical changes by assigning "shadow prices".
3. **adding** the benefits and **subtracting** the costs to decide whether a project is actually worthwhile.

This is normally done by devising a matrix shell of defined benefits and costs (a bit like an EIA matrix), and then filling in the boxes by quantifying them in monetary terms.

9.3.22 Valuation methods for CBA

It is not always easy to work out the exact value of any of the costs or benefits involved in forest conservation. Normally, some kind of **shadow pricing** has to be adopted, that is, estimating or calculating the implicit values of things that are not valued explicitly. Box 9.2 lists some of the ways that may be appropriate.

9.3.23 Classifying the values in a CBA

It is possible to classify the potential values in various ways which help us to appreciate them better and carry out the three-stage process outlined above. The following categories are from McNeely (1988):

Direct values ("goods")
- Consumptive use value
- Productive use value

Indirect values ("services")
- Non-consumptive use value
- Option value
- Existence value

Direct values

These are concerned with the enjoyment, satisfaction or basic sustenance received directly by consumers of biological resources, in other words, the "goods". Of course, in a conservation project, the number of values may be limited if they conflict with conservation, in which case they should still be considered in a cost-benefit analysis, but as costs (i.e. benefits foregone) rather than benefits accruing to the project.

Consumptive use value is the value placed on nature's products that are consumed directly, without passing through a market. From a forest, products such as timber, forage, firewood, food, wildlife, fish, herbs and medicines would be included if they are used locally and not traded. The value of such products is considerable, but because it does not pass through a market the value never makes it into government figures such as Gross Domestic Product. In a cost-benefit analysis, however, the consumptive use value can be estimated by substituting the market value of the products consumed if they were sold on the market instead of being consumed.

Box 9.2
Some valuation methods for cost benefit analysis.

- **Local market prices.** Local market prices often exist for non-timber forest products. If the forest disappeared, the local people would have to buy these goods from the market. Thus the value of the products harvested by the local people can be worked out as the amount they collect multiplied by the local market price.

- **Market price of substitute.** If the forest disappeared it might not be possible for the local people to buy, for example, fuelwood, on the local market. The only realistic alternative would be for them to buy charcoal instead, imported from outside. In this case, the value to the local people of free collection of firewood from the forest is equivalent to the value of a comparable amount of charcoal that would have to be bought from outside. For estimating the value of bush meat, it would be necessary to estimate the cost of replacing bush meat with the meat from domestic animals bought on the open market.

- **The product is marketed in other areas.** In some forests you may have to pay for collection of poles, or for camping, while in others it is free. The value of these products in the forest where it is free can be calculated from its value in a similar forest where it is not free, since this indicates the collector's/camper's willingness to pay for the products in general.

- **Effect on production**. If a forest were cleared, this could have impacts on production of crops or industry outside the forest, if rainfall or climate or river-flow changed. The loss or gain in production in these affected areas can be quantified per unit area. In another scenario, the only other fuel available if a forest were cleared might be dung. In this case, the value of the forest as a source of fuelwood would have to be worked out based on the cost of using dung as fuel rather than as fertiliser, which could be calculated by measuring the difference in crop yields between crops fertilised with dung and those not fertilised. Alternatively, it could be calculated by working out how much farmers would have to spend on chemical fertiliser to give them the required level of crop production to compensate for the lack of dung being added to their crops.

- **Preventative expenditure**. If a forest were cleared, it might mean that additional expenditure would be involved in preventing the damaging effects of clearing, such as siltation or soil erosion. The cost of forest clearance should therefore include the cost of developing siltation ponds or terraces, etc., or the cost to the government of supplying piped water from alternative sources, i.e. the **market value of the physical effects** of the project, in this case forest clearance.

- **Connected expenditures.** Sometimes expenditures are involved in the consumption of apparently free goods or services. For example, even if camping in a forest is free, people still pay to reach the forest for their free experience (a **travel cost**). These expenses indicate the camper's willingness to pay for the camping. Similarly, tourists who want to go on an African safari in a National Park have to pay not only the park entry fee and the fee charged by the safari company, but also the cost of the flight from their country of origin.

- **Interviews and questionnaires (contingency methods)**. It is possible to get an idea about the value of the forest by asking people how much they think it is worth. For instance, how much would they be willing to pay to save a forest from being cleared, or how much should they be compensated for the loss of a forest. The values given in response can be very variable, depending on how the question is phrased and who is asked, and are normally very high.

Examples:

- 75% of the animal protein consumed in Zaire comes from wild sources, mostly from forests (Sale, 1981). Much of this is consumed without ever being traded.
- Firewood provides over 95% of the total primary energy needs in Uganda, and much of this is consumed without ever being traded (FAO, 1992).
- Large numbers of plant species found in Ugandan forests have uses for either food or medicine (Iwu, 1993; Peters et al., 1992).
- In Sarawak, Malaysia, it is estimated that the cost of replacing the 18,000 tonnes of wild meat harvested from the natural forest with a similar amount of protein from domestic livestock or fish would be $40 million per year (Caldecott, 1988).

Productive use value is the value assigned to products which are commercially harvested. From a forest, timber is the main example, but others include firewood, forage, canes, poles, food, wildlife, fish, herbs and medicines in certain places. The contribution made by wild species to domesticated resources is also a productive use value, such as the value of wild genetic varieties in improving crops, or the value of forest-dwelling pollinators in pollinating crops. In a cost-benefit analysis, productive use values are estimated, where possible, at the production end (i.e. when a product is first traded) rather than at the retail end, when the price has risen because of middle-men.

Examples:

- The calculated net present value of the logging royalties for timber extractable from communally owned forest in Vanuatu, South Pacific, was recently used to come up with the amount of money the local government would have to pay the community for it to hold the land as a protected area on a seventy-five year lease (Tacconi and Bennett, 1994).
- Wild coffee (*Coffea canephora*) in Kibale Forest could produce berries worth $100-200,000 annually at 1985 prices (Struhsaker, 1987).
- In 1982, Indonesia earned $200 million in foreign exchange from non-wood forest products, mostly rattan canes (Gillis, 1986).
- A year's use of natural habitat in Zimbabwe for wildlife production gives an aggregate return that rivals the returns from the most intensive forms of cultivation in the same region (Child, 1984). Most of this value is for sport shooting of game animals, but it also includes meat for consumption.

Indirect values

Indirect values deal mostly with the functions of ecosystems, in other words, the "services", and so do not usually appear in national accounting systems. Despite this, they may far outweigh direct values when they are computed. They tend to reflect the value of biological diversity or forests to society at large rather than to individuals or companies. This can be useful, although it should also be remembered that even if the values accrue to society as a whole, there may be individuals (perhaps local people) for whom these are outweighed by the costs.

Non-consumptive use value is the value placed on nature's functions or services rather than goods, and as such is not consumed, traded or reflected in national income accounts. A wide range of services come under this category, such as photosynthetic fixation of solar energy, pollination, maintenance of water cycles, recharging ground-water, protecting watersheds, buffering extreme water conditions (such as flood and drought), regulating climate, production of soil and prevention of erosion, storage and cycling of essential nutrients including the constituents of air, absorption and breakdown of pollutants, and provision of recreational, aesthetic, scientific, educational, spiritual and historical experiences. Some of these values are relatively easy to monetarise, but others are not. For example, it is relatively easy to work out the watershed value of a protected forest, by considering how many people living downstream of it depend on that water (even if they do not physically consume it), and what it would mean to them in monetary terms if that water supply became undependable. It is less easy to work out the contribution played by a single forest to regulating world climate, especially if you have to put a monetary value on it.

Examples:

- Forests keep soil from eroding into rivers. Siltation of reservoirs costs the world economy about $6 billion per year in lost hydroelectricity and irrigation water (FAO, 1994). Existing catchment forests must prevent greater losses, while reforestation of deforested catchments could reduce losses.
- In India, forests provide water regulation and flood control valued at $72 billion per year (FAO, 1994).

- The viability of the $1 billion salmon fishery in the Pacific Northwest of the United States is
- Replacing the carbon storage function of all tropical forests would cost $3.7 trillion (FAO, 1994).
- Each lion in Amboseli, Kenya, has been estimated to be worth $27,000 per year live as a tourist attraction, while a herd of elephants is worth $610,000. The park yields net earnings of $40 per hectare per year, which is about fifty times what any form of agriculture could produce (Western, 1984).
- Tourists in Kenya have stated during a survey that viewing elephants accounts for 13% of the total value of their safaris, representing $23-27 million annually. In another survey, enough tourists said they would pay $100 each to ensure that the elephant population in Kenya stayed at least at its present level to give a total value for the elephants of $25 million to $30 million annually. Furthermore, half the tourists stated that if elephants declined by another 50%, then they would no longer want to visit Kenya, so tourism revenue would drop by as much as $85 million annually (Brown and Henry, 1989).
- On the other hand, it has recently been argued (Norton-Griffiths and Southey, 1994) that conservation (including tourism and forestry) is still a net cost to Kenya, to the tune of about $203 million per year, because of the benefits foregone (opportunity costs) in not developing the land for other uses. Although their analysis is certain to be disputed, the authors are not against conservation: they merely argue that this is the sum that should be provided by the international community to make conservation in Kenya more popular and successful.
- Flatley and Bennett (1994) estimate that just two rainforest areas of Vanuatu have a net present value of at least A$6.8 million per year, based on the number of Australian tourists who expressed willingness to pay a total of up to A$682,000 per year on top of their other holiday expenses to see the rainforests protected, and calculated on the basis of a 10% discount rate in perpetuity. The conclusion is that there are strong economic benefits to be enjoyed from setting up protected areas in Vanuatu, and it would only be necessary to draw on the resources of tourists to fund their establishment.
- In eight out of its nine administrative regions, the US Forest Service calculates that the recreation, fish, wildlife and other non-extractive benefits of National Forests are

  said to depend on the survival of the region's old-growth forests (FAO, 1994).

  more valuable than timber, grazing, mining and other benefits (FAO, 1994).

Option value is the value placed on being able to use a resource at some future date. It is a means of assigning a value to risk aversion in the face of uncertainty. After all, who can say what our future needs and desires will be? The future is uncertain, and extinction is forever. Therefore, it makes sense to maintain as much biodiversity as we can now. Option values are likely to be even higher in the future than they are now, as resources continue to get depleted all around protected areas, making the protected areas themselves more valuable. In future, we may just want to use more of the same resources that we value now (such as timber, genetic resources, tourism, wildlife), or it may be something that we least expect. Option values can be used as justifications for not pursuing ecologically harmful developments, because it can be argued that we do not know the value of what we are losing. This relies on something called a "**quasi-option**" value, which is the value of learning about future benefits that would be precluded by development or irreversible change in the *status quo*.

Examples:

- In 1979, a new species of wild maize was discovered on a hillside in Mexico that was being cleared for agriculture. It now looks as though this maize could enable the development of a perennial variety of cultivated maize, which means that this wild plant, so nearly extinguished, may prove to have an annual value of $6.82 billion).
- The collection of a wild species of tomato in the Andes in 1963 resulted, after ten generations of crossing with cultivated varieties, in a noticeable commercial improvement valued at about $8 million per year (Swanson, 1991).
- Merck and Co., a pharmaceuticals multinational, recently agreed to pay $1 million to Costa Rica's National Biodiversity Institute for the right to investigate the chemical properties of the species found in the country's rainforests, in the hope that some of them may be found to have useful properties some time in the future. This was based on the assumption that a single research discovery would earn a net present value of $200 million (Aylward, 1993).

- The wild relatives of avocado, banana, cashew, cacao, cinnamon, coconut, coffee, grapefruit, lemon, paprika, oil palm, rubber and vanilla - the exports of which were worth more than $20 billion in 1991 - are all found in tropical forests (FAO, 1994).
- Based on the current value of the pharmaceuticals industry and their dependence on plants from tropical forests, it has been estimated that the annual value to OECD countries of an as yet untested plant species is between $300,000 (Aylward, 1993) and $1.6 million (Farnsworth and Soejarto, 1985). Based on the value of lives saved by plant-derived drugs, the annual value per untested plant species rises to $23.7 million at 1990 prices, but only $1.5 billion if the analysis is extended to the whole world (since people in poorer countries value human lives at a far lower level than those in richer countries). These rates translate to net present values of from $52 to $46,000 per plant species for a host country seeking to licence or get royalties from pharmaceuticals companies (Aylward, 1993).

Existence value is the value attached to the existence of a species or protected area by people who may never see it for themselves but nevertheless are pleased that it is there, regardless of whether it will ever have a use for humans. Some people attach such a value because they would like their descendants to be able to know that it still exists. It is impossible to estimate this value in monetary terms, but it is clear that it is a large value if we consider how much money people in richer countries are prepared to give as voluntary contributions to various conservation agencies involved in promoting conservation of forests etc.

Example:

- WWF (World-wide Fund for Nature), an international NGO that promotes conservation, receives private donations of nearly $100 m annually (McNeely, 1988).

9.3.24 Strengths and weaknesses of CBA

CBA is not the only tool in use by welfare economists, but it is an important one. It has many strengths, but also some weaknesses. These are listed in Box 9.3.

Box 9.3
Strengths and weaknesses of cost benefit analysis (Bennett, 1993)

Strengths

- It provides a logical structure for the systematic collection and presentation of information from the perspective of the trade-offs involved in decision-making, especially encouraging the consideration of indirect effects.
- It forces an active search for information, in order to fill in the matrix.
- It increases the explicitness of decision-making, especially when carried out as a public exercise.
- It provides a check on the actions of decision-makers.
- It enables the detection of clearly deficient options.
- It allows for some comparability between widely divergent projects and increases the likelihood of consistency across decisions.

Weaknesses

- Accurately measuring costs and benefits in monetary terms is often difficult and costly in itself.
- It faces problems of dealing with uncertainty when projecting streams of costs and benefits into the future.
- It must face the problem of the time value of money, i.e. what discount rates to use.
- It is principally a tool of efficiency maximisation, and largely ignores equity implications.
- The complexity of the impacts of a project may mean that the general public's degree of understanding is so poor that their contribution to CBA valuation can be meaningless.
- It is unethical for some people, as it seeks to monetarise everything and is very utilitarian.

9.4 CASE STUDIES OF ECONOMICS WORKING FOR CONSERVATION

9.4.1 Comparison of benefits of conservation versus agriculture in Bwindi Forest

A recent study (Kazoora, 1995) looked at the economics of two different scenarios for Bwindi Forest. One scenario is conservation, including ecotourism (especially tracking mountain gorillas) and some small-scale controlled harvesting of forest products. The other scenario is that the forest could be converted to agricultural use, like the surrounding land. Both scenarios have positive net present values, but the conservation scenario is seen to be two orders of magnitude larger than the agricultural one (Figure 9.1).

Before concluding that conservation is a thoroughly good thing, we should look at the criteria that were considered in the valuation. For agricultural conversion, it was a relatively straightforward assessment based on the total forest area, the total area that could be converted, and the value of surrounding agricultural land under different crops. For conservation, the costs and benefits considered are shown in Table 9.1, together with their values in economic terms, where these have been estimated. It should be noted that one of the main economic benefits from conservation (the forest's value as a carbon sink) is only really appreciated at a global scale; many local people may also fail to benefit from some of the other benefits, such as ecotourism value. On the other hand, most of the costs are still borne locally, so a cost-benefit analysis carried out amongst local communities might be very different. This emphasises the need to bare **equity** in mind.

It could be argued that the Trust Fund established for Bwindi under the Global Environment Facility represents such a transfer of benefits from the global community to the local communities, as might Care's Development Through Conservation programme in the parishes surrounding the forest.

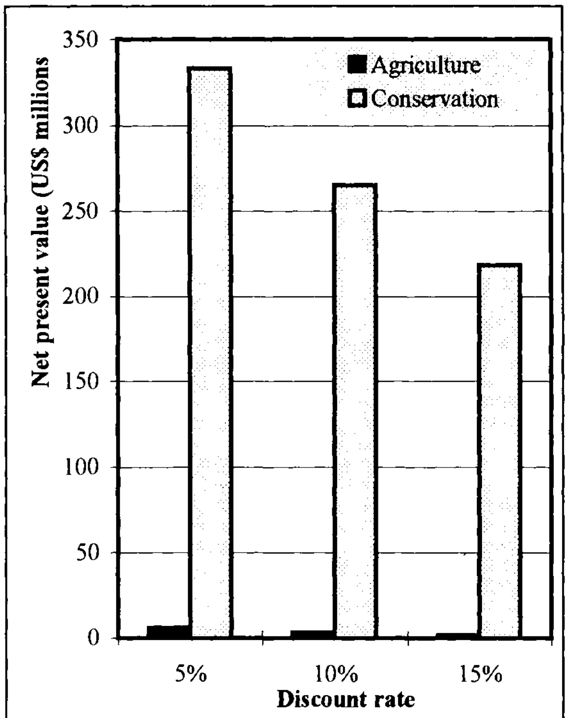


Figure 9.1. The net present value (over ten years) of conservation of Bwindi Forest, Uganda, versus its conversion to agriculture. Three different discount rates are compared. After Kazoora (1995).

Table 9.1.
Costs and benefits accruing to conservation of Bwindi Forest, Uganda. Figures in million dollars and refer to a single year. Note that some costs and benefits have not been quantified. After Kazoora (1995)

COSTS		BENEFITS	
• Capital costs, excluding roads	0.209	• Ecotourism	0.237
• Capital costs of roads	0.100	• Selective cutting of timber	-------
• Operating costs	0.080	• Genetic value	-------
• Lost stumpage value	6.586	• Education	-------
• Lost agricultural production	0.127	• Carbon sink	40.300
• Lost forest use	-------	• Flood/erosion control	9.000
		• Fisheries support	-------
		• Soil fertility maintenance	-------
TOTAL COSTS	**7.102**	**TOTAL BENEFITS**	**42.435**

9.4.2 Social CBA of Korup Forest conservation and development project, Cameroon

Korup National Park covers 126,000 ha of lowland equatorial forest in Cameroon, and is one of the most species-rich forests in Africa. Due to fairly infertile soils, it has never been logged and is little affected by shifting agriculture. However, unsustainable hunting, agricultural encroachment and illegal timber harvesting were posing growing threats to the park's survival, and so in 1987 WWF proposed the Korup Project, to develop both the national park and a buffer zone around it. By developing and disseminating sustainable uses of the forest in the project area, it was hoped to reduce pressures on the forest and reverse the process of degradation. It was recognised that it was essential to involve and motivate the local people so that their own living conditions could be improved from their own means.

A preliminary social cost-benefit analysis of the project was carried out (Ruitenbeek, 1990), to assess its likely impact on both conservation and development, and to compare this with an alternative scenario in which it was assumed that the forest would not be protected, and would be logged out over the next 50 or so years. The analysis used conventional techniques of welfare economics, valuing outputs at world prices for traded goods and using shadow prices where appropriate.

It was found that the present value of the benefits of not proceeding with the project and its protection of the forest were 350 million FCFA (the local currency), mostly derived from timber harvesting, whereas the present value of the benefits of proceeding with the project and forest protection were 6850 million FCFA. Since this gives a difference of 6500 million FCFA, it was concluded that the project and protection of the forest was economically advantageous. This has led to the transfer of large sums of aid money to support the project. Figure 9.2 shows the main benefits in comparison with the benefits that could accrue from timber harvesting.

9.4.3 Comparison of Korup and Oban

A similar study to the Korup one was carried out in and around Oban National Park in Nigeria, just across the border from Korup (Ruitenbeek, 1990). As in the Korup study, a wide range of values was detected that might have been missed in a simpler, more traditional analysis. Figure 9.3 compares the net benefits of these two projects by looking at the sum of their conservation and timber values. As can be seen, in both cases, conservation is seen to be more economically beneficial than timber harvesting. It is possible that a combination of both strategies would be even more economically beneficial, but it has been felt that timber harvesting (under real-life rather than optimum conditions) was incompatible with some of the conservation values which may only accrue way into the future.

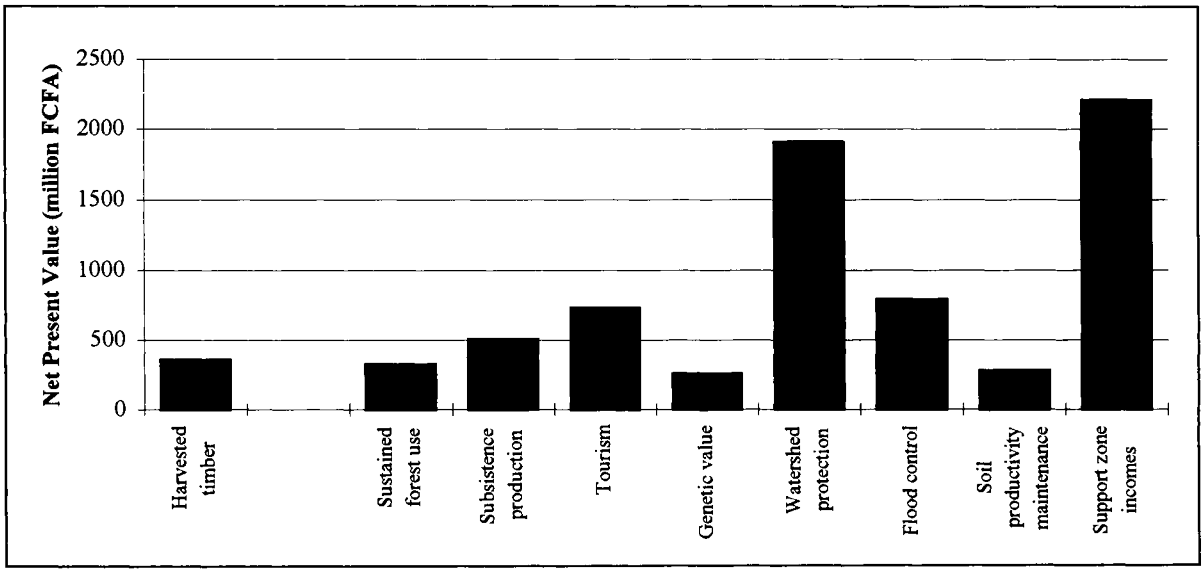


Figure 9.2. The economic value of harvesting timber (first column) compared with values accruing from the development of a conservation plan for Korup National Park, Cameroon, and its surroundings (remaining columns). After Ruitenbeek (1990).

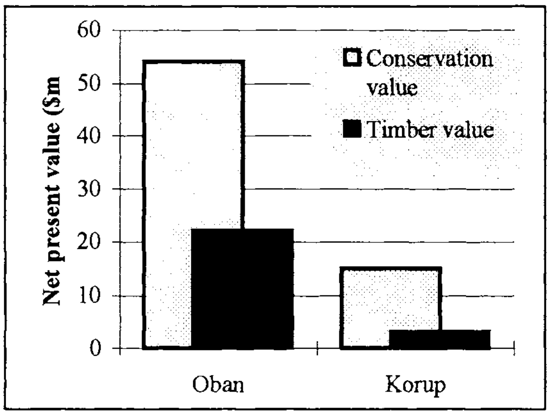


Figure 9.3. A comparison of the conservation and timber values of two conservation and development projects: Oban in Nigeria and Korup in Cameroon. After Ruitenbeek (1990).

Because of these studies, economic development plans in the region are being pursued in ways which complement the conservation goals of the parks. Rather than seeing the various goals as conflicting, the attitude has been that conservation can promote economic development. To this end, in Korup, a management area has been defined consisting of 126,000 ha of core park area plus a buffer zone of 300,000 ha around this core. In Oban, the management area consists of a 250,000 ha park and a 200,000 ha support zone (Ruitenbeek, 1990).

9.4.4 Measuring the value of shelter belt afforestation and farm forestry in Nigeria

When Anderson (1987) carried out an economic analysis of a forestry project in Northern Nigeria, he traced through some of the ecological linkages arising from afforestation of this sparsely-wooded part of the country. A more traditional analysis of tree-growing might identify the benefits as being the value of the tree products (fuelwood, poles and fruit), by multiplying the yield of each of these products by the market price. Anderson also added the following into the calculation:

- the increases in livestock weight brought about by improved dry season fodder;
- the avoided damage from desertification, measured by the difference in crop yields from soils with and without afforestation;
- improvements in yield due to the shelter belt's and farm forestry's effects on soil nutrient recycling and nutrient retention.

He found that, if only wood benefits are considered, then the internal rate of return of the shelter belt afforestation project would be under 5%, well below the 10% discount rate traditionally used in World Bank assessments. Such a project would probably not normally get funding. Once the wider benefits outlined above are included, however, the internal rate of return of shelter belt afforestation increased to between 13% and 17%. Similarly, that of farm forestry increased from about 7% to between 14% and 22%.

9.4.5 Measuring the value of gum arabic planting in Sudan

The gum arabic acacia (*Acacia senegal*) is widely tapped for its yield of polysaccharide gum which is exported throughout the world for use in confectionery, drinks and pharmaceuticals. In 1985, it was Sudan's third most valuable export. It also has many useful environmental qualities, which are easily overlooked by lending institutions and development organisations and even less easy to value. These include:

- its role in stabilising soil because it has a deep tap root and expansive lateral root system, and because it retains soil moisture;
- being leguminous, it fixes atmospheric nitrogen and encourages grass cover, assisting pasture growth;
- leaf and pod decomposition help supply nitrates to the soil, possibly increasing cereal yields by 15% when intercropped; and
- it is a useful source of fodder and fuelwood.

Pearce (1988) found that if fodder and fuelwood yields are allowed for, then the internal rate of return to gum arabic planting could reach 36%. Thus gum arabic can be recommended as a useful tool in anti-desertification projects.

9.4.6 Profitability of logging at different discount rates

Pearce (1987) compared the profitability of different logging systems in Indonesia using different discount rates. The discount rate has an important effect on profitability. He found that selective cutting of natural forest was the most profitable option at low discount rates, but that at higher rates, more intensive management systems were more profitable. There was, however, an upper limit in that the most intensive systems (plantations of fast-growing species for sawn timber) were never as profitable as management of the natural forest. Table 9.2 shows his findings.

Table 9.2. Profitability of different logging systems in Indonesia at different discount rates (Pearce, 1987)

Management regime	5% discount rate	6% discount rate	10% discount rate
Selective cutting regime	2705	2409	2177
Complete harvesting and regeneration	2690	2593	2553
Dipterocarp plantation		2746	2203
Plantations of fast-growing species for pulp		2926	2562
Plantations of fast-growing species for timber, harvested after 20 years		2419	2278
Plantations of fast-growing species for timber, harvested after 10 years		2165	2130

9.4.7 Some other studies

- Howard (1995) carried out a study of protected areas in Uganda, particularly forest reserves, and produced an economic analysis of protected areas management. The analyses had not been published at the time of writing this book, but should be in the near future.
- Peters, Gentry and Mendelsohn (1989), quoted in Word Bank (1994) and Sayer (1991), found during a study in a one-hectare plot in Amazonian Peru that over 41% of the trees yielded products with a market value. The net present value just of fruit production was $6330/ha, assuming that 25% of the fruit crop was left in the forest for regeneration, and a 5% discount rate. The same hectare also contained 93.8 cubic metres of merchantable timber. If liquidated in one felling, this lumber would generate a net revenue of $1000, but an operation of this intensity would damage much of the residual stand and greatly reduce future revenue from fruit and latex trees. If selective cutting were practised, the combined net present value of fruit, latex and selective cutting would be about $6820, with logging contributing only about 7% of the total. In this example, logging appears to be a marginal financial option, especially considering the possible impact of logging on fruit and latex trees. Note, however, that the study plot was only 30 km from a major market town, and that prices of forest products would probably be lower in parts of the forest further away from towns.
- Watson (1988) found that the conversion of tropical production forests in Malaysia for intensive cultivation resulted in a substantial net loss in value, from $2455/ha/yr to $217/ha/yr.
- Jonsson and Lindgren (1990) found that an improved logging system can reduce the total logging costs by 20%, and can reduce the wastage of valuable logs by 7%. In the improved system, mapping and planning increased the costs, as did better supervision, but this resulted in a 50% increase in extraction production, hence the overall decrease in costs relative to revenue. Meanwhile, directional felling and correct felling and bucking techniques further reduced wastage by 7%. This is good for profits, and good for conservation too.
- A study in Honduras found that the forests on the mountains above the capital city have a net present value of $13,300/ha, just for their role in water catchment. This was calculated on the basis of the cost of developing alternative sources of water for the city in the absence of this catchment forest.

9.5 SUMMARY

- Many environmentally harmful developments, including forest destruction and unsustainable exploitation, have been supported by traditional and often narrowly focused economic analyses.
- Welfare economics seeks to make the discipline of economics more socially and environmentally sustainable, by internalising the externalities.
- Cost-benefit analysis is one technique with many uses in conservation. It has many strengths, but also some weaknesses, particularly in how it seeks to monetarise everything and how it does not consider intra-generational equity.
- There are now numerous cases from around the world that demonstrate how economic analyses based on welfare economics can further conservation.
- In the final analysis, economics is only a tool to decision-making. Good economics will carry more weight than bad economics, but there may be other considerations, such as politics, which lie outside the scope of economics altogether.

9.6 FURTHER READING

Dixon, J.A. and Sherman, P.B. 1990. *Economics of protected areas: approaches and applications.* East-West Center, Washington, D.C.

FAO. 1994. Forest development and policy dilemmas. In: *The state of food and agriculture 1994.* FAO, Rome.

Howard, P.C. 1995. M.Sc. thesis, University of Edinburgh. Unpublished.

McNeely, J.A. 1988. *Economics and biological diversity: developing and using economic incentives to conserve biological resources.* IUCN, Gland.

Panayotou, T. and Ashton, P.S. 1992. *Not by timber alone: economics and ecology for sustaining tropical forests.* Island Press, Washington, D.C.

Pearce, D.W., Barbier, E.B. and Markandya, A. 1988. *Environmental economics and decision-making in sub-Saharan Africa.* 25 pp. IIED, London.

Ruitenbeek, H.J. 1990. *Economic analysis of tropical forest conservation initiatives: examples from West Africa.* WWF, Godalming.

Swanson, T.M. and Barbier, E.B. 1992. *Economics for the wilds: wildlife, wildlands, diversity and development.* Earthscan, London.

CHAPTER 10

FOREST ECOTOURISM AND NATURE CONSERVATION

CHAPTER OUTLINE

10.1 INTRODUCTION

A **tourist** can be defined as *a voluntary, temporary traveller, travelling in the expectation of pleasure for the novelty and change experienced on a relatively large and non-recurrent round-trip* (Lea, 1988). **Tourism** can be defined as *the practice of travelling for pleasure, together with the business of providing services for such travellers.* International tourism is mainly a phenomenon of the late twentieth century, and shows no signs of diminishing yet. In fact, tourism is growing at a rate of about 10% per year, meaning that the number of tourist trips is roughly doubling every seven or eight years.

Tourism exists in several forms. ***Mass tourism*** is the sort of tourism that goes for quantity rather than quality. In Africa it is characterised by the package tours offered in Kenya, whereby tourists spend a week on safari and then a week at a beach resort. These tours offer standardised services and prices that are affordable by very many tourists, so that overall it can be quite a profitable business. However, as well as being relatively low-value, it also tends to be high-impact, involving the development of large hotels, fleets of minibuses and so on.

These days, mass tourism is going out of fashion, as tourists become more discerning. ***Special interest tourism*** is therefore on the increase, at a rate of 10% to15% per year. This form of tourism aims to entice discerning tourists by catering for their specific demands, whether it be watching wildlife, playing golf, sailing, visiting museums and art collections or whatever. By doing so, the tourism business can charge relatively high prices for the services offered, so that as much money can be made from far fewer tourists. Theoretically, this form of tourism is high-value, low-impact, but it will only work if a business can offer a service that discerning tourists will pay for.

Ecotourism is a recently-coined word for a form of special interest tourism that also aims to be environmentally sustainable, that is, one of its aims (or by-products) is to meet the needs of the people and environment of the areas being visited without compromising the ability of future generations of those same areas to meet their own needs. Ecotourists seek pleasure from experiencing the natural environment at close quarters, without changing it significantly. Many are prepared to pay handsomely for the experience.

Ecotourism has really come about because of five phenomena:

- Dissatisfaction of many tourists with the standards of mass tourism.
- Dissatisfaction with materialism and other aspects of modern life in the rich countries.
- The greater awareness amongst tourists of their potential impact on receiving environments and societies.
- A greater desire by tourists to see for themselves some of the wildlife and natural

environments which they have seen on television or in magazines.
- Realisation by host countries that ecotourism has much to offer them, especially by countries for which mass tourism is not an option.

Ecotourists are not so bothered about sun, sea and sand; they are more interested in seeing and experiencing the natural world around them. Figure 10.1 illustrates the results of a survey of tourists on safari in Kenya, in which they were asked to asked to attribute the pleasure they gained from their experience to five main categories. Seeing, photographing and learning about the wildlife was the most important, while rest, relaxation and shopping were much less so.

Note, too, that these tourists got pleasure out of simply observing and learning. This may come as a surprise, since a people's culture is almost by definition the normal way of living for those people concerned. Locals do not pay to see locals. But if one comes from a different culture, it can be refreshing to observe and learn about how people live under another culture; tourists are willing to pay for that experience.

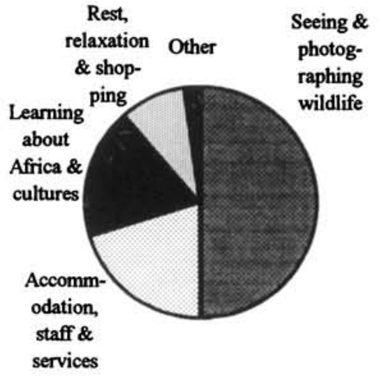


Figure 10.1. Results of a survey of tourists on safari in Kenya, in which tourists were asked to attribute their pleasure while on holiday to the five categories shown. After Brown and Henry (1989).

10.2 WHAT DOES UGANDA HAVE TO OFFER?

Uganda cannot offer the traditional trappings of mass tourism: it has no ocean beaches, and a relatively poorly-developed infrastructure making communication and travel rather difficult and at times uncomfortable. This is one reason why the number of tourists coming to Uganda has remained low compared to other countries. For example, in 1985, Uganda only received 14,000 international visitors, compared to nearly fifty times this number in Kenya. Although the number is rising, it is unlikely ever to reach the Kenyan levels.

Despite this, tourism does have the potential to be an important income-earner for Uganda, and other countries in Africa. In the 1960s, it was the third-largest earner of foreign exchange, and there is no reason why this should not be the case in the future. What Uganda can offer is access to a fascinating range of ecosystems, particularly forests, unrivalled by its neighbours. If we remember that ecotourists are looking for unspoilt beautiful scenery and tranquillity, and a richness of wildlife that they cannot see back home, then Uganda is a natural choice. Many will have seen television programmes about chimpanzees and monkeys, or about the fate of the tropical forests, or about the fabulous snowy mountains on the equator, or about hippos on the Nile or local fishermen on Lake Victoria, and will want to see these things for themselves. Many will like the idea of sleeping in a mud hut, and mingling with bare-footed but smiling children while perhaps buying locally made baskets or carvings. They may want to feel the warmth of the tropical sun, but many will also want to experience a tropical downpour. These are all things they cannot do in their own countries, and can readily do in Uganda. However, they will not want to abandon luxury completely, so being able to get clean water and to buy sodas and local meals is also important, as is personal health and security. That rules out some African countries, but not Uganda.

10.3 PROS AND CONS OF PROMOTING FOREST ECOTOURISM

There is no point in promoting ecotourism if it encourages environmental destruction, or worsens the socio-economic situation. Box 10.1 looks at the possible benefits of ecotourism at three levels: local, national and international. Against these, we need to weigh the potential negative impacts of ecotourism. Box 10.2 looks at some of these. In summary, ecotourism is not suitable for every situation, but certainly has a role to play in a country like Uganda.

Box 10.1
Some possible benefits of ecotourism

Local benefits

- Provides money for the local community, encouraging locals to conserve the forest in their own financial interest.
- Provides job and training opportunities for local people, leading to higher standards of living which are dependant on the conservation of the forest.
- Encourages local participation in forest management, while discouraging illegal or unsustainable forest activities that are incompatible with ecotourism, such as pit sawing and hunting.

National benefits

- Provides money for government, which increases the amount potentially available for bodies such as the Forest Department, and justifies creating and maintaining conservation areas. For example, ecotourism development in the Nyungwe Forest Reserve in Rwanda was, by the early 1990s, generating $15,000 annually for government coffers, which was more than sufficient for paying staff and upkeep of the reserve (Offutt, 1992). Mountain and forest walking in Kota Kinabalu National Park, Sabah (Malaysia), generates sufficient funds to cover the entire Sabah National Parks budget, while tourism revenue in Kenya is soon expected to cover the total cost of managing the country's parks and reserves (Lindberg and Hawkins, 1993). In 1975, the projected annual value of Murchison Falls National Park (south) was £1900/km^2, most of it from tourism, whereas the gross return from timber in Budongo was only £163/km^2 (Laws et al., 1975).
- Boosts the national economy, since tourists visiting the forests will spend as much or more money in other parts of the country. For example, gorilla-viewing in Rwanda earned the country about $1,000,000 annually from direct receipts, but probably ten times this when the full expenditure of those same tourists was taken into account (WCMC, 1992). Eleven per cent of the total value of exports from sub-Saharan Africa comes from tourism (Swanson, 1991). Tourism is now the world's largest employer, employing one in every 15 of the world's employees (WWF/IUCN, 1992).

International benefits

- Visitors will leave with a greater awareness of forests, conservation and the problems faced by local people, giving these subjects a higher profile in their countries of origin and helping to promote greater international awareness and, possibly, increased financial support from donor communities.

10.4 PLANNING FOR FOREST ECOTOURISM AT THE NATIONAL LEVEL

Saving nature by selling it is a risky business: if not well-planned then tourists can love nature to death. This is why forest ecotourism must be part of an overall framework for tourism development.

Uganda has recently produced a **Tourism Master Plan** (Abura-Ogwang, 1994). This emphasises that Uganda intends to promote special-interest tourism, and avoid some of the problems faced by countries that have relied on mass tourism. The plan makes particular mention of Uganda's forests as being one of the country's key attractions, especially as this is something that its East African neighbours cannot rival. In particular, the plan:

- encourages the development of ecotourism as a means of supporting conservation as well as communities adjacent to protected areas;
- advocates for close co-operation between the Forest Department and the Ministry of Tourism and Wildlife in planning and marketing the tourist attractions under the Forest Department's jurisdiction;
- recommends that the Forest Department is represented in the inter-ministry co-ordination committee concerned with tourism development in Uganda.

The Forest Department's own contribution (Sheppard, 1995) was still in draft form at the time of writing. The objectives of the Plan are as given in Box 10.3.

Box 10.2
Some of the possible adverse impacts of ecotourism

Impacts on the physical environment

- High expectations of tourists may mean that resources such as firewood and water are used unsustainably.
- Disposal of litter and waste may become a problem.
- Trampling and erosion may become a problem. This is already evident in the peat-bogs of the Rwenzoris.

Impacts on wildlife

- Animals may be disturbed by tourists, and become rarer as a result or more prone to predation or hunting.
- The behaviour of animals such as gorillas and chimps may become altered through over habituation. This has happened with gorillas in Zaire. It may increase the risk of disease transfer from humans to primates.
- Tourists may create a demand for animal or plant products from the forest, for food or souvenirs, which could easily become unsustainable.

Impacts on local communities

- There can be conflicts of culture between tourists and locals, which can lead to resentment on both sides.
- Tourism can increase the gap between rich and poor in the local community.
- The local community can become exploited by the demands of tourism, resulting in a change of lifestyle for the worse.
- The sudden influx of cash can lead to alcoholism and other social problems in the local community.
- If local people spend their new-found wealth on timber (for house-building) or on expanding their farms into the forest, then this can be a net loss for conservation.

Box 10.3
Objectives of ecotourism development in Uganda's Forest Reserves (Sheppard, 1995)

Main objectives

- To introduce recreational development as one aspect of sustainable resource use within gazetted Forest Reserves.
- To increase public awareness, both nationally and internationally, of the outstanding variety and beauty within Uganda's forests; to foster a general public understanding of the important relationship between environmental conservation and tourism, and the benefits to be derived therefrom.
- To ensure that recreational development is carried out in a sustainable and orderly fashion, through careful planning, monitoring and control, thus helping to safeguard the environmental quality and biodiversity of the forest resource.
- To involve the local community in the planning and management of tourism development, ensuring that their needs and ideas are incorporated.
- To generate benefits for the Forest Department and local communities.

Secondary objectives

- To promote an understanding of the long-term importance of the forest resource by introducing and implementing conservation education and extension to communities adjacent to the forest reserves.
- To provide rural employment to communities bordering forest reserves, as a basis for encouraging forest conservation at community level.
- To maximise economic returns from recreational developments by providing quality facilities and services.
- To create opportunities and a favourable climate for private sector investment.
- To devise an appropriate institutional structure for overall planning and policy co-ordination and for the allocation of implementation responsibilities.

PLANNING FOR FOREST ECOTOURISM IN INDIVIDUAL FORESTS

10.5.1 General planning guidelines

A list of Forest Reserves in Uganda where ecotourism could be promoted as a main objective is currently being drawn up. In each of these, specific tourism/recreation zones will be established, based partly on the biological inventory results (see Chapter 14) and partly on the tourism potential of different parts of the forest. Even in the forests with most tourism potential, it is unlikely that more than a small percentage of the forest will be zoned specifically for tourism.

The Forest Department's tourism policy (Sheppard, 1995) specifies that development for any particular forest reserve must be in line with a forest-specific **Tourism Development Plan**, which should detail:

- the type and level of tourism which is appropriate;
- the current level of tourism and services;
- all required infrastructure and services;
- what provisions for access are needed;
- which organisations are expected to be involved and what role they will play;
- what, if any, investment or local community involvement opportunities exist;
- design and construction plans for facilities;
- training and staffing requirements;
- any other local consideration.

All of these points require careful planning. It would be very easy to ruin the very resource that tourists would want to see, through uncontrolled development of tourism infrastructure. Box 10.4 outlines some of the guiding principles that can help to make ecotourism developments pleasant for their visitors and put the developments on a firm administrative footing. Developments such as these are already under way in Budongo, Kalinzu/Maramagambo and Mabira forests, as well as in several forested National Parks (Semliki, Elgon, Bwindi and Mgahinga).

10.5.2 A case study of forest ecotourism development: Budongo Forest

In Budongo Forest, tourism development started in 1992 (Herd and Langoya, 1994). The underlying aim of tourism development was to find a way for the forest to earn money for local communities and the government, while ensuring its conservation. Two areas were seen as being suitable for tourism development: Busingiro and Kaniyo-Pabidi (Figure 10.2).

Kaniyo-Pabidi was chosen because it represents one of the last remaining unlogged parts of the forest, and tourism was seen as a means of enabling the Forest Department to earn money from it without having to log it. In addition, it was thought to support the highest densities of chimpanzees in Budongo, presenting the possibility of developing special-interest chimpanzee-viewing. It also lies alongside the main road to Paraa in Murchison Falls National Park.

Busingiro was chosen partly because it too lies alongside a main road to or from Lake and Murchison Falls National Park. The forest has been logged, but is still rich in primates and birds and offers other attractions such as views over the forest and a small lake within the forest. An added advantage is that there are nearby local communities who stand to benefit from tourism development.

At each site, a **camp-site** has been constructed and various **forest trails** developed. The camp-sites are simple, consisting of a cleared area on the edge of the forest, with high-quality pit-latrines, cooking areas and thatched communal shelters. A **visitor centre** is planned for Busingiro.

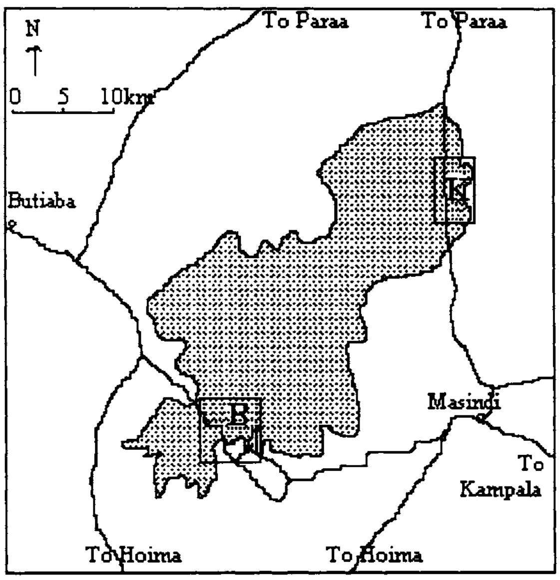


Figure 10.2. Map of Budongo Forest Reserve, Uganda (shaded area), and environs, showing location of the two tourism/recreation development zones. B = Busingiro; K = Kaniyo-Pabidi.

Box 10.4
Some guiding principles for the development of the physical and administrative infrastructure that may be necessary with forest ecotourism

Fees

- Specify fees clearly
- Make no exceptions
- Vary rates for locals, nationals and foreigners
- Give a concessionary rates for educational groups
- Set individual prices for forest entry, guided walks and camping
- Keep good records of income and expenditure
- Distribute profits between Forest Department and local community

Camp sites

- Use low visual impact design, with features adapted from local buildings
- Use local materials, contractors and labour for construction
- Use appropriate technology in the use of energy, water and sanitation
- Locate all permanent structures outside the Forest Reserve
- Maintain quiet and peaceful conditions
- Maintain a good access road
- Maintain security in parking and camping areas
- Provide a mixture of shade and sun
- Locate the site in a scenic location
- Ensure that there is clean and plentiful water
- Allow for privacy
- Keep the camp site clean
- Keep pests at bay (e.g. rats (keep rubbish out of reach), tsetse fly (possibly use traps), mosquitoes (no standing water for breeding)

Access

- Maintain clear signposts directing tourists to camp-sites and other features of interest
- Allow access into the forest only when accompanied by a guide
- Allow camping only in approved camp-sites

Trail systems

- Avoid water-courses and steep gradients to minimise erosion and silting
- Plan trails to be wide enough for two people to walk safely side-by-side, but no wider
- Avoid cutting timber trees
- Make sure trails are free of stumps, rocks etc.
- Avoid fragile areas
- Use board-walks over boggy ground
- Consider developing regularly laid out grid systems for tracking chimpanzees
- Develop gently meandering loop systems for general forest walks
- Make sure trails are clearly marked

Sanitation

- A simple V.I.P. pit latrine is suitable
- Make pit at least 7 m deep
- Locate pit at least 50 m from any water source
- Ensure latrine is cleaned daily
- Prohibit defecating in the forest
- Simple screened bucket showers are adequate, over a free-draining aggregate floor

Fuel supply

- Encourage the use of kerosene stoves or fuel-efficient stoves
- Encourage communal cooking
- Establish a source of fuelwood outside the Forest Reserve, such as a small plantation or on land belonging to local people, so that fuelwood can be sold to tourists

Refuse disposal

- Encourage tourists to take their rubbish away
- Prohibit dropping of litter in forest
- Bury biodegradable items
- Burn burnable items

In the case of Kaniyo-Pabidi, a **grid system of paths** has been established, enabling guided tourists to follow the chimpanzees through the forest without straying far from the path. At Busingiro, a series of **looped trails** have been cut, enabling guided tourists to choose walks of various lengths, without having to double back on themselves to complete their walk.

One of the most important aspects of the developments has been recruiting and training **guides** and other staff, all of whom have to be bright, pleasant, presentable and able to speak reasonable English. All have been recruited from the local communities. The guides have undergone several months of training, in order to ensure that they can interpret the forest for tourists.

For this they must know the names of trees and other plants, birds, mammals and other wildlife, and be able to tell interesting stories about them and about the forest generally, including how local people use the forest and how the forest is managed. The guides are being set up to operate as a co-operative, so that they share the profits from tourism and work together to maintain high standards.

Chimpanzee habituation is another time-consuming process, involving tracking the chimps daily and attempting to stay with them until they no longer see humans as a threat. This has taken over two years so far, and the process is not yet complete. Once it is complete, then small groups of tourists will be able to track the chimpanzees and observe them at close range, in return for their dollars, a potentially lucrative operation.

The project is now entering a second phase during which it is intended to involve the local community more in tourism-related activities (such as selling honey and handicrafts), and in a conservation education programme. Two local committees have been established, comprising people elected by and from the adjacent local communities. These committees are overseeing the development of project activities in their respective areas, and are developing a sense of "ownership" of the projects which is seen as very important for the long-term success of the work. The guides have been trained in participatory rural appraisal techniques, and, together with the project co-ordinators, have carried out baseline surveys in the surrounding communities to find out what development problems exist, what peoples' expectations are of the project, and how the project might be able to contribute to local development.

These developments cost money, and as yet the project is not self-sustaining, relying on funding from the EC Natural Forests Management and Conservation Project, from GTZ and from USAID, together with the input of a Forest Officer and a British volunteer. Ultimately, it is intended that revenue will exceed spending, at which time the profits will be shared between the guide co-operative, the Forest Department and the local community. Within a few years, annual revenue is expected to rise to at least UShs. 28,000,000 and possibly as much as UShs. 243,400,000, making tourism one of the major contributors to the local economy.

10.6 SUMMARY

- Tourism is growing rapidly worldwide.
- Ecotourism is growing particularly rapidly, as tourists increasingly demand a higher quality experience.
- Uganda has much to offer the ecotourist, especially its forests.
- Ecotourism is a means towards an end: promoting conservation through economic and local community development.
- Ecotourism development should progress in line with the national tourism policy and the policy of the Forest Department.
- At the forest level, development should be according to a tourism development plan.
- It is easy to make mistakes with ecotourism, so proceed slowly and carefully, and never lose sight of the objectives.
- If in doubt, consult widely.

10.7 FURTHER READING

Lea, J. 1988. *Tourism and development in the Third World.* Routledge, London. 88 pp.

Lindberg, G. and Hawkins, D.E. 1993. *Ecotourism: a guide for planners and managers.* The ecotourism society, Vermont.

Sheppard, S. 1995. *Recreation in Forest Reserves: objectives of the Forest Department.* Unpublished draft. Forest Department, Kampala. 185 pp.

WWF/IUCN. 1992. *Beyond the green horizon: a discussion paper on principles for sustainable tourism.* WWF/IUCN, Gland.

CHAPTER 11

FOREST POLICY, LAWS AND INTERNATIONAL AGREEMENTS RELEVANT TO NATURE CONSERVATION

CHAPTER OUTLINE

11.1 FOREST POLICY

11.1.1 Forest policy in Uganda

Forest policy in Uganda has a long history, not that much shorter than that of the Forest Department itself. Policies are established to keep management in line with the perceived long-term objectives of the state. As Kamugisha (1993) put it, policy is "*... a general statement of aims or desirable goals in relation to given circumstances. It is stated and approved by government...for use by the appropriate government institutions to guide all their activities...* ". Since forestry is by nature a long-term activity, the need for policy is particularly great in the forestry sector. Despite this, government objectives change over time, and this necessitates periodic revision of policy to bring management in line with the new objectives. Thus there have so far been three revisions of the original (1929) Uganda Forest Policy, to reflect changing objectives of forestry management. These are briefly outlined in Box 11.1.

11.1.2 Implications of the forest policy changes for conservation

The different policies reflect distinct changes in the perceived role of forestry in Uganda as the country has developed. These changes have had important implications for conservation within the Forest Department. The following paragraphs are partly based on Kamugisha (1993).

The **1929** policy was developed at a time when the state (in the form of the colonial power) was seeking to gain formal control over much of the land. The main justification for scheduling forest reserves was to ensure important water catchments were protected. This was a far-sighted policy in that it looked ahead to a time when those water-catchments might be threatened by increasing human cultivation or livestock grazing. Without it, many of the country's largest reserves, including many now recognised as being especially important for nature conservation, may never have come into existence. Timber production forests were also gazetted, since the main demand for timber was coming from the colonial authorities.

By the time of the first formal revision of the policy in **1948**, Uganda was beginning to change more rapidly: the human population was growing, and the empire was reeling from the effects of war which had put heavy demands on countries such as Uganda to produce sufficient timber for export. Likewise, there was a growing awareness of the importance of national economic development in the post-war era. The policy therefore re-emphasised some of the values of the 1928 policy, but fine-tuned it to stress the role of forests in national economic development and in environmental protection, hence the stated need to educate Ugandan foresters, the need for an effective extension service, and the need to acquire more land for planting new forests.

Box 11.1
The Forest Policies of Uganda (Kamugisha, 1993)

The 1929 Forest Policy

1. To retain as forest or reforest all areas of land, the retention of which as forest is considered necessary on climatic or other indirect grounds.
2. To meet, with due regard to vested rights, such of the demands of the population of Uganda as cannot be met by individual or local administration efforts.
3. To advise individuals and local native administrations in all matters concerning arboriculture and forestry.
4. In so far as it is consistent with the three proceeding objectives, to manage the state forests of Uganda so that they will give the best financial returns on the capital invested.

The 1948 Forest Policy

1. To create a permanent forest estate to protect water supplies, to preserve climatic and soil conditions suitable for agriculture, and to supply the needs of the people for forest produce.
2. To manage the forest estate to obtain the best returns consistent with these purposes.
3. To foster among the people of Uganda a real understanding of the value of forests.
4. To encourage sound forestry by local authorities and private enterprise and to train Ugandan foresters.

The 1971 Forest Policy

1. To reserve adequate land as forest estate so as to ensure:
   - sustained production of timber and forest products for the needs of the country and, where feasible, export;
   - protection of water catchments, soils, wildlife and amenity of land.
2. To develop that estate so as to obtain maximum economic return to the country.
3. To ensure efficient conversion of wood and wood products, so as to reduce waste.
4. To carry out extension services aimed at:
   - helping farmers, organisations and other people to grow and protect their own trees;
   - educating the public about the role of forestry and forest industries for their welfare;
   - advising industries and users of wood on suitability and availability of various uses.

The 1987 Forest Policy

1. **To maintain and safeguard enough forest land** so as to ensure that:
   - sufficient supplies of timber, fuel, pulp, paper and poles and other forest products are available in the long term for the needs of the country, and where feasible for export;
   - water supplies and soils are protected, plants and animals (including endangered ones) are conserved in natural ecosystems, and forests are also available for amenity and recreation.
2. **To manage the forest estate so as to optimise economic and environmental benefits** by ensuring that:
   - conversion of the resource into timber, charcoal, fuelwood, poles, pulp, paper etc. is carried out efficiently;
   - the forest estate is protected against encroachment, illegal tree cutting, pests, diseases and fire;
   - the harvesting of timber, charcoal, fuelwood, poles and other products applies appropriate silvicultural methods which ensure sustainable yields and preserves environmental services and biotic diversity;
   - research is undertaken to improve seed sources for planting stock and the silvicultural and protection methods needed to regenerate the forest and increase its growth and yield;
   - research is carried out into tourism and education, with the object of maximising their utilisation potential;
   - research is undertaken to monitor and promote the preservation of environmental services and conservation of biotic diversity.
3. **To promote an understanding of forests and trees** by:
   - establishing extension and research services aimed at helping farmers, organisations and individuals to grow and protect their own trees for timber, fuel and poles and to encourage agroforestry practices;
   - publicising suitability of various timber and wood products for domestic and industrial use;
   - publicising the importance of environmental services provided by forests;
   - holding open days to demonstrate working techniques and bring attention to the positive benefits of forestry.

Under this policy, some natural forest reserves were converted to plantation, in others logging intensified, sawmills flourished, and arboricidal refinement and other technical approaches to silviculture were encouraged. Other natural forests were cleared for agriculture, in the belief that this was a higher priority land-use than forestry in some well-wooded areas. So, although the policy was more planned and detailed, it gave relatively little emphasis to nature conservation other than the formal adoption of the principles of sustained yield in natural forest management.

By **1970**, economic development in Uganda was going on apace, a relatively affluent middle-class was emerging with a new set of values, and the forests were facing increasing demands. The policy emphasised how the state's forests could meet the demands of economic development and of the new consumer society, especially for timber but also for wildlife conservation and recreation, as well as the importance of encouraging tree-planting outside forest reserves. This is the first time that wildlife conservation gets a mention, in line with the new thinking internationally. However, international thinking also promoted the idea of forests as financial assets to be liquidated and reinvested in other sectors of the economy, and such a scheme fitted in well enough with Uganda's situation. But whatever the stated policy, the main emphasis of management thereafter was on extracting revenue, especially in the form of timber, with little regard for other policy objectives. In effect, the policy was made inoperable by the worsening political situation of the time. This was a mixed blessing for nature conservation: many sawmills closed down through lack of skilled staff or spare parts, thus preventing the planned liquidation of the timber resources, but at the same time control of the forest estate was insufficient to prevent massive encroachment and illegal pit sawing.

Following the abuses of the previous two decades, the **1987** policy revision sought to re-emphasise the role of forests in national development, in fulfilling basic human needs, and in environmental protection. This was also in line with international thinking on the role of forestry, and indeed was drawn up at a time of increasing international involvement in the Ugandan forestry sector. The policy emphasises for the first time the need to conserve biodiversity and rare species, and emphasises the need for more active protection of forest resources, for research in silviculture and tourism, for promotion of agroforestry, and an overall emphasis on environmentally sustainable forestry.

The present policy is still sometimes attacked by conservationists for being too complacent about the impacts of forestry on the nature conservation value of natural forests. Box 11.2 outlines points produced by Struhsaker (1987) as recommendations for a shake-up of the Forest Department to re-emphasise nature conservation. Note that they are included here **not as a statement of what should be done**, but as food for thought in the on-going debate about the role of forestry departments in countries such as Uganda. Some of the recommendations have since been fulfilled; others now seem irrelevant; others may yet be appropriate.

Box 11.2
Struhsaker's (1987) ideas on how forest policy in Uganda should evolve in order to be more environmentally sustainable and pro-conservation

1. Natural forests, both reserved and on public land, require greater protection. Most of the larger natural forest reserves are worthy of full protection against destructive exploitation, building on the Man and the Biosphere Reserve model.
2. Mechanised felling and sawmills should be restricted to man-made tree plantations destined for clear felling, but even here extreme caution must be exerted. When timber extraction from natural forests is deemed inevitable, carefully managed and supervised pit sawing is recommended.
3. Every effort should be made to develop alternative, non-destructive uses of the natural forests, such as tourism; harvesting of seeds for wild foods, medicinal and natural pesticide uses; and establishing tree plantations for wood and non-wood requirements; research standard; educational opportunities; and protection of free ecological services.
4. Planted woodlots and tree plantations should become the major sources of fuelwood, poles, and timber, acting as a protective buffer to the natural forests, leaving these for their unique values outlined above.
5. It is urged that reforestation be primarily through the private sector with a de-emphasis on government plantations and a major shift away from exotic trees in favour of indigenous species.

Box 11.2 continued

6. The roles of the government forest department require review with shifts in emphasis and responsibilities. It is proposed that this department be less concerned with managing tree plantations and exploiting natural forests for timber and charcoal. Their primary functions would be: (a) protection of natural forests; (b) research and development of non-destructive uses of natural forests; (c) extension service; and (d) research and development of more efficient use of wood.
7. Implementation of these role changes could be either through a major restructuring of the forest department and/or through a re-allocation of responsibilities with management of several of the large, natural forests being handed over to the Uganda National Parks.
8. International aid agencies wishing to assist Uganda in its forestry problems are urged to give greater consideration to (a) protection forestry; (b) alternative, non-destructive uses; (c) mass education; (d) reforestation through private woodlots; (e) energy conservation; (f) alternative energy sources; and (g) development programmes that are based on long-term ecological planning which are likely to continue beyond the period of direct assistance. Environmental impact statements and follow-up studies should comprise vital components of international assistance.

11.2 FOREST LAWS

11.2.1 Laws relating to forestry and conservation

Legislation is usually established to serve existing policies. When policies are changed, this may be followed by a change in the law. For a fuller summary of the various laws related to forestry and conservation, the reader should consult Kamugisha (1993) and Tukahirwa (1992). Box 11.3 lists some of them.

Box 11.3
Some of the laws that are relevant to forests and conservation in Uganda. From ODA (1992)

Note: There were well-advanced plans to revise the Forestry Act in 1995. 1995 also saw the addition to the statute books of the Environment Bill. Details were not available at the time of publication of this book.

Forests and plants

- Forest Act 1947
- Timber (Export) Act 1950
- Plant Protection Act 1937
- Prohibition of Burning Grass Decree 1974

Wildlife

- Game (Preservation and Control) Act 1959
- National Parks Act 1952
- Rabies Act
- Animals (Prevention of Cruelty) Act
- Animals (Straying) Act
- Cattle Grazing Act 1945
- Fish and Crocodiles Act 1951
- Trout Protection Act 1936

Health, pollution and others

- Public Health Act
- Factories Act
- Electricity Act
- Uganda Planning Commission Act
- Historical Monuments Act
- Penal Code Act

Water

- Water Works Act 1928
- Rivers Act
- National Water and Sewerage Corporation Decree
- Water Boards Act
- Inland Water Transport (Control) Act

Human Settlements

- Town and Country Planning Act 1948
- Urban Authorities Act
- Preservation of Amenities Act
- Reconstruction & Development Corp. Act 1981

Soils and land ownership

- Public Lands Act 1969
- Land Reform Decree 1975
- Soil Conservation (Non-African Land) Act 1958

Minerals

- Mining Act 1949

11.2.2 Details of some particularly relevant laws

There is not space here to go into details of all these laws, but let us take a closer look at a few key ones.

11.2.21 The Forests Act 1947 (revised 1949, 1950 and 1964)

Key components

- *Section 4: Declaration of forest reserves.* The Minister may declare any area to be a central forest reserve or a local forest reserve.
- *Section 12: Issue of licences.* The Chief Conservator (now Commissioner) or forest officers authorised may issue licences on the payment of prescribed fees for the cutting, taking, working or removal of forest produce from central forest reserves and open land.
- *Section 14: Prohibited acts.* 1) Subject to certain exemptions, no person shall cut, take, work or remove forest produce in or from a forest reserve, village forest or open land unless licensed to do so. 2) No person shall (a) clear, use or occupy any land in a forest reserve for (i) grazing, or (ii) camping, or (iii) fish farming, or (iv) the planting or cultivation of crops, or (v) the erection of buildings or enclosures, or (vi) recreational, commercial, residential or industrial purposes, or (b) construct or re-open any road, track or bridge in a forest reserve.
- *Section 15: Domestic use of forest produce.* Africans may in any forest reserve, village forest or open land cut and take for their own personal domestic use in reasonable quantities any forest produce which (a) is not declared by any such rules to be reserved forest produce, or (b) has not been planted by any person; provided that nothing in the Act or in any such rules shall operate so as to prohibit such cutting and taking, or so as to impose any fee on them.
- *Section 16: Protection against fire.* Prohibits any person from starting a fire in a forest reserve, either through negligence or deliberate action. This section makes provision for a forest officer to burn or authorise burning of fire-lines for the better protection of a forest reserve.
- *Section 17: Public to assist in extinguishing fires.* Members of the public living within a reasonable distance of any forest may be required to assist in averting or extinguishing any fire in such forest, or in securing property within the forest from loss or damage arising from fire or other natural causes. It is an offence for a person to refuse or fail to assist as required by a forest officer.
- *Section 18: Damage to forest produce.* Any person lawfully cutting or removing forest produce from any forest or open land shall take all necessary precautions to prevent damage to other forest produce.
- *Section 27 (1): Seizure.* Empowers any Forest Officer or Police Officer to seize and detail any forest produce; livestock; tools, boats, vehicles etc. which he/she suspects to be liable to be forfeited under this Act.
- *Section 29: Power of exemption.* The Minister may exempt any person or class of persons or any land or class of land from any or all of the provisions of this Act.

Interpretation and comments

Although the law provides for local and village forest reserves, the latter does not exist in practice, since all local forest reserves were brought under central administration in 1967.

Forest produce is defined as: *"trees, timber, firewood, poles, slabs, branchwood, wattles, withies, sawdust, charcoal, bark, fibres, resins, gum, latex, fruits and seeds; all honey, grass, litter, soil, stone, gravel or sand as originates in a forest and is not a mineral within the meaning of the Mining Act; and such other things as the Minister may by statutory instrument declare to be a forest product"*.

Section 15 does not offer any guidance of control in the extraction of forest produce for domestic use. *"Reasonable quantities"* is not defined, and has led to large-scale deforestation in forest areas adjacent to settled areas. According to Tukahirwa (1993), *"...such a general invitation for a population increasing at an annual rate of 3% is dangerous to forest conservation... "*.

The law does not provide any guidance or basis for the granting or refusal of a license. This omission may lead to exploitative actions without due consideration of the needs of conservation. No attempt or provision is made within the law to encourage people to provide their own fuelwood. Forest management laws also ignore the interaction between various natural resources, e.g., protection of water catchment, wildlife habitats, game etc.

Note: The Forests Act was due for a full revision in 1995, to reflect better the current forest policy.

11.2.22 The Game (Preservation and Control) Act (1959)

Key components

- *Section 5: Protection of certain animals against unauthorised hunting.* Hunting of all scheduled animals is not permitted, except in a few exceptional circumstances, specified below.
- *Section 8: Right of killing any animal in self-defence.* Any person may, without any special authorisation, kill any animal in self-defence, or defence of any other person.
- *Section 10: Restriction on sale, purchase or export of scheduled animals or trophies.* No person without a licence shall sell, purchase or export any scheduled animal or trophy.
- *Section 33: Right of landholder, etc., to kill animals harmful to property.* The occupier of any land or the owner of any crops or domestic animals may, without the need for authorisation, kill or capture any animal damaging crops or domestic animals. Snares and poisons are not to be used.
- *Section 35: Killing of scheduled animal under section 33 to be reported.* If a scheduled animal has been killed or captured under Section 33, the person killing, capturing or authorising the same must make a report to the nearest administrative officer or game warden, within seven days. Any scheduled animal killed or captured shall be the property of the government.

Scheduled animals include, amongst others, mountain gorilla, owls, colobus monkey and leopard. Lion and elephant are included in the list of animals not to be hunted or captured except under special permit.

Interpretation and comments

This act reverses the general criminal law presumption of innocence of a suspected offender. The person charged has the onus of proving that any animal or trophy was lawfully obtained, when charged with possession, selling, buying, transferring or exporting in contravention of the Act. Wide discretionary powers are given to the licensing officer, without corresponding guidance principles. The interaction between wildlife and other natural resources is ignored. Attempts have been made toward integration in appointment of a forest officer as 'Honorary Game Wardens', but the law is not explicit as to their role, duties and powers as such wardens.

The Act provides for the right of farmers to kill or capture any animal damaging crops or farmland, or in self-defence, and report the action to the nearest administrative officer or game warden, within seven days. However, such hunting is banned within protected areas such as Game Reserves and National Parks, unless licensed. A scheduled animal may be killed in self-defence, or in defence of another person.

11.2.3 The Public Lands Act (1969)

Key components

- *Section 26: Timber.* All trees on public land granted in freehold or leasehold by a controlling authority shall become the property of the person to whom the grant is made. The person to whom the public land is granted shall pay to the controlling authority such price as may be fixed by the controlling authority for any reserved trees within the meaning of the Forests Act.
- *Section 48: Saving for law relating to forests, minerals and National Parks.* Subject to the provisions of section 26, nothing in this act shall affect the operation in relation to public land of the law relating to forests, minerals, or National Parks.

11.2.4 The Land Reform Decree (1975)

Key components

- *Section 1: All land to be public land.* All land in Uganda shall be public land administered by the Commission in accordance with the public lands act.
- *Section 2: Abolition of tenures greater than freehold.* There shall be no interest in land, other than land held by the Commission, which is greater then a leasehold. All freeholds in land and any absolute ownership are converted into leaseholds.
- *Section 6: Unlawful occupation of land.* It is an offence to occupy land unlawfully. A person is an illegal occupant if they occupy land while having no grant of title to it.
- *Section 9: Definition of unused lands.* A piece of land is deemed to be unused if it is not occupied by customary tenure or developed substantially in fulfilment of the purposes for which any lease has been granted.

11.3 INTERNATIONAL AGREEMENTS

11.3.1 The scope of international agreements

Many human activities are becoming increasingly internationalised. There has been a corresponding increase in the number and scope of international agreements aimed at harmonising these activities. Although there is as yet no universally-accepted international law-court to make sure that signatories respect these agreements, they do nevertheless carry a lot of weight internationally, and most countries aim to respect them even if they do not always get round to incorporating the main points in their own national law.

Uganda is a signatory to many of these agreements. Some of those relating to forestry and conservation are listed in Box 11.4.

11.3.2 Details of some particularly relevant agreements

11.3.21 *United Nations Convention on Biological Diversity*

This agreement is one of the major outcomes from the UN Conference on Environment and Development, held in Rio de Janeiro, Brazil in 1992. The key objectives of the convention are to promote *the conservation of biological diversity, the sustainable use of its components and the fair and equitable sharing of the benefits arising out of the utilisation of genetic resources.*

Box 11.5 lists some of the articles particularly relevant to forestry and conservation.

11.3.22 The Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES)

This convention monitors and regulates the trade in species whose survival is thought to be jeopardised by international trade. About 34,000 species are listed on the three appendices so far. Species in Appendix I are those in which international trade is banned completely because they face extinction. Appendices II and III are for species whose international trade is regulated by a system of import and export permits.

Ugandan species that currently appear in Appendix I include mountain gorilla, elephant, cheetah, leopard and rhinoceros. Species in Appendix II include chimpanzee, crocodiles, lion, python and, since 1994, African plum *Prunus africana*, giant ground pangolin, long-tailed pangolin, turacos, and African grey parrot. An attempt was made in 1994 to add African mahoganies and African blackwood to Appendix II, but this failed.

Box 11.4
Some international agreements relating to forestry and conservation. Uganda is a signatory to all of these apart from the ITTA. After ITTO (1995) and IUCN (1993)

- United Nations Convention on Biological Diversity (1992)
- Convention on International Trade in Endangered Species of Wild Fauna and Flora (1975)
- Convention on the Protection of the World Cultural and Natural Heritage (1975)
- United Nations Framework Convention on Climate Change (1992)
- United Nations Convention to Combat Desertification in Those Countries Experiencing Serious Drought and/or Desertification (1994)
- United Nations Authoritative Statement of Principles for a Global Consensus on the Management, Conservation and Sustainable Development of All Types of Forests (1992)
- United Nations Agenda 21, Chapter 11: Combating Deforestation (1992)
- World Trade Organisation (1994)
- International Tropical Timber Agreement (ITTA) (1983/1994)
- Lomé IV Convention (1989)
- Convention on the Conservation of Wetlands of International Importance particularly for Birds (1975)
- African Convention on the Conservation of Nature and Natural Resources (1968)

Box 11.5
Some of the articles of the UN Convention on Biological Diversity that are particularly relevant to forestry and conservation (Glowka, Burhene-Guilmin and Synge, 1994)

Article 6b: Each contracting party shall, in accordance with its particular conditions and capabilities:
- integrate, as far as possible and as appropriate, the conservation and sustainable use of biological diversity into relevant sectoral or cross-sectoral plans, programmes and policies.

Article 7: Each contracting party shall, as far as possible and appropriate:
- identify components of biological diversity important for its conservation and sustainable use;
- monitor, through sampling and other techniques, the components of biological diversity identified in (a) above, paying particular attention to those requiring urgent conservation measures and those which offer the greatest potential for sustainable use;
- identify processes and categories of activities which have or are likely to have significant adverse impacts on the conservation and sustainable use of biological diversity, and monitor their effects through sampling techniques;
- maintain and organise data derived from identification and monitoring activities in (a) to (c) above.

Article 8: Each contracting party shall, as far as possible and appropriate:
- establish a system of protected areas or areas where special measures need to be taken to conserve biodiversity;
- develop, where necessary, guidelines for the selection, establishment and management of protected areas or areas where special measures need to be taken to conserve biological diversity;
- regulate or manage biological resources important for the conservation of biological diversity whether within or outside protected areas, with a view to ensuring their conservation and sustainable use;
- promote protection of ecosystems, habitats and maintenance of viable populations of species in natural surroundings;
- promote environmentally sound and sustainable development in areas adjacent to protected areas with a view to furthering protection of these areas;
- rehabilitate and restore degraded ecosystems and promote the recovery of threatened species through the development and implementation of plans or other management strategies;
- prevent the introduction of, control or eradicate those alien species which threaten ecosystems, habitats or species;
- endeavour to provide the conditions needed for compatibility between present uses and the conservation of biological diversity and the sustainable use of its components;
- subject to its national legislation, respect, preserve and maintain knowledge, innovations and practices of indigenous and local communities embodying traditional lifestyles relevant for the conservation and sustainable use of biological diversity and promote their wider application with the approval and involvement of the holders of such knowledge, innovations and practices and encourage the equitable sharing of the benefits arising from the utilisation of such knowledge, innovations and practices;
- develop or maintain necessary legislation and/or other regulatory provisions for the protection of threatened species;
- where a significant adverse effect on biological diversity has been determined, regulate or manage the relevant processes and categories of activities;
- co-operate in providing financial and other support for *in-situ* conservation, particularly to developing countries.

Article 10: Each contracting party shall, as far as possible and appropriate:
- integrate consideration of conservation and sustainable use of biological resources into national decision-making;
- adopt measures relating to the use of biological resources to avoid or minimise adverse impacts on biodiversity;
- protect and encourage customary use of biological resources in accordance with traditional cultural practices that are compatible with conservation or sustainable use requirements;
- support local populations to develop and implement remedial action in degraded areas where biological diversity has been reduced;
- encourage co-operation between its governmental authorities and its private sector in developing methods for sustainable use of biological resources.

Article 11: Each contracting party shall, as far as possible and appropriate:
- adopt economically and socially sound measures that act as incentives for the conservation and sustainable use of components of biological diversity.

Article 13: The contracting parties shall:
- promote and encourage understanding of the importance of, and the measures required for, conservation of biological diversity, as well as its propagation through media, and the inclusion of these topics in educational programmes.

Article 14: Each contracting party, as far as possible and as appropriate shall:
- introduce appropriate procedures requiring environmental impact assessment of its proposed projects that are likely to have significant adverse effects on biological diversity with a view to avoiding or minimising such effects and, where appropriate, allow for public participation in such procedures;
- introduce appropriate managements to ensure that the environmental consequences of its programmes and policies that are likely to have significant adverse impacts on biological diversity are duly taken into account.

11.3.23 Convention on the Protection of the World Cultural and Natural Heritage (World Heritage Convention)

This convention provides for designation of areas of "outstanding universal value" as World Heritage Sites. The principal aim is to foster international co-operation in safeguarding these important areas. Sites are nominated by the signatory nation, and evaluated by the International World Heritage Committee. There are now over 420 World Heritage Sites worldwide.

Ugandan sites on the World Heritage List are Queen Elizabeth, Bwindi Impenetrable and Rwenzori Mountains National Parks.

11.4 INTERNATIONAL FUNDING MECHANISMS

There is now a wide range of international funding mechanisms providing support for forestry and conservation in countries such as Uganda, sometimes as grants, other times as loans. Some prominent ones include:

- Global Environment Facility (World Bank, UNDP and UNEP)
- World Heritage Fund (UN World Heritage Committee)
- Wetlands Conservation Fund (under Ramsar Convention)
- International Tropical Timber Organisation (under the ITTA)
- Tropical Forestry Action Programme (World Bank, UNDP and World Resources Institute, through FAO)
- UNEP, UNESCO, UNFAO, UNDP
- World Bank/International Monetary Fund
- Multilateral and bilateral arrangements between the governments of two or more countries

Details of the Global Environment Facility, a particularly relevant funding mechanism for conservation, are given in Box 11.6.

Box 11.6
The Global Environment Facility

The GEF was established in 1990 as an experimental programme, co-ordinated by the World Bank, UNDP and UNEP, to disburse over a billion dollars over three years, in projects that addressed one or more of four environmental problems that were considered global priorities:

- Destruction of biological diversity
- Global warming
- Pollution of international waters
- Depletion of stratospheric ozone

The 40% share that was to be spent on biodiversity projects represents the largest commitment ever made to this issue by the international community. The second phase of the GEF, agreed in 1994/5 and now run from within the World Bank, increased the amount of money available for disbursement substantially. It is now seen as the main funding mechanism for the Biodiversity Convention.

The main project running in the field of biodiversity in Uganda has been the *Institutional Support for Biodiversity Conservation in Eastern Africa*, which has included several components, one of which, the Forest Department's biological inventory, has been particularly important for forest nature conservation (see Chapter 14).

11.5 SUMMARY

- Forest policy has a long history in Uganda. It has gone through many changes, reflecting changes in the way governments and societies have perceived the value of forests. Since 1987, the conservation of biodiversity has been one of the main policy objectives.
- Policies are generally backed up by laws. In Uganda, there are numerous laws that refer to the environment, forests and conservation, but none that yet bring all the strands together. The new Environment Bill and the proposed revision of the Forests Act should fill this role.
- Even without these new laws, there is much in the existing legislation to provide for good forest management and conservation; the problem is in enforcing the laws.
- International agreements concerned with forestry and conservation are proliferating. Many came out of the UNCED process in Rio in 1992, in particular the Biodiversity Convention. However, a long-awaited Forests Convention failed to materialise.
- International funding is increasingly being directed through organisations associated with these agreements. Particularly important for biodiversity conservation is the GEF.

11.6 FURTHER READING

Glowska, L., Burhene-Guilmin, F. and Synge, H. 1994. *A guide to the conservation of biological diversity*. IUCN, Gland. 161 pp.

Kamugisha, J.R. 1993. *Management of natural resources and environment in Uganda: policy and legislation landmarks, 1890-1990.* Regional Soil Conservation Unit, Nairobi: 100 pp.

Klemm, C. de and Shine, C. 1993. *Biological diversity conservation and the law: legal mechanisms for conserving species and ecosystems.* IUCN, Gland. 292 pp.

ODA. 1992. *Environmental synopsis of Uganda.* IIED, London. 27 pp.

Tukahirwa, E.M. 1992. *Uganda: environmental and natural resource management policy and law: issues and options.* Makerere University, Kampala.

CHAPTER 12

THE ROLE OF PROTECTED AREAS IN NATURE CONSERVATION

CHAPTER OUTLINE

12.1 AN OVERVIEW OF PROTECTED AREAS

12.1.1 What are protected areas?

Protected areas are ***areas of land and/or sea especially dedicated to the protection and maintenance of biological diversity, and of natural and associated cultural resources, and managed through legal or other effective means*** (IUCN, 1994). Not all protected areas are preservation areas: some allow for extraction of certain renewable resources such as timber, while others allow for multiple use by a whole range of user groups. But whatever the details of management, the main purposes of management of protected areas generally include one or more of the following (IUCN, 1994):

- scientific research;
- wilderness protection;
- preservation of species and genetic diversity;
- maintenance of environmental services;
- education;
- tourism and recreation;
- protection of specific natural and cultural features;
- maintenance of cultural and traditional attributes;
- sustainable use of resources from ecosystems.

There are several categories that are widely recognised internationally, such as National Park, Game Reserve and Forest Reserve. But the management objectives of these areas can differ from country to country. In some countries, a Forest Reserve is managed only for timber production with no allowance for use by local people, while in others the same name might refer to an area specifically established for use by locals.

To get around this problem of nomenclature, IUCN has devised a set of international categories, into which all national categories can be fitted. Box 12.1 lists these in order of decreasing emphasis on preservation of nature (Makombe, 1994). Note that the basis of categorisation is by primary management objective: other activities may also be compatible with the primary objective. Under this classification, most natural Forest Reserves in Uganda are theoretically managed according to the principles under Category VI: *Managed Resource Protected Area*, whereas National Parks fit in Category II and Game Reserves probably fit in Category IV. But the strict nature reserves within some Forest Reserves fit into Category I.

12.1.2 Biosphere reserves and buffer zones

It is now widely recognised that conservation goes hand-in-hand with sustainable development: both processes should benefit from each other. A logical conclusion of this is that, if we want protected areas to work for nature conservation, then they should also be seen to be providing benefits for society. In many parts of the world, including Uganda, the future of many conservation areas depends on the attitudes of people living near to these areas. Alienating them from the protected area may make the conservation situation worse, not better.

Box 12.1
IUCN Protected Area categories (Makombe, 1994)

Category I: Strict Nature Reserve/Wilderness Area: protected areas managed mainly for science or wilderness protection. Either (1a) areas of land and/or sea possessing some outstanding or representative ecosystems, geological or physiological features and/or species, available primarily for scientific research and/or environmental monitoring (strict nature reserves); or (1b) large areas of unmodified or slightly modified land, and/or sea, retaining their natural character and influence, without permanent or significant habitation, which are protected and managed so as to preserve their natural condition (wilderness areas).

Objectives: Strict Nature Reserve

- to preserve habitats, ecosystems and species in as undisturbed a state as possible;
- to maintain genetic resources in a dynamic and evolutionary state;
- to maintain established ecological processes;
- to safeguard structural landscape features or rock exposures;
- to secure examples of the natural environment for scientific studies, environmental monitoring and education, including baseline areas from which all avoidable access is excluded;
- to minimise disturbance by careful planning and execution of research and other approved activities;
- to limit public access.

Objectives: Wilderness Area

- to ensure that future generations have the opportunity to experience understanding and enjoyment of areas that have been largely undisturbed by human action over a long period of time;
- to maintain the essential natural attributes and qualities of the environment over the long term;
- to provide for public access at levels and of a type which will serve best the physical and spiritual well-being of visitors and maintain the wilderness qualities of the area for present and future generations;
- to enable indigenous human communities living at low density and in balance with the available resources to maintain their lifestyle.

Category II: National Park: protected areas managed mainly for ecosystem conservation and recreation. Natural areas of land and/or sea, designated to (a) protect the ecological integrity of one or more ecosystems for this and future generations, (b) exclude exploitation or occupation inimical to the purposes of designation of the area and (c) provide a foundation for spiritual, scientific, educational, recreational and visitor opportunities, all of which must be environmentally and culturally compatible.

Objectives

- to protect natural and scenic areas of national and international significance for spiritual, scientific, educational, recreational or tourist potential;
- to perpetuate, in as natural a state as possible, representative examples of physiographic regions, biotic communities, genetic resources, and species, to provide ecological stability and diversity;
- to manage visitor use for inspirational, educational, cultural and recreational purposes at a level which will maintain the area in a natural or near natural state;
- to eliminate and thereafter prevent exploitation or occupation inimical to the purposes of designation;
- to maintain respect for the ecological, geomorphologic, sacred or aesthetic attributes which warranted designation;
- to take into account the needs of indigenous people, including subsistence resource use, in so far as these will not adversely affect the other objectives of management.

Category III: Natural Monument: protected areas managed mainly for conservation of specific features. Areas containing one, or more, specific natural or natural/cultural feature which is of outstanding or unique value because of its inherent rarity, representative or aesthetic qualities or cultural significance.

Objectives

- to protect or preserve in perpetuity specific outstanding natural features because of their natural significance, unique or representational quality, and/or spiritual connotations;
- consistent with the foregoing, to provide opportunities for research, education, interpretation and public appreciation;
- to eliminate and thereafter prevent exploitation or occupation inimical to the purpose of designation;
- to deliver to any resident population such benefits as are consistent with the other objectives of management.

Box 12.1 continued

Category IV: Habitat/Species Management Area: protected areas managed mainly for conservation through management intervention. Areas of land and/or sea subject to active intervention for management purposes so as to ensure the maintenance of habitats and/or to meet the requirements of specific species.

Objectives

- to secure and maintain the habitat conditions necessary to protect significant species, groups of species, biotic communities or physical features of the environment where these require specific human manipulation for optimum management;
- to facilitate scientific research and environmental monitoring as primary activities associated with sustainable resource management;
- to develop limited areas for public education and appreciation of the characteristics of the habitats concerned and of the work of wildlife management;
- to eliminate and thereafter prevent exploitation or occupation inimical to the purposes of designation;
- to deliver such benefits to people living within the designated area as are consistent with the other objectives of management.

Category V: Protected Landscape/Seascape: protected areas managed mainly for landscape/seascape conservation and recreation. Areas of land, with coast and sea as appropriate, where the interaction of people and nature over time has produced an area of distinct character with significant aesthetic, cultural and/or ecological value, and often with high biological diversity. Safeguarding the integrity of this traditional interaction is vital to the protection, maintenance and evolution of such an area.

Objectives

- to maintain the harmonious interaction of nature and culture through the protection of landscape and/or seascape and the continuation of traditional land uses, building practices and social and cultural manifestations;
- to support lifestyles and economic activities which are in harmony with nature and the preservation of the social and cultural fabric of the communities concerned;
- to maintain the diversity of landscape and habitat, and of associated species and ecosystems;
- to eliminate where necessary, and thereafter prevent, land uses and activities which are inappropriate in scale and/or character;
- to provide opportunities for public enjoyment through recreation and tourism appropriate in type and scale to the essential qualities of the areas;
- to encourage scientific and educational activities which will contribute to the long term well-being of resident populations and to the development of public support for the environmental protection of such areas;
- to bring benefits to, and contribute to the welfare of, the local community through the provision of natural products (such as forest and fisheries products) and services (such as clean water or income derived from sustainable forms of tourism).

Category VI: Managed Resource Protected Area: protected areas managed mainly for the sustainable use of natural ecosystems. Areas containing predominantly unmodified natural systems, managed to ensure long term protection and maintenance of biological diversity, while providing at the same time a sustainable flow of natural products and services to meet community needs.

Objectives

- to protect and maintain the biological diversity and other natural values of the area in the long term;
- to promote sound management practices for sustainable production purposes;
- to protect the natural resource base from being alienated for other land-use purposes that would be detrimental to the area's biological diversity;
- to contribute to regional and national development.

On the other hand, many species cannot tolerate much human disturbance, even if the level of disturbance is low. If they are to survive, they must have areas free of any disturbance. So allowing people increasing access to and use of a protected area tends to make them more inclined to accept the presence and protected status of that area, but at the same time, increasing human use can degrade the ecosystem, even if it only affects a few species at first. How do we resolve this apparent dilemma?

One solution is to develop protected areas according to the model of **biosphere reserves**. These are protected areas recognised as being internationally important under the UNESCO Man and Biosphere Programme (UNESCO/UNEP, 1984). Inclusion of a protected area on the UNESCO list gives it international recognition, but even for areas that will never make the list, the concept of a biosphere reserve is useful. In fact, in Uganda, only Queen Elizabeth National Park is officially designated as a UNESCO biosphere reserve.

Biosphere reserves ideally consist of a strictly protected **core** zone comprising a relatively intact natural ecosystem, surrounded by a **buffer** area (Sayer, 1991). The use of the word "buffer" has led to some confusion. In a UNESCO biosphere reserve, the buffer can be *outside* the main protected area, in which case the buffer can contain settlements and agricultural activities. In other cases, the buffer consists of a zone *within* the overall protected area, in which case such activities would not normally be permitted, but certain others might be. In either case, the idea is to surround a core preservation area with one or more zones where sustainable development will be encouraged, involving various activities that are compatible with preservation of the core area. Those activities that are most compatible with preservation should be permitted in the zone nearest the core area, while those that are less compatible should be permitted, if at all, in a zone a bit further from the core area.

Figure 12.1 illustrates the conceptual arrangement of zones that could make up a biosphere reserve. We will go on to consider how this might be adapted to natural Forest Reserves with a high nature conservation value in Chapter 15.

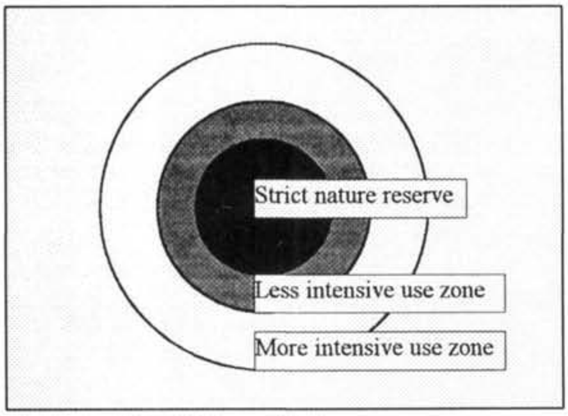


Figure 12.1. Possible management zones in a biosphere reserve. After Howard (1991).

12.1.3 The growth of the protected areas network

Many cultures worldwide have traditionally given some sort of protection to certain areas, particularly forests, often for cultural or religious reasons. But the formal designation of protected areas did not really begin until the last century. In Uganda, the first Forest Reserves were designated in the 1930s, and other protected area categories have followed since. No new areas have been designated recently. Globally, the protected areas network continues to expand, as Figure12.2 shows. However, certain ecosystems seem to have been getting rather better protection than others.

Within Africa, savannah ecosystems have received far more attention, because they support some very obvious and "charismatic" species of wildlife. Africa's forests have generally fared far worse, as Figure 12.3 demonstrates. By 1990, about 7% of Africa's savannah lands had been gazetted as protected areas, but only 3% of the natural forests (Sayer et al., 1992). This makes Uganda's Forest Reserve network all the more important.

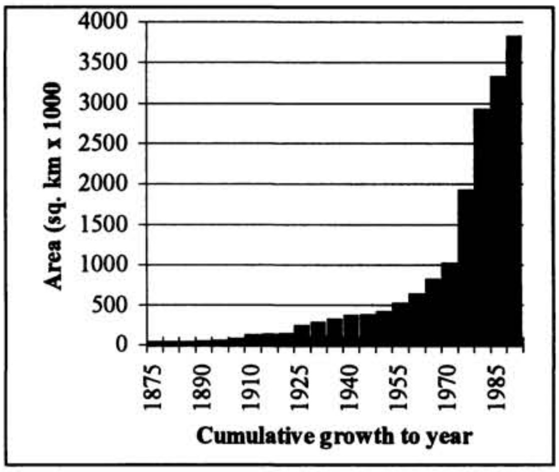


Figure 12.2. The growth of the world's protected areas network. After WCMC (1992).

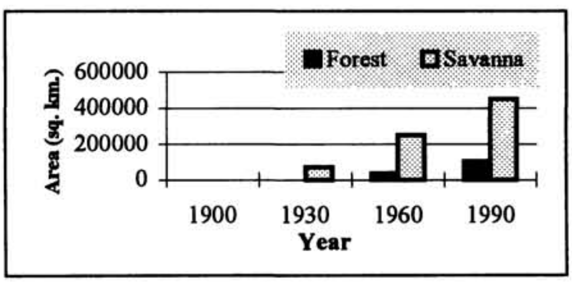


Figure 12.3. The uneven growth of the protected areas network in Africa. After Sayer et al. (1992).

12.2 PROTECTED AREAS IN UGANDA

The main categories of protected area in Uganda are Forest Reserve, National Park, Game Reserve, Game Sanctuary and Controlled Hunting Area. Table 12.1 gives some information on their functions.

It has proved difficult (and in some cases impossible) to get definitive figures for the size or even the number of Uganda's protected areas. This is partly because some are known by more than one name, have recently changed status, or have dual status, or partial dual status. Consulting different publications gives different answers.

The list of Forest Reserves of Uganda, given in Appendix 1, is complete as far as is known. Protected areas in the other categories are summarised in Box 12.2. Figure 12.4 attempts to show the location of all the protected areas in Uganda.

To date, just over 15% of Uganda's land area is gazetted as either Forest Reserve, National Park or Game Reserve, as Figure 12.5 demonstrates. Forest Reserves still make up the largest part of the protected areas network, both in area, in the diversity of ecosystems represented, and in the number of sites.

Since these reserves include many of Uganda's most important areas for nature conservation, this makes the Forest Department the primary custodian of Uganda's extraordinary wealth of plant and animal life. Despite this, the network in Uganda is still incomplete. According to NEAP (1992), some 40% of the vegetation types of Uganda recognised by Langdale-Brown et al.(1964), particularly various woodlands, scrublands and wetlands, are still not well represented in the protected areas network.

Table 12.1. The main categories of protected area in Uganda and their functions

Category	Authority	Management objectives	Permitted activities	Prohibited activities
Forest Reserve	Forest Department	• Ensure sustained yield of forest products for the nation, including local people • Protect plants and animals, including endangered ones	• Licensed cutting, taking, working and removal of forest produce • Collection of non-timber forest products by local people for personal use • Tourism with approved guide • Research • Educational use	• Human settlement • Cultivation • Grazing • Construction of roads or buildings • Hunting
National Park	National Parks	• Protect natural and scenic areas of international importance • Provide for recreational, educational and scientific use	• Controlled tourism • Research • Educational use • Some local use by license-holders in some parks	• Uncontrolled access • Human settlement • Cultivation • Grazing • Hunting
Game Reserve	Game Department	• Protect animals from hunting and encroachment of their habitat • Buffer National Parks from encroachment	• Tourism • Research • Licensed hunting	• Uncontrolled access • Human settlement • Cultivation • Grazing • Unlicensed hunting
Game Sanctuary	Game Department	• Protect endangered species of animals	• Human settlement • Cultivation • Grazing • Licensed hunting	• Unlicensed hunting
Controlled Hunting Area	Game Department	• Protect animals from hunting	• Human settlement • Cultivation • Grazing • Licensed hunting	• Unlicensed hunting

Box 12.2
Protected areas in Uganda (other than Forest Reserves). Data mostly from NEAP (1992). Figures in brackets refer to area in square kilometres

National Parks	Game Reserves	Game Sanctuaries	Controlled Hunting Areas
Bwindi/Impenetr. (321)	Ajai (158)	Dufile (10)	Buhuka (228)
Kibale (560)	Bokora Corridor (2034)	Entebbe (51)	East Madi (900)
Kidepo Valley (1400)	Bugungu (748)	Jinja (33)	Kaiso-Tonya (830)
Lake Mburo (264)	Karuma (713)	Kazinga (22)	Karamoja (18773)
Mgahinga Gorilla (25)	Katonga (207)	Malawa (8)	Karuma (18)
Mount Elgon (1145)	Kibale F. Corridor (339)	Mount Kei (452)	Katonga (2269)
Murchison Falls (3900)	Kigezi (328)	Otze Forest (204)	Lipan (241)
Queen Elizabeth (1978)	Kyambura (165)		Napak (?)
Rwenzori (997)	Matheniko (2587)		Sebei (?)
Semliki (212)	Pian Upe (2287)		Semliki (504)
	Toro (549)		Teso (227)
			West Madi (1752)

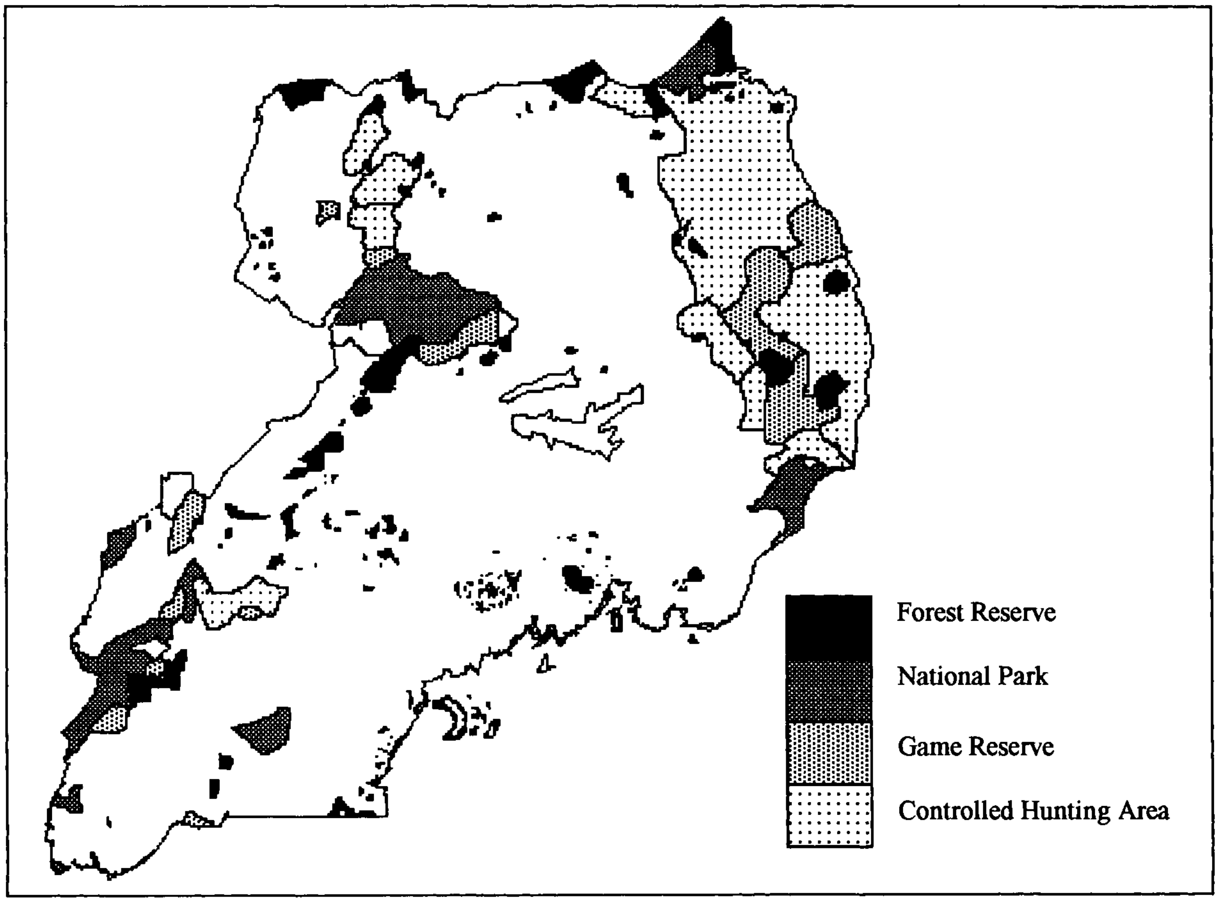


Figure 12.4. The protected areas of Uganda. Note that some areas have dual status, although on the map Forest Reserves within National Parks, or Game Reserves within Forest Reserves, are not depicted. Partly after Kamugisha (1993).

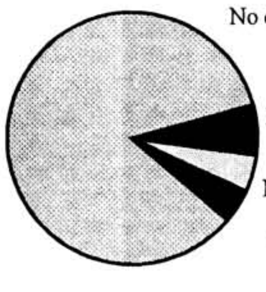


Figure 12.5. Protected areas in Uganda as a proportion of the total land area. Game Sanctuaries and Controlled Hunting Areas have been excluded, because in practice they receive virtually no protection. From various sources.

Some people might argue that "locking up" so much land is unethical in a country with high population growth like Uganda, especially since so many people are dependent on the land for their survival. However, quite apart from the argument that protected areas are more valuable as they are than if they were converted (see Chapter 9), it should also be clear that, with population growth at nearly three per cent per year, it would not take many years for the "extra" land within protected areas to be completely settled. In fact, the effect would be so short-lived that after less than seven years, the human population would have grown by more than enough to replace completely all the protected areas with cultivation, and then Uganda would be back to where it was, except with more people and none of the benefits of the protected areas that exist today.

12.3 ISLAND BIOGEOGRAPHY AND THE DESIGN OF PROTECTED AREAS

12.3.1 The theory of island biogeography

Protected areas are the fundamental units of nature conservation. The main question that concerns us here is, how can we make sure that protected areas are designed to achieve the best results for conservation while minimising conflict with other potential legitimate land-uses?

When considering these questions, it is useful to bare in mind the ideas that make up the theory of **island biogeography** (MacArthur and Wilson, 1967). In brief, the theory states that ***the number of species able to survive long-term in a given area is a function of the balance or equilibrium between the rate at which species can colonise the area in question and the rate at which species become extinct in that area***. The reference to islands stems from the original analyses that looked at differences in species richness on oceanic islands of different sizes and distances from the mainland (the presumed source of colonising species). It was found that:

- smaller islands have fewer species than larger ones, regardless of the distance from the mainland;
- more distant islands have fewer species than nearer ones, regardless of size.

This is because an increase in distance from source of colonists lowers the immigration rate (because few species can colonise over long distances), while an increase in island area lowers the extinction rate (because more species can coexist).

12.3.2 Species-area curves and the effects of ecosystem loss or fragmentation

The observation that small islands have fewer species than larger ones has been found to be true for very many ecosystems, and not just for oceanic islands. In theory, any ecosystem that is surrounded by a different sort of ecosystem or ecosystems can be considered to function a bit like an island. Something like a forested mountain-top surrounded by lowland savannah is an obvious example.

The concept can even be extended to isolated patches of forest in an "ocean" of agricultural land. The general relationship takes the form of a curve, referred to as a *species-area curve*. Figure 12.6 is an example of a species-area curve, based on the cumulative number of tree species recorded in mixed forest in Budongo. Note that the larger the area sampled, the more species there appear to be, but that after a while further sampling hardly leads to the recording of any further species. In general, the larger the area of a given ecosystem, the more species it is likely to support, but beyond a certain size it does not make much difference how large the area is. In practice, protected areas are seldom big enough for species-area curves to be completely levelling off to a plateau for all groups of plants and animals.

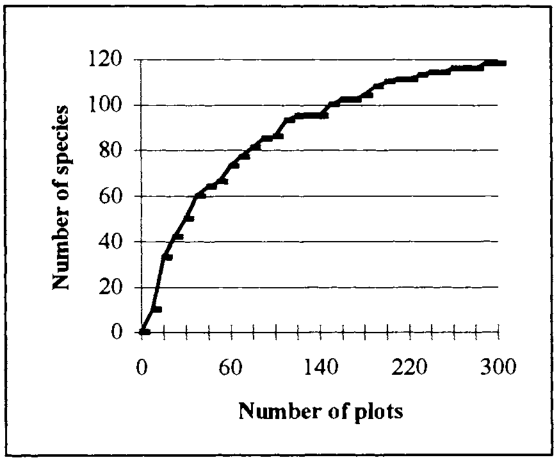


Figure 12.6. A species-area curve for tree species in mixed forest in Budongo Forest, Uganda. Redrawn from Plumptre et al. (1994).

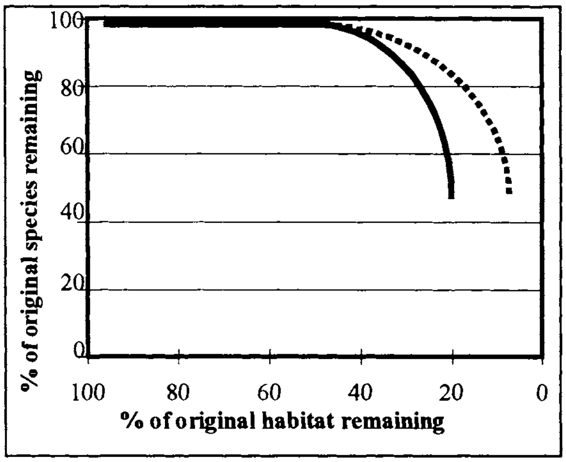


Figure 12.7. The effect of ecosystem loss or fragmentation on the number of species able to survive long-term. The vertical axis shows the proportion of the original species pool remaining. Two extremes are plotted: one for a group of species that requires a large area and has poor powers of dispersal (solid line) and a second for a group that requires smaller areas and has better powers of dispersal. After Wilcove et al. (1986).

The theory makes another important prediction for nature conservation: if the area of an ecosystem is reduced artificially (for example, deforestation, or the expansion of logging into undisturbed forest), or if the ecosystem becomes progressively more isolated from other fragments of the same ecosystem type (e.g. forest fragmentation) then the number of species that can continue to exist in that area will decline. Species will start to go extinct, one by one, until a new equilibrium point is reached as dictated by the size and degree of isolation of the remaining ecosystem fragment. This is like drawing the species-area curve on its side (Figure 12.7). Several studies have now shown this prediction to be observable. The general relationship is that "specialist" species, with narrow ecological niches and/or poor powers of dispersal, go extinct first, followed eventually by the "generalist" species that have broad ecological niches and/or good powers of dispersal.

Forest Reserves and other forested protected areas in Uganda represent a small fraction of the original natural forest cover in the country (see Chapter 1). This means that, if the predictions of island biogeography are correct, we will have already lost and will continue to lose species from the forest. Two examples that seem to bare this out are elephants and chimpanzees. Elephants used to occur over the whole of Uganda, but they require such large areas that there are few forests that still support them. As elephants die out, so too will species dependent on them for dispersal (including several tree species: see Section 5.6.32), and then the species dependent on those species, and so on. Chimpanzees probably once occurred throughout the forests of western Uganda, but are now confined to a handful of the larger reserves.

As ecosystems have a certain amount of in-built inertia, they take time to respond to changes, so even if the area of forest does not decline further we should still expect to lose more species from past declines.

The reason that species go extinct is related to how much habitat individuals of that species require for their survival. But on top of this, current thinking is that it is no use reserving enough habitat for just a few individuals of a species, because sooner or later the population will become in-bred or will become extinct due to chance events, disease and so on. We really need to look at the concept of ***minimum viable populations***. For most species, a working figure of 500 breeding individuals, or 250 breeding pairs, is seen as a minimum population size to ensure long-term survival in any one area. Some examples of estimates of minimum areas needed to support minimum viable populations of certain species are given below:

- Tropical forest trees (natural population density 1/ha): 5 km^2;
- Leaf beetles (natural population density $1/m^2$): 0.0005 km^2;
- Chimpanzees (natural population density $1\text{-}2/km^2$): 125-250 km^2;
- Northern spotted owl (USA) (natural population density 1 pair/9 km^2): 2,250 km^2;
- Brown hyena (Namibia) (natural population density 1 pair/250 km^2): 62,500 km^2.

Thus most forest reserves or nature reserves are large enough to ensure the survival of most tropical forest trees and leaf beetles in Uganda (assuming they are managed well), but few will be able to support chimpanzees in the long term. Leopards are likely to require even larger reserves than the Northern spotted owl (a bird confined to old-growth forest fragments in the NW USA), which means that perhaps none of Uganda's forest reserves or other protected areas are large enough for the long-term survival of this species. Leopards do currently exist in a number of forests, but their future is uncertain, unless they can also effectively occupy the land that lies between the forests, alongside humans. Figure 12.8 is a schematic representation of how the fragmentation process may affect a forest as human population pressure increases.

Soulé et al. (1979) carried out a study of several national parks in East Africa, and predicted that each of them would suffer a "***faunal collapse***" amongst the large mammals as they become more and more isolated in a sea of farmland. The collapse is partly attributed to the interdependence of species, such that if one goes extinct, others will automatically follow. The study predicted that a park such as Murchison Falls would lose 50% to 65% of its currently extant large mammal species over the next 3,000 years or so, and would not reach equilibrium until perhaps 5,000 years from now, by which time up to 75% of the original species would have gone extinct.

Since the study, at least one species (the white rhino) has gone extinct there. There is no reason to suppose that other species will not also go extinct there, or that forest reserves will be immune to the same effects. Indeed, recent studies by Dranzoa (Howard, pers. comm. 1994a) suggest that some of the bird species found in Zika Forest (a small patch of remnant forest on the Entebbe peninsula) in the 1960s are no longer present, probably because the forest is now too small to support them in the long term.

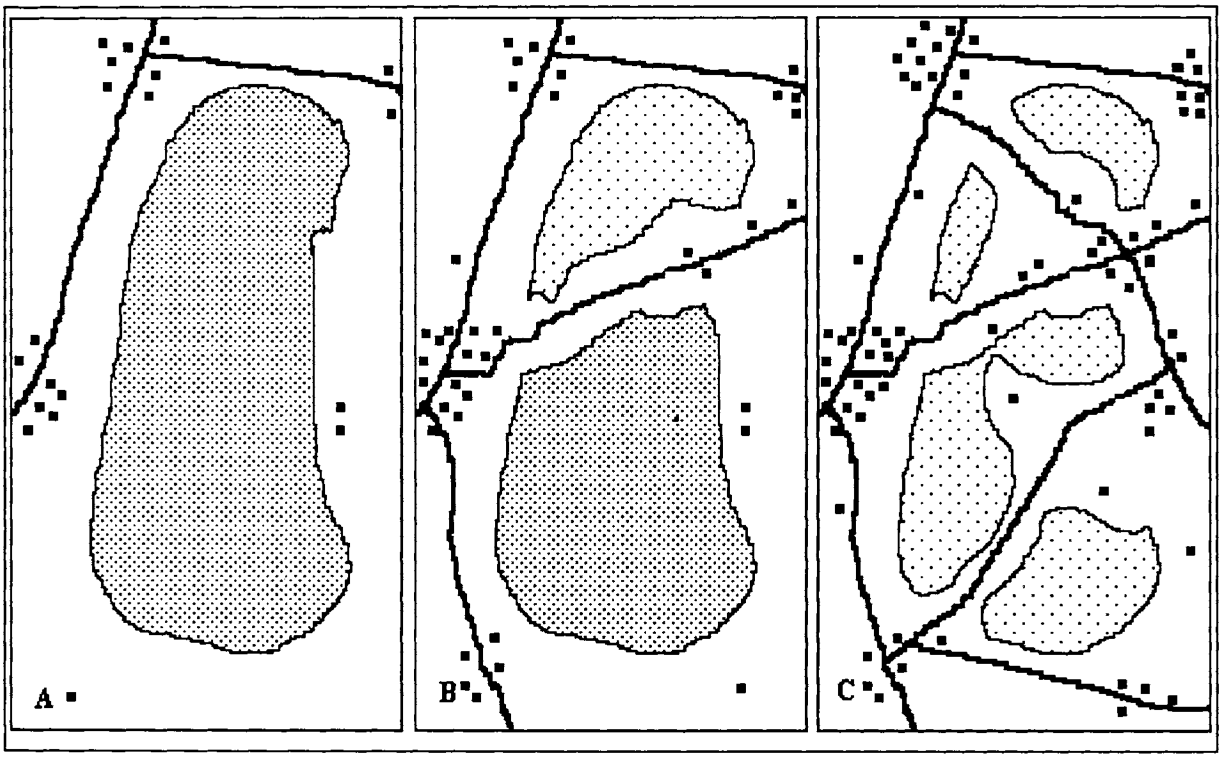


Figure 12.8. Schematic representation of the fragmentation process on a forest over time. The sequence is from left (A) to right (C). The darker shading indicates the forest areas that are large enough to support a viable population of a hypothetical species, while lighter shading indicates those fragments that are no longer large enough to support viable populations of that species. Thick lines indicate roads, black squares represent houses, and white is agricultural land. Note that, as fragmentation proceeds, the species is progressively limited to smaller and smaller areas until none of the forest fragments are large enough and the species goes extinct.

12.3.3 Applying these ideas to the design of protected areas

It has already been stated that some species survive better in smaller fragments than others. Likewise, many species can survive in forests modified by human activities (such as logging) but others cannot. As human activity intensifies, the number of original species than can survive in the long term decreases, although new, opportunistic species may colonise to take advantage of the new conditions (see Section 8.4). These ideas all support the design of protected areas along the lines of biosphere reserves, a concept which has been adopted by the Forest Department in the zoning of Forest Reserves. Reserves of importance for nature conservation will contain one or more strict nature reserves, where as many forest species as possible will be able to survive without interference. In theory, around these nature reserves, zones of low-intensity management will be established, where most (but not all) of the species found in the undisturbed forest will be able to survive. Beyond this zone may be areas of the forest that will be set aside primarily for intensive production forestry: in these zones, fewer forest species will be expected to survive, but for some species these outer zones will be important in that they increase the effective size of the nature reserve, ensuring that the Forest Reserve as a whole can support minimum viable populations.

When establishing nature reserves, such as those within Forest Reserves, an understanding of ecology and island biogeography leads us to the set of guidelines given in Figure 12.9. Note that there is a caveat that says "all things being equal". Often, there are other considerations to bear in mind, such as economic or political arguments, or the need to use clearly-defined natural boundaries such as streams or ridges. Also, some of the guidelines are potentially conflicting. At the end of the day, they are only guidelines, and the final design of any nature reserve will depend on local conditions and the skills and knowledge of the implementers.

12.4 SUMMARY

This chapter has reviewed the rationale for different sorts of protected areas and their role in nature conservation. The following points emerge as being particularly important:

- A range of activities may take place in protected areas. It helps to decide upon which activities can and cannot take place in any particular protected area and designate it accordingly. Internationally accepted categories make this process easier.
- Increasingly, managers of protected areas are adopting the concept of biosphere reserves, to cater for nature preservation as well as wise use of the natural resource.
- The global protected areas network is still growing, but tropical forests are relatively poorly represented, especially in Africa.
- Uganda's protected areas system is, on paper, one of the more comprehensive in Africa, although some key ecosystems are still poorly represented, and some protected areas exist in name only.
- The theory of island biogeography, and the idea of minimum viable populations, provide us with a sound basis for designing protected areas that will function well, and at the same time help to explain why forest fragmentation and degradation can be so harmful for nature conservation.

12.5 FURTHER READING

Diamond, J.M. 1975. The island dilemma: lessons of modern biogeographic studies for the design of natural preserves. *Biological conservation*, 7, pp. 129-146.

IUCN. 1994. *Guidelines for protected area management categories*. IUCN, Gland.

Kamugisha, J.R. 1993. *Management of natural resources and environment in Uganda: policy and legislation landmarks, 1890-1990*. Regional Soil Conservation Unit, Nairobi: 100 pp.

MacArthur, R.H. and Wilson, E.O. 1967. *The theory of island biogeography*. Princeton University Press, New Jersey. 203 pp.

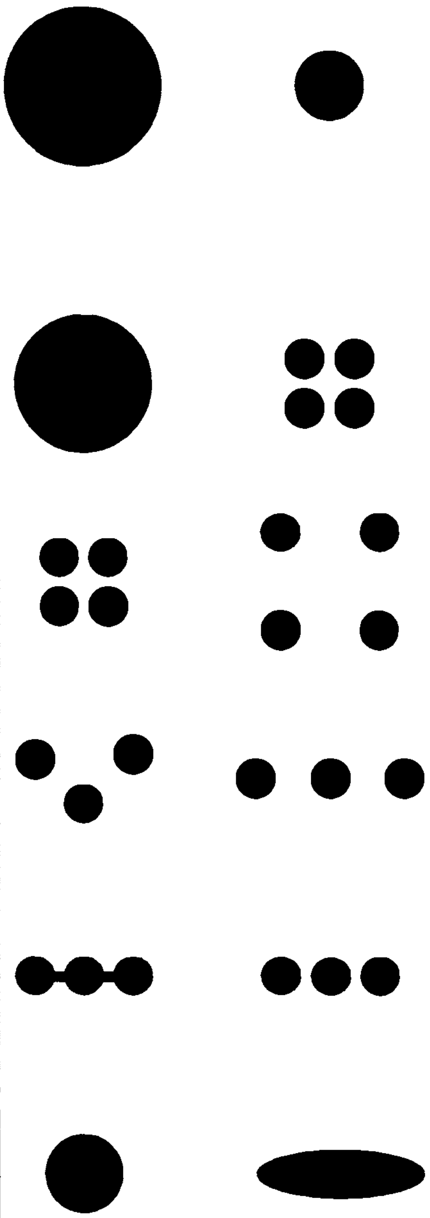
NEAP. 1992. *Issues paper on terrestrial biodiversity: forestry, wildlife, tourism*. National Environmental Action Plan, Kampala.

Sayer, J.A. 1991. *Rainforest buffer zones: guidelines for protected area managers*. IUCN, Gland.

Sayer, J.A., Harcourt, C.S. and Collins, N.M. 1992. *The conservation atlas of tropical forests: Africa*. IUCN/World Conservation Monitoring Centre, Cambridge.

ALL THINGS BEING EQUAL:

BETTER **WORSE**



1. Reserves should be as large as possible, because:
   - they support more species at equilibrium;
   - more habitats can be represented within them;
   - they have a shorter edge compared to area (less "edge effect");
   - they can support larger predators and species dependent on patchy resources;
   - they are more robust in the face of outside influences such as pollution and exotics;
   - they are less sensitive to unusual natural disturbances such as storms or drought;
   - they can allow natural succession and cyclical changes to maintain natural diversity rather than causing extinctions;
   - they can allow the survival of specialist species with poor powers of dispersal;
   - they can retain a natural balance between predators and prey.

2. Reserves should be divided into as few fragments as possible, for the same reasons as above, since each fragment is smaller than the original.

3. If reserves must be split, then they should be located as close to each other as possible, because closeness increases colonisation between reserves, and thus reduces the possibility of extinction.

4. Reserves should be grouped in clusters rather than in lines, because this allows more opportunities for recolonisation should a species go extinct in one of the reserves.

5. Provision of "corridors" between reserves should be encouraged, as these aid dispersal and colonisation and improve the conservation function of individual sites, with little cost in land.

6. Any given reserve should be as nearly circular as possible to minimise dispersal distances within the reserve and to minimise "edge effects".

Figure 12.9. Guidelines for designing protected areas. After Diamond (1975) and Beeby (1993).

CHAPTER 13

LOCAL USE OF FORESTS, FOREST MANAGEMENT AND NATURE CONSERVATION

CHAPTER OUTLINE

13.1 INTRODUCTION

In this chapter we explore some of the issues surrounding local use of the forest and how this relates to nature conservation. First we look at to what extent local people make use of the forest, then at how compatible this may be with nature conservation objectives, and finally we look at some of the options open to managers of forests to involve local people in management while at the same time promoting conservation.

13.2 FOREST MANAGEMENT AND LOCAL COMMUNITIES

Forests mean different things to different people. To a commercially-minded forester, they mean timber, to a hydrologist they mean water catchments, and to a nature conservationist, they mean areas of high biodiversity. These three values of forests are those that have often been taken by forest departments the world over, to be the only values worthy of consideration when prescribing management of the forest estate; they will probably continue to do so. Summarising the characteristics of forest departments in Africa, we might note the following (Mather, 1991):

- Emphasis on commercial forestry, and on growing timber that could be sold either within the country (primarily for mines and industries) or for export;
- Corresponding emphasis on exotic species, with little interest in indigenous species (except for logging concessions);
- Little enthusiasm for the knowledge systems of local people, usually regarded as ignorant about forestry and as spoilers of the environment;
- Emphasis on setting aside certain proportions of the total land area for forest reserves;
- Foresters have been regarded by local people as auxiliary police, since one of their functions has been to keep people out of reserves and to prosecute them for infringement of regulations.

We are only now beginning to realise that one major group of stakeholders has been left out of this process, namely the **local people** living around the forest. There are at least two reasons why we need to change our policies to take account of local people and their use of the forests:

- They are often numerically important. In any democratic society their needs and aspirations should be taken into account. Foresters should be seen to be serving their interests too.
- Their use of the forest can have a large impact on it, which may conflict with the interests of other stakeholders especially if the use is unregulated. Foresters need their co-operation in carrying out management.

Bringing local use of forests into the planning process can be seen as an obligation, or at least as a means of averting possible conflict over the use to which forests should be put. Nature conservation, the subject which concerns us here, is therefore closely linked with the livelihoods of people living near the forests.

13.3 LOCAL USE OF FORESTS

13.3.1 General

There is a whole range of ways in which local people use forests. Box 13.1 lists some of these. In Uganda, a large proportion of the native plants are used in some way, either as food, medicine, or in construction of buildings, baskets etc. Appendix 2 lists some of the woody plants native to Uganda that are thought to have medicinal value, while Appendix 3 is a similar list for edible species. Globally, out of a total of 250,000 higher plant species, at least 75,000 are probably edible. Despite this, only 12,000 have been used as food at some time; 200 have been domesticated; and only 150 have been commercially cultivated. In fact, 30 plant species provide 90% of the world's nutritional needs (Hamilton, 1993). However, in Africa, an estimated 80% of vitamin A and more than a third of vitamin C are still supplied by traditional food plants (UNEP, 1993). Bush meat is an important food source in many countries in Africa. Even in Uganda, bush meat was estimated to provide 5% of meat protein supply in 1977 (WCMC, 1992).

Box 13.1
Some of the possible uses to which forests are put by local people. After Raintree (1991)

- Food for people: fruits, nuts, oils, pods, relishes, spices, starch, sugary sap, beverages, honey, mushrooms, caterpillars, stimulants and other ingestibles;
- Feed for livestock, fish, bees, silkworms, mushrooms etc.: leaves, fruits, nuts, pods, bark, roots, wood
- Fertiliser: from prunings, litter, root dieback, animal dung;
- Energy: firewood, charcoal, wood chips, sawdust, oils, latex, resins;
- Building materials: poles, posts, planks, sawnwood, lumber, thatch, flooring;
- Raw materials for local industry: wood (carving, turnery, furniture, hand tools, musical instruments, utensils, weapons, wheels), fibre (rope, clothing, basketry), wrappings (leaves), processed foods (dried fruits and leaves, juices, coffee and tea);
- Medicinals, pharmaceuticals, stimulants, narcotics etc.

13.3.2 Case studies of local use in Uganda

There has been an upsurge of interest in documenting the use made of forests by local people, in recognition of the need to take these values into account in deciding on forest management. Forests that have been studied include Bwindi, Elgon, Rwenzori and Budongo. Summaries of some of the findings from Bwindi and Budongo are given below.

13.3.21 Local uses in Bwindi Forest

The following information is drawn from Cunningham (1992), from a study aimed at determining which uses were sustainable, which should continue to be allowed within the National Park and on what basis, which needed monitoring or control, and which should be prohibited. Three hundred and seventy-seven plant species are noted as being used by local people. Some of the main uses are listed below, while a fuller list of the more commonly used plants is given in Box 13.2.

- **Edible species** include *Dioscorea bulbifera* (a very popular wild yam), the fungus *Lentinus prolifer*, the "forest pineapple" *Myrianthus holstii* and several others. Most are collected and eaten chiefly by the poorer people.
- **Honey** is collected widely, not only from honeybees *Apis mellifera*, for which hives are erected, but also from six species of wild stingless *Trigona* spp. bees. Hives are set in an estimated 4% of the forest area.
- **Medicinal plants** include the very important worming remedy *Rytigynia kigeziensis*, and several species whose bark is sold commercially in local markets, including *Polyscias fulva*, *Symphonia globulifera*, *Croton macrostachyus*, *Ocotea usambarensis*, *Entandrophragma excelsum* and *Hallea rubrostipulata*. The bark of *Prunus africana* is also collected for the international trade.
- **Basketry and weaving** is a major user of native plants. For baskets, favoured species are the palms *Raffia farinifera* and *Phoenix reclinata*, the climbers *Loesneriella apocynoides* (especially for tea baskets) and *Smilax kraussiana*, papyrus sedge *Cyperus*

papyrus, and the bamboo *Arundinaria alpina*. For woven stretchers, *Dracaena laxissima* is favoured, while for woven granaries, *Hippocratea adongensis* is used. Bamboo is used by about half the population in the area, and 92% of this comes from the forest (half of it bought under licence, the rest collected for free).

- **Wood carving** for pestles, mortars and hoe handles uses hardwoods such as *Alangium chinense*, *Drypetes gerrardii*, *Sapium ellipticum*, *Millettia dura* and *Prunus africana*.
- **Beer boats** are usually made from *Prunus africana*, *Sapium ellipticum*, *Ficus* spp. and *Erythrina abyssinica*.
- **Building poles** are now mostly obtained from exotics outside the forest, chiefly from eucalyptus and from *Acacia mearnsii*. These can be grown at a density that yields over 1300 poles per hectare, whereas the best areas of natural forest will only yield 525 usable poles per hectare. Communities living nearest to the forest still use natural forest trees of many species for poles.
- **Bean stakes** are an important and scarce commodity for farmers. Millions of stakes are needed every year in the parishes surrounding Bwindi. *Alchornea hirtella* is heavily used for this, as are a few other species including *Acanthus arboreus*, *Rytigynia kigeziensis* and *Sapium ellipticum*. Crop residues are also used, especially by communities living at some distance from the forest.
- **Fuelwood** is now mostly obtained from farmland, chiefly from crop residues, eucalyptus and *Acacia mearnsii*. Only about 7.5% of the fuelwood of surrounding parishes comes from the forest, and it is chiefly fallen dead wood that is collected.

The extent of use of some of these products was found to be very variable. In general, it has been felt that some restrictions on harvesting are necessary to ensure that uses are sustainable and compatible with wildlife conservation in the National Park. One reason for this is that there is rapidly decreasing forest cover outside the Park, so pressure for the resources contained within the park may be expected to increase. In 1954, there were 120 km^2 of forest within a 15 km radius of Bwindi's boundary, but by 1972 it had been reduced to 42 km^2, by 1983 to less than 20 km^2 and by 1992 to virtually none. It has been suggested that the following restrictions should apply, although not all suggestions have yet been agreed upon or followed up:

- **Open access** for specialist uses, such as beekeeping and the non-commercial harvesting of medicinal plants.
- **Seasonal access** to popular plant resources with limited distributions, by harvesters elected within local user groups (for example for the plants used for basketry work).
- **Seasonal access** for specialist harvesters, together with **rotational management** of their resource, such as bamboo, with potential resource-users involved in assessing the resource and setting quotas.
- **No access** to resources where sustained use is not possible due to either complexity of management, high demand or slow plant growth-rates (such as resources for beer-boats, building-poles and bean-poles). This may also have to apply for fuelwood. In each case, emphasis needs to be placed on providing alternatives outside the Park.

13.3.22 Local uses in Budongo Forest

These notes are based on the findings of Johnson (1993), who carried out a questionnaire survey of 224 inhabitants of Nyabyeya parish, on the edge of Budongo Forest, examining to what extent they used the forest and what their attitudes were towards it. The main uses identified, together with some of the species involved, are given below:

- **Edible species**: the forest is not viewed as a major source of wild plant food, although there are some exceptions: 91% of interviewees consume forest mushrooms; 23% forest *Dioscorea* yams; 35% the fruits of *Afromomum*. Fruits of "forest pineapple", *Myrianthus arboreus*, are only eaten by one per cent. Guava, an exotic well-established within the forest, was more popular, and 43% claim to consume forest-grown guava fruit.
- **Medicinal plants** are used as the usual treatment for common illnesses and diseases by 36% of interviewees.
- **Building poles** are mostly obtained from nearby plantations or from farmland, but some are still taken from the forest.
- **Beer boats** are made from many species, but the endangered *Cordia millenii* is favoured.
- **Basketry and weaving** employs several species, chiefly the rattan cane *Calamus deerratus* for baskets, stools and whips for construction, the palm *Phoenix reclinata* for baskets and floor mats, papyrus sedge *Cyperus papyrus* for sleeping mats, and *Marantochloa leucantha* for baskets, binding and food wrapping.

Box 13.2
Some of the more commonly-used plants around Bwindi Forest, Uganda. After Cunningham (1992)

Acalypha sp.	Midwives
Acanthus arboreus	Bean-stakes
Aframomum sp.	Edible
Agauria salicifolia	Midwives, Charcoal
Alchornea hirtella	Bean-stakes, Building
Alangium chinense	Bee-hives, Bee nectar, Pestles, Bean-stakes
Aidia micrantha	Spear-handles, Pipes
Allanblackia kimbiliensis	Spear-handles, Building
Anthocleista zambesiaca	Herbalist
Arundinaria alpina	Building, Weaving, Bee-hives, Bean-stakes
Ataenidia conferta	Weaving
Basella alba	Midwives, Edible, Veterinary
Beilschmiedia ugandensis	Building, Firewood, Bee-nectar
Bersama abyssinica	Midwives, Herbalist
Borreira princeal	Midwives
Bosqueia phoberos	Edible, Building, Bee-nectar
Bridelia micrantha	Midwives, Herbalist, Building, Charcoal, Bean-stakes
Brillantisia niteus	Bee-nectar and nesting-sites
Carapa grandiflora	Edible, Building, Bee-nectar, Fats, Bean-stakes
Celtis durandii	Building
Chrysophyllum gorungosanum	Building, Bean-stakes
Croton macrostachyus	Midwives
Croton megalocarpus	Building, Bean-stakes
Cyathea manniana	Building
Cyperus papyrus	Weaving
Dioscorea bulbifera	Edible
Dodonea viscosa	Veterinary, Dental care
Dombeya goetzenii	Midwives
Dracaena laxissima	Weaving
Drypetes bipindensis	Spear-handles, Walking-sticks, Building
Drypetes ugandensis	Building, Bee-nectar, Bean-stakes
Entandrophragma excelsum	Herbalist, Building, Beer-boats
Euphorbia schimperiana	Midwives
Faurea saligna	Bee-hives and nectar, Building
Ficalhoa laurifolia	Building, Bee-hives, Bean-stakes
Ficus urceolaris	Spear-handles
Ficus sur	Edible, Beer-boats
Galiniera coffeoides	Bean-stakes, Building, Firewood
Glyphaea brevis	Twine and rope, Granaries, Firewood
Grewia sp.	Granaries, Weaving
Hagenia abyssinica	Firewood
Hallea rubrostipulata	Bee-nectar, Veterinary, Herbalist
Harungana madagascariensis	Building, Bean-stakes, Bee-nectar and nesting-sites
Lantana trifolium	Midwives
Linociera johnsonii	Spear-handles
Loesneriella apocynoides	Weaving, Granaries, Bee-hives
Macaranga kilimandscharica	Building, Bee-nectar, Bean-stakes
Macaranga schweinfurthii	Midwives
Maesa lanceolata	Midwives, Herbalist, Building, Firewood, Bean-stakes
Maesopsis eminii	Herbalist, Bee-nectar, Building
Marantochloa leucantha	Weaving, Veterinary medicines
Markhamia platycalyx	Mortars, Building
Maytenus acuminata	Herbalist, Walking-sticks, Veterinary
Mimulopsis solmsii	Bee-nectar and nesting-sites
Monanthotaxis sp.	Granaries
Musanga leo-errerae	Herbalist, Firewood
Myrica salicifolia	Midwives, Herbalist
Myrianthus holstii	Midwives, Edible
Neoboutonia sp.	Covers for food, pots etc.
Newtonia buchananii	Building, Firewood, Beer-boats
Ochna sp.	Herbalist
Ocotea usambarensis	Herbalist, Building, Firewood, Beer-boats
Oxyanthus speciosa	Spear-handles, Hoe-handles
Oxyanthus subpunctatus	Bean-stakes
Parinari excelsa	Building, Charcoal
Peddiea fischeri	Herbalist, Twine and rope
Pennisetum purpureum	Granaries, Bean-stakes
Pentas longiflora	Midwives
Phoenix reclinata	Weaving
Phyllanthus fischeri	Midwives
Phytolacca dodecandra	Midwives, Veterinary
Piper capensis	Bean-stakes, Bee-hives
Pleiocarpa pycnantha	Pipes
Podocarpus latifolius	Building
Polyscias fulva	Herbalist, Bee-hives
Premna sp.	Straw for drinking beer
Prunus africana	Midwives, Hoe-handles, Bee-nectar, Beer-boats, Mortars
Psychotria megistosticta	Bean-stakes, Walking-sticks
Psychotria schweinfurthii	Bean-stakes
Raffia farinifera	Weaving
Rawsonia spinidens	Bee-nectar, Combs
Rinorea ferruginea	Rakes, Building
Rhipsalis baccifera	Midwives, Herbalist, Weaving
Rothmannia longifolia	Spear-handles
Rubia cordifolia	Midwives
Rubus steudneri	Midwives
Rytigynia kigeziensis	Midwives, Herbalist
Sabicea sp.	Herbalist
Salacia elegans	Granaries, Bee-hives
Sapium ellipticum	Bean-stakes, Building, Firewood, Pestles
Schefflera barteri	Herbalist, Hunting-dog medicines, Building, Bee-nectar and nesting-sites
Sesbania sesban	Herbalist
Smilax kraussiana	Weaving
Solanum nigrum	Edible
Strombosia scheffleri	Building, Bee-
Symphonia globulifera	Herbalist, Bee-nectar, Building, Bean-stakes
Synadenium sp.	Bean-stakes, Walking-sticks, Veterinary
Syzygium guineense	Building, Charcoal, Bee-nectar
Tabernaemontana holstii	Midwives, Hunting-dog medicines, Building
Tabernaemontana odoratissima	Building
Teclea nobilis	Walking-sticks, Building
Trichilia rubescens	Bows and arrows
Triumfetta macrophylla	Midwives, Twine and rope, Veterinary
Xymalos monospora	Bean-stakes, Hoe-handles, Building
Zanthoxylum gilletii	Herbalist, Building
Zanthoxylum leprieurii	Herbalist

- **Firewood** is mostly collected from the forest; 83% of interviewees collect at least some of their firewood there, whereas only 8% collect it from savannah and 17% collect at least some of theirs from their own land. Only 3% use charcoal. Firewood is mostly collected for domestic use, but 13% of interviewees also collect it for curing tobacco, and 13% for distilling alcohol.
- **Sawnwood** still comes almost entirely from pit sawyers operating illegally in the forest. Thirty-two per cent of interviewees admitted to obtaining sawnwood this way, and a further 30% refused to respond. Only 11% said they obtain it from the sawmill.
- **Hunting** is widespread, and about 18% of interviewees admitted to hunting; a further 10% said they would do if it were legal. Most hunting is for family consumption. Quarry species, in decreasing order of frequency of use, are bush pig, duiker, bush buck, cane rat, squirrel, and others including hyrax, pangolin, mongoose, porcupine, guinea-fowl, snakes, tortoise and primates. Thirty-seven per cent buy wild game meat from local hunters from time to time. Twelve per cent admitted to eating primate meat. Termites are eaten by 92% of respondents, and grasshoppers by eighty-four per cent.
- **Destructive animals**: the forest is seen as a source of many destructive animals. Seven per cent of interviewees would like to see all baboons killed. Baboons were mentioned as problems by 96% of respondents, bush pigs by 72%, other monkeys by 42%, cane rats by 16%, squirrels by 13%, bush buck by 9%, porcupines by 8%, duiker by 5%, chimps by 4%, birds by 3%, guinea-fowl by 2% and civets by one per cent.

Overall, the people in the survey felt overwhelmingly that the forest should remain (90% in favour); only 5% said it should be cut down for agriculture. The overall values that people associate with the forest are listed in Box 13.3. It should be noted that some of the interviewees are relatively well-educated because of the presence of the forestry college in the parish.

Box 13.3

The overall values that people in Nyabyeya Parish associate with Budongo Forest, Uganda, according to the frequency with which it featured in their responses to a questionnaire. After Johnson (1993)

- Firewood (61%)
- Craft materials (6%)
- Prevention of soil erosion (2%)
- Building materials (52%)
- Fruit collection (4%)
- Seed collection (2%)
- Timber (51%)
- Soil fertility maintenance (4%)
- Boat construction (1%)
- Employment (20%)
- Mushroom collection (3%)
- Wind protection (1%)
- Animal resources (18%)
- Tuber collection (3%)
- Electricity poles (1%)
- Rainfall attraction (17%)
- Air cooling (3%)
- Fishing (1%)
- Water collection (13%)
- Scientific research (2%)
- Pit sawing (1%)
- Medicine (11%)
- Tourists (2%)
- Provision of dry season seed beds (1%)
- Government (7%)
- Wood for furniture (7%)

13.4 OPTIONS FOR FOREST MANAGEMENT INVOLVING LOCAL COMMUNITIES

It is clear that forests can be a very important part of the local economy. Whatever we decide to do with the forest estate has important implications for local people. It is clear that local people can suffer if their access to the traditional forest resources is taken away (FAO 1989b). This is not only bad for the people concerned, but it can present conservation problems too if the people feel alienated from the forest or from the forest's managers. If they cannot use the forest, it may lose value to them, and they may prefer to see the forest put to some other use such as farmland. There are thus very good conservation arguments for involving local people in forest management in some way or other.

13.4.1 Possible management options

There is a range of possible management options for involving local people in management and decision-making. Most are still experimental, and so no particular course can be recommended. Options range from handing over the entire management of a forest reserve to local communities, to simply discussing the implementation of a management plan with community representatives. The important thing is that, in the long term, ***the more the local people are excluded from this process, the less likely it is that management will succeed.*** Chapter 7 looks more closely at management planning and how local communities could be involved at this stage, while Chapter 10 looks at ecotourism as one possible way of involving local communities.

There is a common feeling amongst foresters that, given the chance, local people will destroy the forest and its resources. This is sometimes the case, if the local people do not value the forest as much as the land on which it sits. But in other cases, there exist strong cultural control systems over the use of resources, to stop over-exploitation or a "free-for-all". Which situation exists depends on who is seen to "own" the forest and who is responsible for looking after it. There is a range of possible ownerships (Rodgers, 1994):

- Closed (private or state)
- Common (communal/traditional)
- Open (no ownership perceived)

Forest reserves in Uganda fall into the first category (state ownership), although sometimes this is not recognised locally because the Forest Department does not maintain sufficient legitimate presence on the ground. This is one reason why some forest reserves are treated as open resources, resulting in a free-for-all. For instance, work with local communities surrounding Mount Elgon (Scott, 1994) has revealed that the locals are very aware of which of their activities are sustainable and which are not; they are aware that some of their activities are destroying their own resource-base, but since the forest was made into a reserve they have had no incentive to restrict their harvesting to sustainable levels, since they have perceived the forest as no longer being theirs.

Table 13.1 shows the control systems used in traditional forest management by local communities in Nepal. The possibility that such systems could exist in Uganda, or could be introduced, should not be dismissed. The main problem is that forest resources usually already have to be scarce before people will voluntarily introduce controls. Until that time, they have no need for controls, and the forest can become severely degraded, losing much of its conservation value in the process.

Table 13.1.
Control systems used in traditional forest management in Nepal (Arnold and Campbell, 1985)

Basis of group rules	Examples
Harvesting only selected components	• Trees: timber, fuelwood, fruit, nuts, seeds, honey, leaf fodder, fibre, leaf mulch, other minor products • Grass: fodder, thatching, rope • Other wild plants: medicinal herbs, food, bamboos • Wild animals: mammals, birds, bees, other insects
Harvesting according to condition of product	• Stage of growth, maturity, alive or dead • Size, shape • Plant density, spacing • Season of flowering, leaf-fall, etc. • Part: branch, stem, shoot, flower
Limiting amount of produce	• By time: season, days, year, several years • By quantity: of trees, headloads, baskets, animals • By tool: sickles, saws, axes • By area: zoning, blocks, types of terrain, altitude • By payment: task, kind, food, liquor, manure • By agency: women, children, contractor, animal
Using social means for protecting area	• By watcher: paid in grains or cash • By rotational guard duty • By voluntary group action • By making mandatory use of herders

13.4.2 Joint forest management

Joint forest management, involving both the Forest Department and local communities, is perhaps best suited to small, already degraded forests in highly populated areas. In such situations, it could help to stabilise the situation, and perhaps even reverse degradation. Even when this condition is met, however, there are many questions that would have to be addressed before implementing joint forest management. These questions would include (Moench, 1990):

- Who uses the forest area and for what?
- What forest resources are available and what condition are they in?
- How much direct economic interest are local communities likely to have in forest resources?
- How many communities use the forest area, and how divided or united are they?
- Is it clear that current degradation is linked to a problem of access to the forest?
- What resources can the forest department allocate to support joint forest management?

Box 13.4 suggests how the overall shift of emphasis of management that would be involved in joint forest management might take shape. It should be noted that even if joint management is not fully taken on board by the Forest Department, the shift of emphasis is still a useful one to be undertaken.

Box 13.4
The shift of emphasis in management required to operate joint forest management (Rodgers, 1994)

Achieving single, pre-set objectives	➠➠➠➠➠	Fulfilling multiple, needs-based objectives
Area management	➠➠➠➠➠	Site-specific management
Timber or single forest product	➠➠➠➠➠	Multiple non-timber forest products plus, water and soil
Single technical package	➠➠➠➠➠	Menus of options
Fixed procedures	➠➠➠➠➠	Experimentation and flexibility
Single-species forestry	➠➠➠➠➠	Multi-species forestry

13.5 SUMMARY

- Nominal ownership of the forest estate by government agencies is sometimes a help in enabling conservation to be carried out, but it can also be a hindrance if local people thereby perceive the forest resource as being open access or effectively unmanaged.
- Local people may traditionally make wide use of forest resources, including many non-timber forest products that have previously been largely ignored by forest departments. Some of these uses are theoretically sustainable, while others are not.
- There is no one formula for successfully involving local people in forest management; different situations require different solutions. Although involving local people is a worthy objective, it is not something that can be hurried if they have been excluded from the management and decision-making process for a long time.
- Whatever approach is adopted, it is clear that single-objective forestry is likely to be largely replaced by multiple-objective forestry. The task faced by managers is to ensure that the uses to which a forest is put are compatible with each other and, in particular, with nature conservation objectives.

13.6 FURTHER READING

Cunningham, A.B. 1992. *People, park and plant use: research and recommendations for multiple-use zones and development alternatives around Bwindi-Impenetrable National Park, Uganda.* CARE-International, Kampala.
Iwu, M.M. 1993. *Handbook of African medicinal plants.* CRC Press, Boca Raton.
Peters, O'Brien and Drummond. 1992. *Edible wild plants of sub-Saharan Africa.* RBG, Kew.
Raintree, J.B. 1991. *Socio-economic attributes of trees and tree planting practices.* FAO, Rome.
Springall, H. (ed.). 1994. *Proceedings of workshop on nature conservation for senior forest officers, 19th-23rd September 1994.* Forest Department, Kampala.

CHAPTER 14

BIOLOGICAL INVENTORY AND ITS APPLICATION IN FOREST NATURE CONSERVATION

CHAPTER OUTLINE

14.1 INTRODUCTION

The forest estate of any country, Uganda included, is not homogeneous. Different forests support different forest types and species; some are larger than others; some are surrounded by dense rural populations; some are near main roads or towns. If we decide that we would like to have a rational system of management that ensures that all that is of conservation value is protected, then how do we decide which parts of the forest estate to protect? It is generally unrealistic to try to protect everything, because conservation (like most forms of management) costs time and money and resources. So we have to be selective. In essence, we need to have a scientific or rational method of finding out which are the most important areas for conservation.

There are many criteria on which to base our assessment of which areas are most important for conservation. Box 14.1 lists some of the more commonly-used ones. These criteria beg another question, which is, how do we find out the information about each forest that we will need to make rational judgements about their value for conservation? Part of the answer is that we need some kind of **biological inventory**.

14.2 BIOLOGICAL INVENTORY

14.2.1 What is a biological inventory?

Most foresters are familiar with timber inventories. The primary aim of a timber inventory is to assess the distribution and value of timber trees, so that they can be exploited rationally. A thorough timber inventory will also assess the distribution of regeneration, in which case this information can be used to guide exploitation and silviculture many years ahead, usually through a working plan or management plan.

A biological inventory is in some ways similar to a timber inventory. It too is concerned with assessing the value and distribution of a resource so that its use and protection can be rationalised through the use of management plans. The main difference is in its scope: rather than limiting itself to timber species, the biological inventory seeks to assess the status of the whole biological resource of the forest.

14.2.2 The use of indicator groups

Obviously it is not feasible to inventory every species of plant and animal that lives in a forest: we have seen from Chapter 2 that there are just too many species, and we do not know anything about most of them. We need to choose certain groups of plants or animals, a sub-set of the total species pool, that can serve as **indicators** of the general ecological conditions of the forest. Box 14.1 lists some characteristics that have to be borne in mind when choosing indicator groups.

Box 14.1
Some of the more commonly-used criteria for assessing sites for their nature conservation value. Adapted from Margules and Usher (1991)

- **Species diversity**. A site with many species is likely to be more valuable than one with few species.
- **Ecosystem diversity**. A site with several ecosystems is likely to be more valuable than one with only one.
- **Naturalness**. A natural site is likely to be more valuable than a semi-natural or man-made site. By natural we mean unaffected by human activities. Note that few sites are truly natural these days.
- **Species rarity**. A site supporting rare species is likely to be more valuable than a site supporting only common species, because most common species can look after themselves and do not need special conservation measures, whereas rare species often cannot.
- **Ecosystem rarity**. A rare ecosystem is likely to be more valuable than a common one. This is partly because rare ecosystems will be more likely to support rare species, and partly because a rare ecosystem supports an unusual combination of species.
- **Area**. Island biogeography tells us that large sites are likely to be more valuable than small sites.
- **Threat of human disturbance**. Sites representing ecosystems or containing species that are widely threatened by human activities are likely to be more valuable than sites not so threatened, because unless such a site is protected then those ecosystems or species may disappear.
- **Amenity value**. Some sites have more appeal for humans than others, and these are likely to be more valuable than sites without such appeal, because conservation depends on the goodwill of people and can also benefit from revenue generated by visitors.
- **Educational value**. Sites than can be used for educational purposes, by nature of their accessibility or some other attribute, may in some circumstances be more valuable than sites that cannot be used in this way.
- **Representativeness and typicalness**. If we want to protect the full range of characteristic species and ecosystems of a given region, then we should look for representative sites that support a characteristic assemblage of species and ecosystems. The best of these, i.e. those that support the most characteristic species/ecosystems including rare ones, will be the best representatives of their type. Others may be typical but not exceptional. Both criteria are useful in determining conservation value of sites.
- **Scientific value**. This embraces both the intrinsic scientific value of a site, determined by the species and ecosystems present, as well as the opportunities the site offers for scientific study. Well-studied sites can tell us much about ecology and conservation.
- **Uniqueness**. A site may be unique in that it is the only one that supports a certain species, range of species or ecosystems. This uniqueness has conservation value, especially if the species or ecosystems it supports are themselves of particular conservation value.
- **Replaceability**. Fragile ecosystems are easily damaged and cannot easily recover from damage. Their conservation is therefore more important than that of more robust ecosystems. By the same token, climax communities are more valuable than communities at earlier stages of a succession.
- **Management considerations**. This criterion can be used to identify one site from a list of sites which are otherwise equally valuable. A site which is more easily policed or protected is worth conserving more than one where protection is likely to fail.

- **The ease with which the species in the group can be collected**. For example, choosing canopy-dwelling beetles would not be very fruitful because one would not be able to sample them effectively from ground-level.
- **The ease with which the species in the group can be identified**. For example, choosing forest mosses would not be very fruitful because there are no easy ways to identify them: no guide-books, and few experts qualified in their identification.
- **The ease with which the species in the group can be stored for later identification or reference**. For example, choosing forest slugs would necessitate carrying numerous fragile collecting-tubes of expensive preserving fluid to the field, and frequent curation of the collection back in the office or laboratory.
- **The degree to which the ecology of the species in the group is already understood**. For example, choosing forest earthworms would not be very fruitful because, even if the

species could be identified and stored, there are few if any experts who could say what the presence or absence of a particular species of earthworm meant in ecological terms.

- **The degree to which the distribution of the species in the group is already understood.** For example, choosing forest leaf-beetles would not be very fruitful because, even if the species could be identified, there are few if any experts around who could say whether a given species was widespread or endemic to a particular area, and whether it was common or internationally rare.

This is why the Uganda Forest Department chose five relatively well-known groups as indicators. These are woody plants, birds, small mammals, butterflies and two families of moths (Saturniidae and Sphingidae). Together they represent quite a wide range of taxonomic groups, and, it is hoped, ecological diversity.

14.2.3 Inventory procedures for the different indicator groups: a case study from Uganda

The biological inventory programme that has been carried out by the Uganda Forest Department has involved surveys of all 54 forest reserves exceeding 5000 ha in extent, plus 8 smaller reserves selected to represent vegetation types that do not occur in the larger reserves. Thus the programme has covered 62 forests, which together account for 75% of the total area of the forest estate (Howard and Viskanic, 1994). Other, smaller, forests were not covered, partly because of the costs of doing so and partly because smaller forests are less likely to be so valuable for nature conservation compared to other values (see Section 12.3).

In carrying out the field programme, the aim has been to list as many as possible of the species present in each forest. As far as possible, a standard amount of sampling effort is made in each forest, corresponding to roughly six weeks per forest, by a team of five trained Forest Department inventorists. Four such teams covered all the targeted reserves between 1993 and 1995.

14.2.31 Woody plant inventory

Field sampling at each site was aimed at providing coverage equivalent to at least one day per 20 km^2, so as to list the majority of woody plant species present in each forest. The field team comprised two experienced botanists, who used existing access routes (roads, paths) to visit as many parts of each forest as possible, recording and collecting as they went. In principle, they tried to visit the highest and lowest point of each forest; all distinct vegetation types (distinguished on 1:50,000 topographic maps and/or aerial photographs); all geologically distinct areas; and sites covering all aspects. The route taken each day is recorded, and the relative abundance of each species encountered during the day is recorded on a checklist. Two voucher specimens and a full description of each species is taken from each forest for verification by herbarium staff. The field records thus provide a list of woody plants from each reserve, and enable "species accumulation rates" to be monitored throughout the sampling period, to give an indication of the completeness of the data.

14.2.32 Bird inventory

Field sampling for birds involved two main methods for each area of forest. The first was to walk through the forest, listening for the distinctive calls made by different species of birds, and looking for birds with the use of binoculars. Skilled observers can identify most species this way. The second method, involving the use of **mist-nets**, was useful for confirming identifications based on the first method, and also revealed the presence of further, more secretive species. Mist-nets consist of fine nylon mesh formed into nets 12 m long and about 3 m high. When erected in the forest, between poles set along cleared lines through the undergrowth, they appear almost invisible to birds. Most birds that fly into them become entangled in the net, and can be examined at close quarters before being released. If there is any doubt about the specimen's identification, it can be killed by wringing its neck, and the skin retained for examination by other experts. Sampling intensity is expressed in terms of "metre-net-hours", based on the total length of net set and the number of hours left open.

14.2.33 Small mammal inventory

Field sampling for small mammals involved the use of various **traps**, set in different forest types, mostly at ground-level but also amongst branches. They are particularly effective when set in the evening and left overnight; they also work best along natural barriers such as stream-banks, where small mammals often congregate. Artificial barriers, such as wire or netting, can also be used to funnel small mammals towards the traps. The main traps used were **break-back traps**, **pitfall traps** and **Sherman traps**. The former are the familiar model used domestically to catch and kill rats and mice in the house.

Pitfall traps consist of small containers (such as old margarine tins) dug into the soil so that their open top is level with the soil surface; inquisitive small mammals often simply fall into them, sometimes even if the trap has no bait. Sherman traps consist of collapsible aluminium boxes open at one end, and baited with strong-smelling food such as ground-nut sauce or fish. When a small mammal enters the box, its weight on the foot-plate releases a flap that closes the entrance, entrapping it live within. With both sorts of live trap, the small mammals can either be identified live and then released, or killed and preserved in preserving fluid or as skins for later identification by other experts.

14.2.34 Butterfly inventory

Field sampling for butterflies involves two methods. The first is with the use of a hand-held **net**, which enables particular butterflies to be collected as the collector walks along a path or through the forest undergrowth. These can either be identified live or killed by squeezing the thorax between thumb and forefinger, put into individually labelled envelopes, and stored for later identification by experts. The second method involves **baited traps**, suspended from branches along forest paths and in clearings and gaps. These are cylindrical structures made of fine netting, with a base of stronger material on which is laid the bait of rotten fruit or fish. Gaps in the netting just above the base enable butterflies to enter, but when they fly upwards at the end of their meal they end up congregating at the closed top of the trap with no exit. The collector can remove them one by one, and either release them live or kill them for later identification.

14.2.35 Moth inventory

Field sampling was carried out with a **light trap** operated each night near to the inventory team's camp. A light trap is basically an aluminium box housing a powerful mercury-vapour lamp powered by a generator. The top of the box comprises clear Perspex grating pointing downwards towards the light. Moths (and other nocturnal insects) are attracted to the light within from a distance of many hundreds of metres; they find their way through the grating and take refuge amongst pieces of cardboard box laid out on the floor of the box. By the morning, a light trap may contain hundreds of insects, including many moths of the two families chosen as indicators. All specimens of these two families were collected, killed by gently squeezing the thorax between thumb and forefinger, and retained for later examination and identification by specialists. In the field, they were stored in individually labelled envelopes.

14.3 RANKING SITES ACCORDING TO THEIR NATURE CONSERVATION VALUE

14.3.1 The ranking process

If a biological inventory is to be put to maximum use, it must be carefully planned to fit in with overall objectives. In the case of the Uganda Forest Department, the objective has been to ensure that the forest biodiversity is adequately protected while at the same time avoiding conflict with other legitimate land-uses as much as possible. We therefore need to know which forests are most important for nature conservation, so that we can devote more resources to important forests.

"Phase One" of the nature reserve planning programme within the Uganda Forest Department has involved a process through which each forest is scored for its importance for biological conservation (and other factors) and decisions taken on how much of each forest should be designated as nature reserve. Box 14.2 outlines the procedure once the inventory is complete.

14.3.2 Ranking forests on the basis of how many species are recorded

Table 14.1 is a **provisional** ranking of the 42 forests that make up the minimum critical set of sites needed to protect all of the 739 species of woody plants recorded during the inventory. Note that it is not the final version. Nevertheless, it is clear that some forests are far more important than others for the conservation of woody plants. The "best" forests, such as Budongo, support many unique species, and therefore their conservation is a priority because if they were allowed to disappear then those unique species would effectively become extinct in Uganda's forest estate. However, this ranking does not take account of sampling *intensity*: Budongo Forest is undoubtedly species-rich, but maybe the inventory teams spent more time there or were able to collect more samples because of the ease of access. Until such factors are taken into account (which they can be using information on species accumulation rates), we should not conclude too much from this table.

Box 14.2
Phase One of the nature reserve planning programme within the Uganda Forest Department (Howard and Viskanic, 1994)

1. **Derive biodiversity importance scores**. For each forest, and each indicator group, an **importance score** for species conservation has been calculated, which takes into account both the number of species recorded, and the level of endemism/rarity. The highest scoring forests are those with most species and the greatest representation of species not found elsewhere.

2. **Adjust scores according to sampling intensity**. Since no species list is likely to be complete, and the sampling intensity has varied between forests, the biodiversity importance scores have to be adjusted so that they reflect an estimate of the total list for any given forest or indicator group. These adjustments are based on observed species accumulation rates over the period of sampling.

3. **Combine adjusted scores for all indicator groups to derive overall biodiversity importance score for each forest**. This overall score can then be used to guide decisions on the amount of each forest to be designated as nature reserve.

4. **Examine complementarity between sites**. To protect as many species as possible in the most efficient way, nature reserves need to be established in forests which are as biologically different from one another as possible. This complementarity between forests has been examined by firstly ranking them according to the number of species each can contribute to the protected total, and then sorting them into groups of similar forests through computer analysis (TWINSPAN), to examine their relatedness.

5. **Define a minimum critical set of sites**. In order to protect as many species as possible, it has been necessary to define a minimum critical set of sites that would be necessary to ensure that every species is represented at least once. This minimum set includes all forests which support unique species, together with other sites selected to include any other species not already represented in the network.

6. **Decide on the area of each forest to be designated as nature reserve**. This has been done by combining a variety of scores assigned to each forest, quantifying attributes contributing to its suitability for nature conservation. These attributes include biodiversity importance scores, as well as hydrological functions, timber values, local community needs, management requirements and so on. By combining scores for these various attributes into composite "suitability scores for nature reserve establishment", quantitative values for each forest are derived, which can be used in apportioning the areas of each forest to be designated as nature reserves.

Furthermore, the table refers only to woody plants, and does not take account of the other indicator groups that were also inventoried. It is likely that the "best" forests for woody plants will also be the best for other indicator groups, but it is not a foregone conclusion, and a composite ranking based on all indicator groups would give us a better picture.

14.3.3 Examining complementarity between forests

If we have limited resources then we want to make sure we protect a **representative** range of forest types. Just protecting the most species-rich forests may miss some interesting but species-poor types. Figure 14.1 is the result of a TWINSPAN computer analysis of the provisional inventory data for saturniid moths. It allows us to compare forests on the basis of overall similarities or differences in species composition. It is clear that the saturniid moth fauna of Bwindi is very similar to that of Echuya, and fairly similar to Mafuga. If we only have limited resources for conservation, we might want to pick the "best" from this group to ensure that most species representative of this type of forest are protected. On the other hand, these three forests are all very different, in terms of their saturniid moth faunas, from Kazooba, Nsowe and Zoka, so we should also seek to protect at least one of this latter group as well since they form a distinct forest type, even if it transpires that they are relatively species-poor. Note that this discussion refers only to saturniid moths: we may get a slightly different picture if we used data on all the inventoried groups.

Table 14.1.
Provisional ranking of forests which make up the minimum critical set of sites needed to protect all 739 species of woody plants recorded by the Uganda Forest Department inventory teams, 1992-1994 (Howard and Viskanic, 1994)

Rank	Forest	No. spp. collected	No. spp. unique	No. spp. added	Cumulative no. spp.
1	Budongo	277	7	277	277
2	Mount Moroto	182	7	112	389
3	Kasyoha-Kitomi	220	4	83	472
4	Otze	188	6	49	521
5	Mount Rwenzori	116	9	29	550
6	Sango Bay	188	3	25	575
7	Labwor Hills	200	4	23	598
8	Mount Kei	179	5	16	614
9	Mount Elgon	186	6	15	629
10	Mpigi	206	0	12	641
11	Nyangea-Napore	201	6	9	650
12	Kalinzu-Maramagambo	236	2	8	658
13	Mikanebolola	66	1	7	665
14	Morogole	115	5	6	671
15	Semliki	181	3	6	677
16	Bwindi	152	5	5	682
17	Kasagala	103	2	5	687
18	Timu	117	3	4	691
19	Echuya	66	2	4	695
20	Kibale	220	3	3	698
20	Jubya	122	3	3	701
20	Era	144	3	3	704
21	South Busoga	135	2	3	707
21	Kasana Kasambya	103	2	3	710
21	Mafuga	73	2	3	713
22	Bugoma	227	2	3	716
22	Maruzi	74	2	3	719
23	Mount Kadam	198	2	2	721
23	Rom	127	2	2	723
23	Itwara	223	2	2	725
24	Kagambe	196	1	2	727
24	Aswa	43	1	2	729
25	Agoro-Agu	172	1	1	730
25	Napak	149	1	1	731
25	Namwasa	108	1	1	732
25	Kibeka	44	1	1	733
25	Rwoho	92	1	1	734
25	Matiri	99	1	1	735
25	Ogili	117	1	1	736
25	Opit	62	1	1	737
25	Mpanga	173	1	1	738
26	Kazooba	78	0	1	739

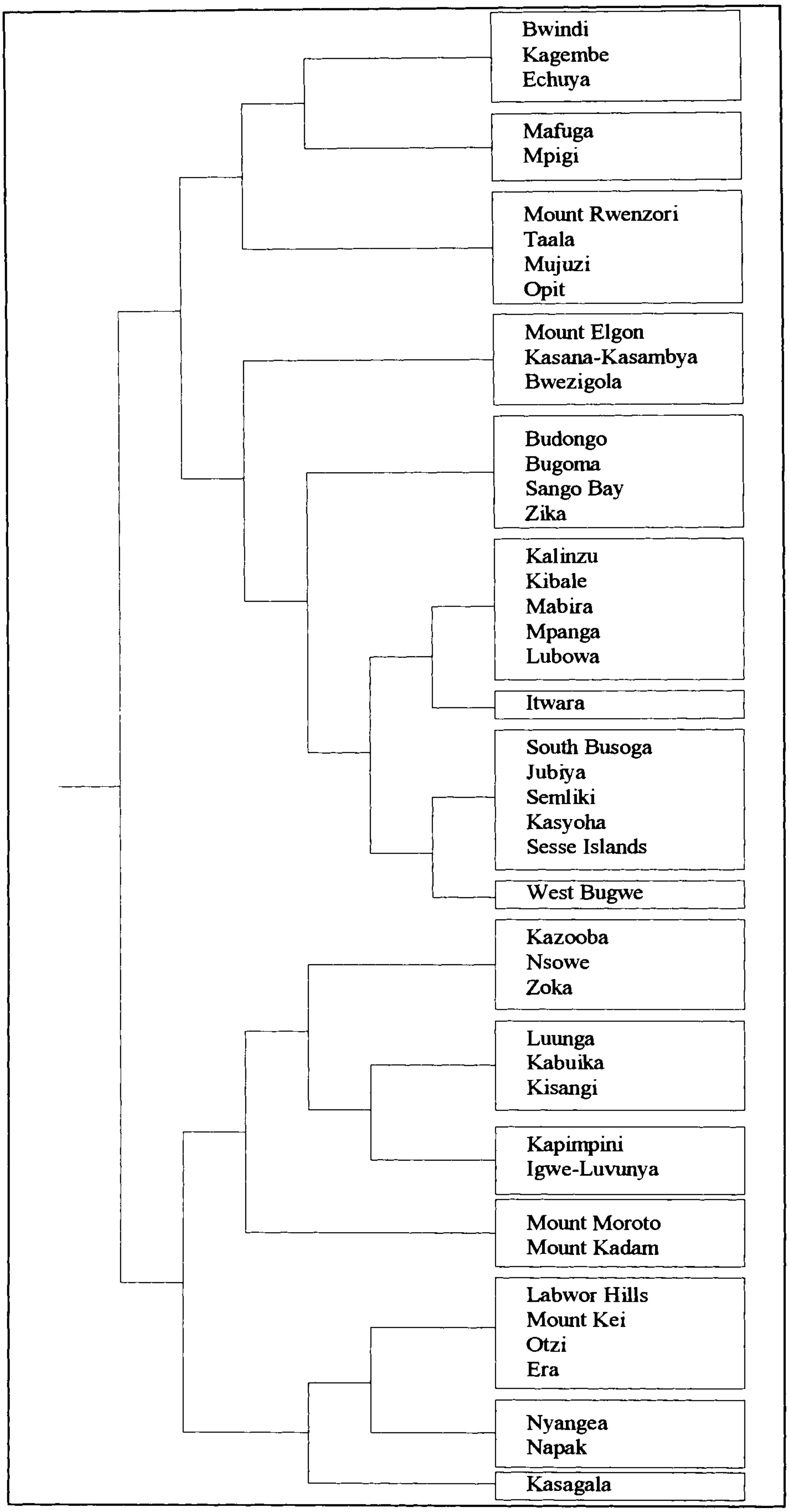


Figure 14.1. Results of a TWINSPAN computer analysis showing the relationship between Ugandan forests based on consideration of their known saturniid moth faunas. Redrawn from Howard and Viskanic (1994).

14.4 SUMMARY

The Uganda Forest Department's biological inventory and nature reserve planning process has been widely acclaimed internationally, and it is likely that other countries will seek to follow Uganda's example. Although the process takes a lot of time, money and resources, it is a very rational method that enables nature conservation objectives to be met with minimum conflict with other legitimate land-use objectives.

The inventory and subsequent planning process involves several stages, which can be summarised as follows:

- Defining indicator groups;
- Carrying out the inventory;
- Ranking the forests according to species-richness;
- Grouping the forests on the basis of similarity of species composition;
- Using the limited resources available to protect as many of the most species-rich forests as possible including as many species overall as possible while at the same time representing as wide a range of forest types as possible.

14.5 FURTHER READING

Howard, P.C. and Viskanic, P. 1994. *Biodiversity assessment for the planning of Forest Nature Reserves in Uganda.* Paper presented at IUFRO Forest Biodiversity Symposium on Measuring and Monitoring Biodiversity in Tropical and Temperate Forests, Chiang Mai, Thailand, 28th August - 2nd September 1994.

Pomeroy, D. 1989. *The making of inventories: an introductory survey of methods for trees and shrubs, mammals and birds.* 36 pp. Makerere University, Kampala.

Springall, H. (ed.). 1994. *Proceedings of workshop on nature conservation for senior forest officers, 19th-23rd September 1994.* Forest Department, Kampala.

CHAPTER 15

ZONING FORESTS FOR MULTIPLE USE AND NATURE CONSERVATION

CHAPTER OUTLINE

15.1 INTRODUCTION

Pressure on forest resources is increasing rapidly in Uganda as in many developing countries, and will continue to do so for the foreseeable future. It is therefore important that the existence of Forest Reserves is justified by ensuring that they can provide for a range of uses, rather than just one. It is clear that, while demand for timber is high and rising, demand for other products and services from the forest, such as supplying building poles, firewood, clean water, soil protection services, amenity opportunities and wildlife conservation, is often just as high or higher.

Many countries now recognise that different forests have different values, which determine the uses to which they can best be put. Timber production may remain the primary aim in some, but nature conservation or catering for the needs of local people may take priority in others. The philosophy of **multiple-use**, which is beginning to be widely adopted, can be implemented in two ways:

- by trying to cater for all possible management options in each and every forest reserve;
- by allocating different uses (or combinations of uses) to different reserves.

Table 15.1 lists some of the management options that would need to be considered in the management of the entire forest estate, and assesses how compatible each one is with other options, in the opinion of the authors (Panayotou and Ashton, 1992). It is clear that some options are totally compatible, others are totally incompatible, while others can be compatible in certain circumstances. What this means is that if we want multiple-use management to succeed, we must have some sort of ***zoning*** scheme, where different management options are permitted, encouraged or prohibited in different zones. We must zone the forest estate, and we may have to zone individual forests. Although the idea is a relatively new one for most foresters, there are some forests that have been zoned for many decades. An early example is Mount Kilimanjaro, which has had a buffer zone of planted forest around the base (outside) of the protected forest since 1941, known as the "half-mile forestry strip" (Kivumbi and Newmark, 1991).

15.2 ZONING THE FOREST ESTATE

15.2.1 Designing a zoning scheme

The Uganda Forest Department has taken on the task of zoning the entire forest estate to cater for a range of management options. To some extent, this is formalising an existing informal system, in which some forests were labelled "production forests" and others "protection forests". In 1988, the Forest Department made a policy decision that the forest estate would be zoned into three broad categories, in the following proportions:

- Nature reserves (20%)
- "Buffer" zones (30%)
- Production zones (50%)

Each of these zones would place different priority on the main management options (Table 15.2).

Table 15.1. Compatibility matrix for various forest management options. After Panayotou and Ashton (1992). Primary options are listed in capitals down the left-hand side; secondary options are listed across the top

	Timber production	Fuelwood production	Non-wood production	Soil and water conservation	Genetic resource conservation
TIMBER PRODUCTION	• Trade-offs between high-quality and general purpose timber • Complement-arity between high-quality and general purpose timber (shade, pollination)	• Encroachment • Possible damage to standing timber • Thinning • Short-term income • Trade-offs but generally compatible	• Encroachment • Possible damage to standing timber • Short-term income • Biological inter-dependence • Trade-offs, but generally compatible	• Imposes constraints on logging methods • Complement-arity with sustainable yield • Management and selective or strip logging	• Generally incompatible except for generalist species, as corridors, and where there is a very selective harvest of high-value species by non-destructive harvest methods
FUELWOOD PRODUCTION	• Selective logging of high-value species not incompatible • Additional income • Logging may provide more profit	• Fuelwood from natural forests versus fast-growing plantations/village forest • Fuelwood versus charcoal versus substitution	• Generally compatible in natural forest and multi-species plantations • Additional income • Constraint on fuelwood species	• Imposes constraints on access and harvest • Complement-ary with sustainable yield • Additional value • Trade-offs, but compatible	• Generally incompatible except for managed fuelwood • Corridors for generalist species
NON-WOOD PRODUCTION	• Compatible except where logging or silvicultural methods damage non-wood production • Additional income	• Compatible for only certain species • Encroachment • Additional income • Possible damage to non-wood income	• Choice of areas • Choice of species • Densities • Local versus national and export market	• Generally compatible • Additional value • Constraints on fodder harvest • Ground cover	• Imposes constraints on the collection of plants and animals • Higher management costs • Trade-offs, but compatible
SOIL AND WATER CONSERV-ATION	• Compatible only if logging methods do not disturb, compact or expose the soil to erosion • Higher logging and mangt. cost but additional value	• Encroachment • Possible damage to ground cover and the soil • Additional value • Compatible if properly managed	• Encroachment • Possible damage to ground cover and soil • Additional income • Compatible if properly managed	• Selection of critical watershed areas, densities, and cover species • Monitoring and protection • Substitutes • Rehabilitation of degraded areas	• Generally compatible but most watersheds degraded or poor in species • Additional value
GENETIC RESOURCE CONSERV-ATION	• Generally incompatible	• Generally incompatible	• Generally incompatible except for collection of species samples for research	• Generally compatible • Watershed areas can also serve as corridors	• Choice of areas • Choice of species • Generalist versus specialist species

Table 15.2. Management objectives of forest zones (Howard, 1991)
Objectives are ranked in order of decreasing priority.

Strict nature reserve	Buffer zone	Timber production zone
Gene pool conservation	Gene pool conservation	Sustained timber production
Habitat preservation	Water catchment protection	Other consumptive uses
Research control	Dispersal centre	Non-consumptive uses
Dispersal centre	Non-consumptive uses	Gene pool conservation
Non-consumptive uses	Low-impact uses	Water catchment protection

This is a very simplified version of what is in practice a highly complicated procedure. Since it was devised, the term *buffer zone* has rather gone out of favour, because it is used by other organisations to signify areas *around* a protected area but outside the jurisdiction of the authority managing the protected area. In the Forest Department's case, the term was meant to signify an internal zone. A provisional revised classification of zones has recently been proposed and accepted, in which the 50-50 split between "protection" and "utilisation" is maintained, but the term *buffer zone* no longer features. The policy is now to zone the estate as shown in Table 15.3 and Figure 15.1.

15.2.2 Deciding which zones are represented in which forests

Deciding on which zones are to be represented in which forests, and in what proportions, requires us to examine each zone in turn. The following paragraphs provide a **provisional** idea of how the Uganda forest estate should be zoned, based on a paper presented to senior Forest Officers by Howard (1994c).

Table 15.3. Current Uganda Forest Department policy for zoning the forest estate.
After Howard (1994c)

Primary division	**Protection**					**Utilisation**			
Zone	Strict nature reserve	Minimal disturb-ance zone	Water-shed protection zone	Recreation zone	Research zone	Commerc-ial use/ production zone	Commerc-ial use/ silviculture zone	Commun-ity use zone	Plantations
Approx. % of forest estate	20%	10%	15%	3%	2%	35%		10%	5%
Primary manage-ment objective	Biodivers-ity preserv-ation	Mainten-ance of integrity of nature reserves	Waters-hed protection, prevention of soil erosion	Recreation and amenity	Protection of areas of special scientific import-ance	Sustain-able timber production	Restorat-ion of timber production	Subsist-ence use by local commun-ities	Sustain-able timber production outside the natural forest
Criteria for selection/ design-ation	Biodivers-ity value, minimal past disturb-ance etc.	Location of nature reserves	All areas exceeding 25^{0} slope	Intrinsic appeal, accessibil-ity etc.	Disturbed sites of high conservat-ion value but not warrant-ing nature reserve status	Standing timber volume, accessibil-ity little erosion prospect	Areas degraded by unsustain-able timber harvesting or encroach-ment	Local demand	Land suitability, timber trial results
Permit-ted activities	Research	Subsist-ence use, research, seed collection	Subsist-ence use	Recreation	Research, education	Controlled timber harvesting, silviculture	Restorat-ion planting, silviculture	Subsist-ence use	Intensive timber production
Prohibit-ed activities	All other	Timber harvesting	Timber harvesting	Timber harvesting, subsistence use	All other	Recreation and subsist-ence use	Recreation, subsist-ence use	Commerc-ial use	All other

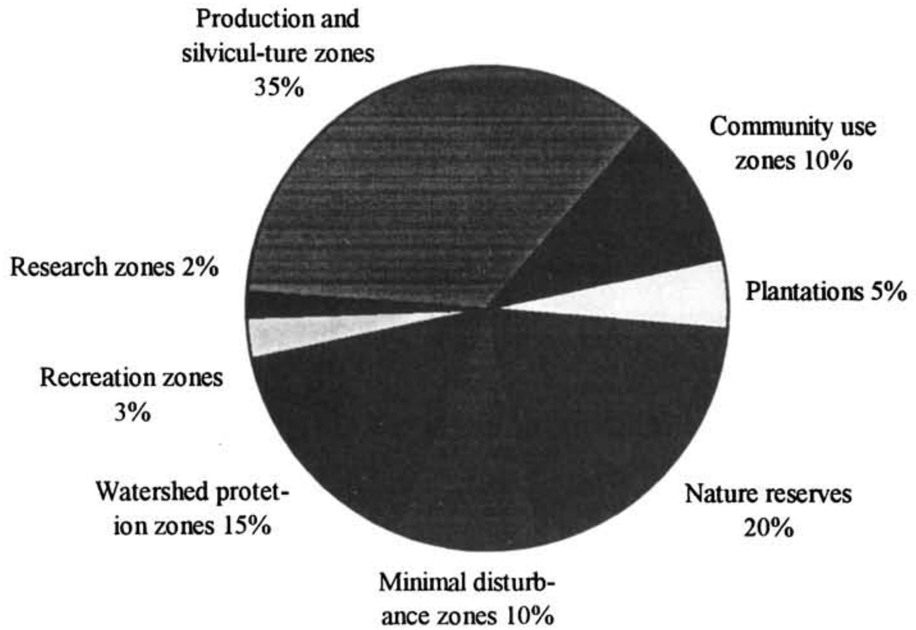


Figure 15.1. Proposed management zones for the entire forest estate of the Uganda Forest Department. After Howard (1994c).

Nature reserves and minimal disturbance zones

The biological inventories that have been conducted in 75% of the forest estate of Uganda (see Chapter 14) will enable priorities to be set regarding the size and location of nature reserves. Reserves with more species, or with many rare or threatened species or habitats, or with large areas of climax communities, will normally require a larger percentage devoted to nature reserves than reserves that seem to be less important for biodiversity conservation. Such conditions are more likely to be met in large reserves (see Section 12.3). Many small and medium-sized reserves may have no nature reserves at all if they are not important enough for biodiversity conservation, but nature reserves will probably be established in most of the large production forests. Minimal disturbance zones, perhaps comprising a strip one compartment or 500 m wide, will be established around these as true buffers, to minimise the impact of any activities outside the buffer.

Watershed protection zones

A large proportion of the forest estate is on slopes exceeding 25^{o}, and therefore is unsuitable for development for timber extraction and important for prevention of soil erosion and for water catchment protection. Thus many forest reserves, particularly those in the north and east of Uganda, will be almost exclusively allocated to watershed protection zones.

Recreation zones

Since the major forest reserves with tourism potential were transferred to National Parks, there remain relatively small areas of forest which are still suitable for development as recreation zones. To qualify, such areas should have an obvious attraction, such as easy access, safety, interesting wildlife or scenery (see Chapter 10). Recreation development should also only proceed where it can serve a useful purpose.

Research zones

Some parts of the forest estate have a long history of research, and other parts could also be opened for research, either ecological or silvicultural, on the advice of academics or foresters. Areas designated specifically for research will only be a very small fraction of the estate, yet they may potentially provide a great deal of useful information for forest management.

Commercial use zones

These are the zones estate where sustainable timber production will be carried out. Timber inventories should provide much information on suitable areas for designation, in combination with other inventories. The suggested percentage represents a sizeable proportion of the estate, probably greater than is actually under this use at present.

Half of this area already has the potential to produce timber sustainably, while the other half should have the potential in the future once it has recovered from past encroachment. Rehabilitating such areas will require major silvicultural input.

Community use zones

A relatively small percentage of the forest estate will be designated as community use zone. It will therefore be important to make sure that the areas designated are appropriate for local use, so designation should be preceded by surveys and consultations with the potential users (see Chapter 13). It should be remembered that community use need not be confined to such zones, but within such zones the community should be the major user.

Plantations

The percentage quoted for plantations reflects the current position. It is hoped that the area of plantation in Uganda will rise, but the extra area should not be taken from other zones. Uganda needs more plantations, but not at the expense of gazetted natural forest that is already serving other uses (see Chapter 8). One suggestion worth pursuing is the possibility of afforesting part of the large areas of grassland that make up a significant proportion of forest reserves such as Budongo and Bugoma.

It is clear that not all forest reserves are equally important for every management option. In general, large natural forest reserves are likely to be most important for nature conservation, while small reserves are likely to be more important for local community use. In Uganda, there are relatively few large forest reserves, and very many small forest reserves, as Figure 15.2 illustrates. Thus nature reserves and other protection areas will almost certainly be confined to the few large forests, but even so, many large forests will be zoned primarily for utilisation. Table 15.4 gives a proposed breakdown of how the forest in these different size categories might be zoned so that, overall, the 50:50 split between protection and utilisation is maintained.

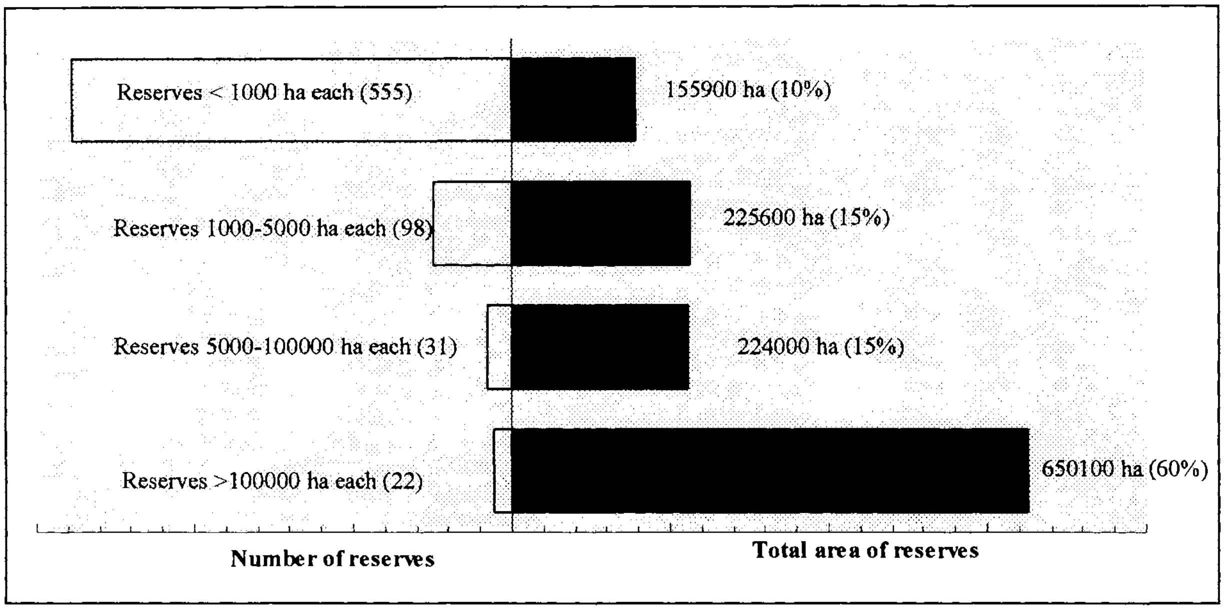


Figure 15.2. The contribution of different size-categories of forest reserves to the forest estate of Uganda. After Howard (1994c).

Table 15.4.
Suggested zoning allocations for Ugandan forest reserves of different sizes (Howard, 1994c)

Reserve size (km^2)	Number of reserves	Total area (km^2)	% Protection zones	% Utilisation zones
>100	22	6501	75	25
50-100	31	2240	34	66
10-50	98	2256	25	75
< 10	555	1559	4	96
TOTAL	706	12556	50	50

15.3 ZONING INDIVIDUAL FORESTS

One of the key factors on which the zoning of individual forests in Uganda is to be based is **the conservation value** of each forest. This is derived from the results of the ranking exercise based on the biological inventory procedure discussed in Chapter 14. In addition, we need to take into account other factors such as the role of each forest in watershed protection and their current value for timber production and local use.

Because nature conservation is most important in the largest forest reserves, let us confine our discussion to this group. Table 15.5 lists the 22 forest reserves in Uganda that exceed 100,000 ha, together with a **preliminary** indication of how each may be zoned. Large forest reserves that lie wholly within national parks (Mount Elgon, Rwenzori, Bwindi and Semliki), and the parts of other forest reserves that lie within national parks (Zulia, Kalinzu/Maramagambo, Nyangea Napore and Morongole), have been excluded from the table, since their national park status already implies 100% protection. Note that the scheme enables these large forests once again to be broadly classified into "production" and "protection" forests.

The table does not go into the detail about how much of the protection zones should be strict nature reserves. This is something that would have to be decided on the basis of each forest's conservation value (based on the biological inventory), weighed up with the other factors. Once it has been decided what proportion of a forest reserve should be protected as a nature reserve, there is still much work to do in actually defining precisely which area should be protected. In theory, the second phase of the biological inventory, in which important forest reserves are investigated in detail, should point to the most important areas needing designation. Whether this happens or not, there are many questions that would need addressing at this stage. Box 15.1 lists some of them.

Table 15.5.
Suggested allocation of protection and production zones in Uganda's major forest reserves (after Howard, 1994c)

FOREST TYPE	Forest Reserve	Total area outside N.P.s (km^2)	Protection zones (km^2)	Protection zones (%)	Utilisation zones (km^2)	Utilisation zones (%)
PRODUCTION FORESTS	Budongo (forested part)	428	107	25	321	75
	Budongo (grassland part)	397	297	75	100	25
	Kalinzu	132	46	35	86	65
	Maramagambo (South)	151	151	100	0	0
	Bugoma (forested part)	300	120	40	180	60
	Bugoma (grassland part)	65	0	0	65	100
	Kasyoha-Kitomi	399	199	50	200	50
	Mabira	300	60	20	240	80
	South Busoga	164	41	25	123	75
	Sango Bay	151	76	50	75	50
	Kagambe	113	57	50	56	50
PROTECTION FORESTS	Mount Zulia	700	700	100	0	0
	Mount Moroto	483	459	95	24	5
	Labwor Hills	437	415	95	22	5
	Nyangea Napore	317	301	95	16	5
	Mount Kadam	399	379	90	20	5
	Mount Kei	384	358	93	26	7
	Agoro-Agu	236	212	90	24	10
	Napak	203	193	95	10	5
	Otze	188	178	95	10	5
	Morongole	76	72	95	4	5
	Timu	117	105	90	12	10
	Rom	124	118	95	6	5
	Kilak	102	97	95	5	5

Box 15.1
Some of the many questions that would need to be addressed in any plan for zoning forest reserves for multiple use including nature conservation

- How important is it to include representative areas of all the forest types present, in a strict nature reserve?
- Should we also try to include any grassland?
- Are all forest types of equal conservation value, or should we favour the mature types, or the rarest?
- Is it feasible to protect a whole catchment, for example as a mixture of nature reserve and buffer zone?
- How important or feasible is it to protect examples of forests from the full range of altitudes represented?
- Are there any rivers, valley bottoms or hill-tops that might make easily-demarcated boundaries for zones?
- How important is it to site a nature reserve as far as possible away from surrounding settlements?
- Can the location of settlements, roads and pit sawn areas help us decide which areas local people would find most useful as buffer zones?
- Should we assume that any logged areas are now of low conservation value, and beyond recovery?
- Should the condition of any sawmills or existing access road affect our decisions about where mechanical logging should be permitted in the future?
- Does the location of the any guard-post help us to decide where to locate any boundaries between zones?
- To what extent does high basal area of timber trees imply high conservation value?
- To what extent should we minimise conflict with timber interests by avoiding designating areas with high basal area as nature reserves or buffer zones?
- Does a currently low basal area mean that an area is intrinsically poor for long-term timber production, or is it more likely that it reflects past logging, in which case the basal area will soon increase?
- Is an area's species richness in any indicator group a good indication of its conservation value?
- Do rare species automatically occur in areas richest in species?
- Is there any relationship between an area's species richness and its value for forest products?
- To what lengths should we go to make sure that any rare species are protected in nature reserves?
- How risky would it be to assume that any rare species present would be safe outside a strict nature reserve?
- Are the rare species recorded during the inventory likely to be the only rare species in the forest?
- If there are likely to be other rare species, might we expect them to be found in those already recorded?
- The scientific guidelines for designing nature reserves assume an ideal situation. Do we have one here?
- If the situation is not ideal, how much should we deviate from the guidelines?
- If it is impossible to include all conservation areas in a single nature, should we consider having several nature reserves instead, embedded in a buffer zone?
- How far should we deviate from the idealised "concentric circle" zoning scheme?
- How much weight should we put on the results of scientific surveys and analyses, as opposed to our own feelings and those of the local community, politicians and businessmen?

The Uganda Forest Department is attempting to rationalise the selection of strict nature reserves by using computers to analyse the inventory information so as to find the most appropriate parts of any forest reserve for designation. Figure 15.3 shows how this might work in practice for a single forest reserve, and for just three of the many possible variables that might deserve consideration: total tree species richness, presence of a rare species, and suitability for timber harvesting. The computers can be used to "weight" the information so that, for instance, the presence of species unique to a particular forest reserve has more influence on the location of the strict nature reserve than, for instance, the presence of a red data book species which is nevertheless found in several other reserves. Computers can help the process, but they are only as clever as their operators, and the location of nature reserves and other zones will depend more on human judgement.

15.4 SUMMARY

- Forests have frequently been managed for single objectives, such as timber production or watershed protection. In the future, more forests will be managed for multiple objectives, including local community use. Sometimes this will involve zoning so that different objectives apply to different areas.
- Local communities have often been excluded from the planning and management process. Sometimes this has led to their alienation from

the forest, which has contributed to encroachment and resource degradation in the absence of firm control of the forest by the Forest Department. In the future, local communities ought to have a greater say in the management of some of the forests, both for their own benefit and for the benefit of the forest resources and their conservation.

15.5 FURTHER READING

Howard, P.C. 1991. *Nature conservation in Uganda's tropical forest reserves.* IUCN, Gland.

Springall, H. (ed.). 1994. *Proceedings of workshop on nature conservation for senior forest officers, 19th-23rd September 1994.* Forest Department, Kampala.

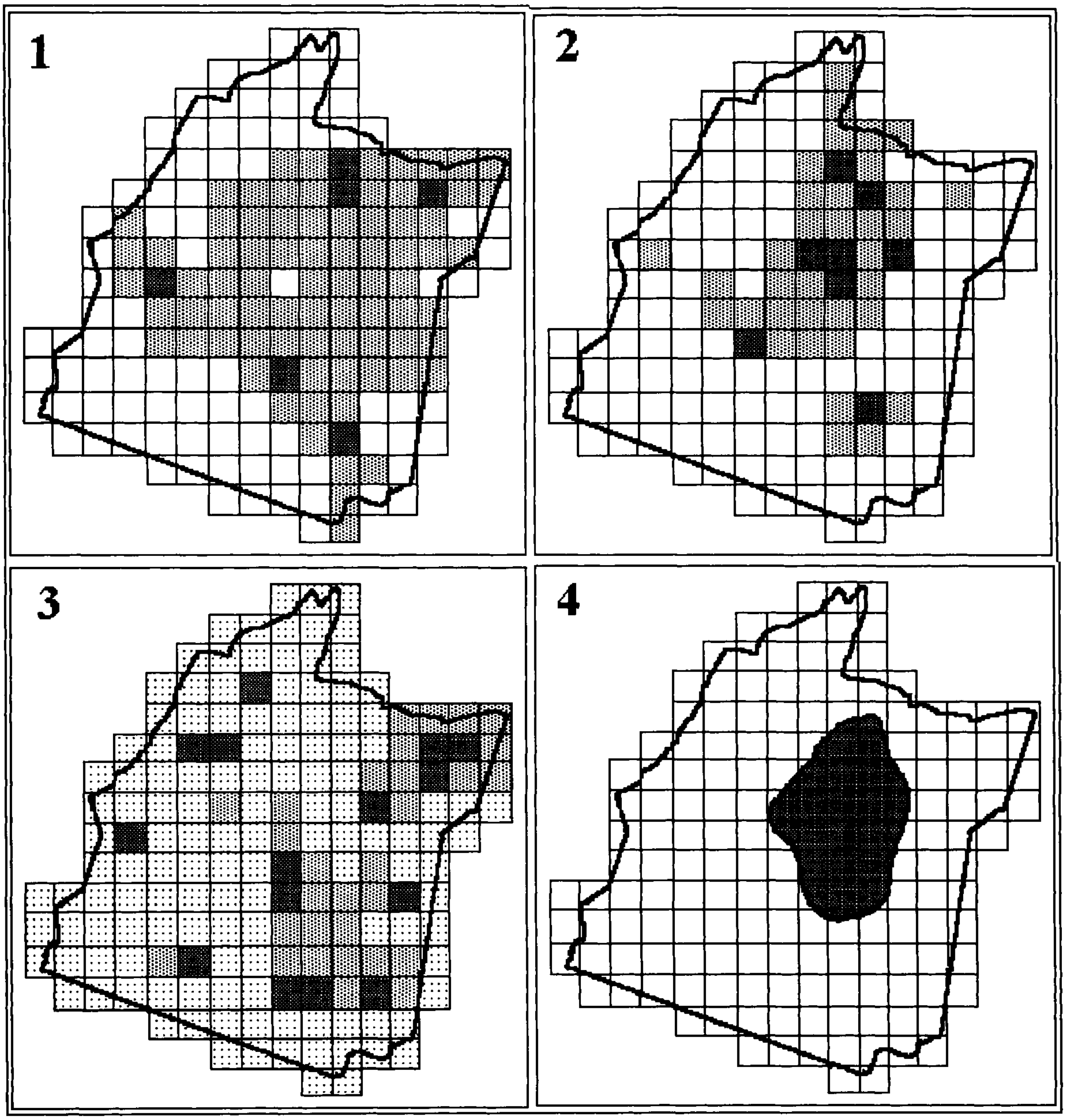


Figure 15.3. Maps showing how inventory information can help decide on the location of a strict nature reserve and other zones. The maps are based loosely on Itwara Forest Reserve, but are for illustrative purposes only. In the first three maps, the intensity of shading indicates the density of the variable in question. 1: Tree species diversity; 2: Distribution of the tree Isolona congolana, *a rare species; 3: basal area of class 1 timber trees; 4: a possible location for a strict nature reserve, based partly on the criteria in the three previous maps. After Howard and Viskanic (1994). See text for further details.*

CHAPTER 16

SUMMARY

This book has been about nature conservation in tropical forests. Although it has been written with particular reference to Uganda, it is hoped that the principles can be applied more widely. It was written at a period in our history when plants, animals and forests are vanishing at an unprecedented rate worldwide.

Nature conservation is seen to embrace a wide variety of activities, some of them very familiar to traditional foresters, others less so. These activities range from establishing nature reserves, to promoting wise and sustainable uses of forests, promoting ecotourism and the involvement of local communities in management. Ultimately, conservation is really a guiding philosophy for wise management of forests rather than a specific branch of forestry divorced from other branches. It seeks to put our relationship with forests and wildlife back on a sustainable footing. Over the long term, this is seen to be in the interests not only of the forests but also of humanity as well.

Everyone working within the field of forestry, and many outside that field, will have a role to play in furthering this philosophy. There has already been much progress, but in the end conservation will only take hold if adopted at a variety of levels, both within existing forestry institutions and beyond: in academic and training establishments, in local government and amongst the general public. The reader of this book should now be in a strong position to help the conservation message get through to a wide audience, and to put conservation into practice in his or her own work and way of life.

If there is one published source that summarises what this book has been about, it is a report by the International Tropical Timber Organisation (ITTO, 1991), aimed specifically at forestry institutions. It comprises a series of guidelines for the conservation of biodiversity. Although it refers specifically to forests managed for timber production, it does cover a lot of ground that is relevant to all forests and provides a useful reminder of much that has been covered in this book. The guidelines are quoted in full in Box 16.1.

Box 16.1
Guidelines for the conservation of biodiversity in production forests (ITTO, 1991)

1. Provide a national agency, or reform and strengthen existing institutions, to include biodiversity conservation in their mandate.
2. Provide this agency with sufficient human and financial resources to effectively achieve integrated biodiversity conservation involving both the totally protected area and production forest systems.
3. Develop and adapt practical techniques, such as environmental impact assessment, for assessing the consequences of different forest management techniques on biodiversity. Incorporate biodiversity monitoring into on-going management programmes for all forests.
4. Identify, survey and delineate the various categories of the permanent forest estate and develop complementary management plans in consultation with forest dwellers and surrounding populations, taking into account their present and future needs for agricultural land and their customary use of the forest.
5. Within the constraints of prevailing social and economic circumstances, design totally protected areas to cover as large an area of natural forest as socially and economically feasible, with due attention to optimising their shape. Surround these totally protected area cores with sympathetically managed near-natural production forests to minimise edge effects, and ensure the protection of ecological function.
6. Link totally protected area reserves by providing "corridors" of natural forest and ensuring that the habitat at known major resting sites and the known ends of migration routes are retained. Locate production forests to maximise the connectivity between natural forest totally protected areas at the landscape level.
7. Particular care should be taken in applying silvicultural treatments to ensure that adequate populations of species which are important in food chains or in providing ecological functions (keystone species) are retained. In the case of plantations, the use of indigenous species should be encouraged.
8. Trees with hollows, standing dead trees (snags) and decomposing fallen trees all have ecological importance for a range of species and not all should be removed from the forest in any silvicultural treatment to improve timber yields.
9. The use of pesticides or other chemicals should be kept to a minimum in any silvicultural treatment, and the manufacturer's instructions for the use of each product should be strictly observed.
10. In forest areas of recognised importance for biodiversity conservation, incorporate consideration of the effects of rotation length, felling cycles, girth limits and size of the annual area cut-over in deciding the allocation of the annual allowable cut.
11. When determining yield allocations and rotation lengths for particular management units, plan logging operations so that a mosaic of recently logged and old growth forests is maintained.
12. Within each major management area, a system of small virgin reserves should be designated on the management plan and maps. Reserve boundaries should be marked in the field where feasible.
13. Management inventories should aim to locate key areas within all production forest units that are known to have higher biodiversity values as outlined above.
14. Working plans should prescribe appropriate management measures in accordance with the specific biodiversity value of these key areas. Buffer strips of no intervention should be established along streams and around lakes and wetland areas.
15. Reduce individual gap size as far as possible, unless specifically required for the regeneration of key species. Avoid creating very large gaps that equate to areas of local clear felling.
16. Minimise machinery and felling damage to the residual stand, undergrowth and soil.
17. Utilise market mechanisms and economic incentives at the national and international level to encourage maintenance of biodiversity services.
18. Efforts should be made to involve local people in the management of the forests, and to ensure that they obtain benefits, which will motivate the people themselves to use their traditional knowledge in support of the conservation of biodiversity.
19. Investigate and adapt existing systems to develop locally specific, rapid, cost-effective and efficient biodiversity surveys and monitoring systems that could be carried out by, or in conjunction with, forest inventory teams during their survey activities. Implement such systems as a part of normal forest inventory processes.

APPENDIX 1
DISTRICT-BY-DISTRICT LIST OF FOREST RESERVES IN UGANDA

Sizes are in hectares. This list is based on one in NBU (1994). Information on vegetation types was provided through consultation with various FD staff, who also made some amendments regarding the names of reserves and their areas. Some inaccuracies undoubtedly remain.

APACH DISTRICT

Aber	10	Savannah woodland
Aboke	13	Savannah woodland
Acet	256	Savannah woodland
Achaba	3	Savannah woodland
Aduku	29	Savannah woodland
Alido	6	Savannah woodland
Aloro	262	Savannah woodland
Amineke	256	Savannah woodland
Amiteng	220	Savannah woodland
Aneneng	264	Savannah woodland
Anyeke	5	Savannah woodland
Apac	5	Savannah woodland
Apworocero	246	Savannah woodland
Arweny	324	Savannah woodland
Atura	10	Savannah woodland
Awinakulu	264	Savannah woodland
Chegere	8	Savannah woodland
Gung-Gung	303	Savannah woodland
Gweri	155	Savannah woodland
Icheme	16	Savannah woodland
Kulo-Obia	210	Savannah woodland
Lele-Olok	215	Savannah woodland
Maruzi	7099	Savannah woodland
Nabieso	8	Savannah woodland
Ngai	3	Savannah woodland
Ngonyeboke	3	Savannah woodland
Obet	145	Savannah woodland
Ojwiting	269	Savannah woodland
Opit (part)	1593	Savannah woodland
Otwal	5	Savannah woodland
Palango	10	Savannah woodland

ARUA DISTRICT

Ajupane	47	Eucalyptus plantation
Arua	236	Eucalyptus plantation
Ave	777	Eucalyptus plantation
Barituku	155	Bamboo (encroached)
Enjeva	738	Savannah woodland
Enyau	401	Eucalyptus plantation
Eruba	8	Plantation
Ezuka	18	Plantation
Giligili	31	Plantation
Iyi	2437	Savannah woodland
Kadre	785	Savannah woodland
Kafu	2600	Savannah woodland
Koboko	18	Plantation
Kulua	614	Savannah woodland
Kuluva	10	Plantation
Laura	2764	Savannah woodland
Liru	497	Savannah woodland
Lodonga	106	Savannah woodland
Logiri	16	Plantation
Lokiragodo	117	Plantation
Ludara	5	Plantation
Guramwa	1546	
Hoima	5	Eucalyptus plantation
Ibanda	313	
Luku	4043	Woodland
Manibe	60	Plantation
Maracha	21	Plantation
Mbaraka	8	Plantation
Mount Kei	38360	Savannah woodland
Nyio	62	Plantation
Odrua	18	Plantation
Okavu-Reru	399	Plantation
Olovu	85	Plantation
Otrevu	549	Plantation
Ovujo	135	Plantation
Ozu	8	Savannah woodland
Ozubu	681	Savannah woodland
Suru	368	Plantation
Utumbari	85	Plantation
Wati	764	Savannah woodland
Yivu	49	Plantation

BUNDIBUGYO DISTRICT

N. Rwenzori (part)	3422	Savannah woodland
(Rwenzori)	(included under Kabarole)	
Semiliki	21900 (now N.P.)	High forest

BUSHENYI DISTRICT

Kabwohe	10	
Kalinzu	14126	High forest
Kasyoha-Kitomi	39900	High forest
Koga	8	
Kyamuhunga	8	
North Maramagambo	29127	High forest

GULU DISTRICT

Abera	1191	Softwood/savannah
Amuka	1101	Savannah woodland
Anaka	3	Savannah grassland
Bobi	5	Savannah woodland
Got-Gweno	2310	Savannah woodland
Gulu	93	Eucalyptus plantation
Gwengdiya	171	Savannah woodland
Keyo	759	Savannah woodland
Kilak	10205	Savannah
Koich-Goma	5	Savannah woodland
Labala	1673	Savannah woodland
Lagute	332	Savannah woodland
Lukodi	163	Savannah woodland
Olwal	1386	Savannah woodland
Opaka	210	Savannah woodland
Opit (part)	3509	Savannah/softwood
Opok	536	Savannah woodland
Wiceri	6470	High forest

HOIMA DISTRICT

Budongo (part)	637	High forest
Bugoma	36500	High forest/grassland
Bujawe	4869	Savannah woodland
Kaburukobwire	1088	
Kagadi	8	
Kagombe	11331	

Kakumiro	26	
Kamaga	650	
Kasato	2691	
Kibale	3	
Kihaimira	572	
Kijubya	34	Eucalyptus plantation
Kijuna	1225	
Kyamurangi	417	
Mpanga	554	
Muhunga	399	
Mukihani	3619	
Nakuyazo	342	
Nandanda-Nsobya	2556	
Nyabigoye	495	
Nyabika	355	
Nykatongo	3535	
Rukara	456	
Ruzaire	1160	
Rwengeye	329	
Wambabya	3350	High forest

IGANGA DISTRICT

Budunda	106 (not yet gazetted)	Savannah
Bugaali	117 (not yet gazetted)	Savannah
Bugiri	16	Eucalyptus plantation
Bukaleba	4686	Softwood plantation/savanna
Bulyabwita	5	Cassia plantation
Bunafu	28	Cassia plantation
Busembatya	16	Eucalyptus plantation
Buwola	28	Cassia plantation
Buyenvu	622	Savannah
Igwe	1080	Savannah
Irimbi	298	Savannah
Iziru (part)	304	Savannah
Luvunya	844 (not yet gazetted)	Savannah
Nabukolyo	31	Savannah
Namafuma	108	Softwood plantation
Nawaikona	13	Plantation
Nsize	13	Maesopsis plantation
Siavona	124 (not yet gazetted)	Savannah
South Busoga	16382	Savannah woodland
Wakatanga	47	Eucalyptus plantation
Walugogo	34	Plantation
Walulumbu	109	Savannah

JINJA DISTRICT

Busegula	47	
Butamira	1257	
Iziru (part)	312	
Kagoma	277	
Kamigo	36	
Kimaka	47	
Lubani	453	
Matene	52	
Mutai	287	
Mwiri	142	
Namasiga	484	Softwood plantation
Namavundu	704	
Namazingiri	215	
Ngereka (part)	431	
Nile Bank	606	
Nsube	878	

KABALE DISTRICT

Bwindi/Impenetrable	32100 (now N.P.)	Montane forest
Echuya	3403	Montane forest
Kabale	129	Eucalyptus plantation
Mulega	80	High forest/savanna
Namatembe	277	High forest
Nkasa	8	Totally encroached
Nkose	117	High forest (encroached)
Sekazinga	3	High forest
Tonde	65	High forest
Towa	1349	High forest
Mafuga	3699	Softwood/montane forest
Mgahinga gorilla	3200 (now N.P.)	Montane forest forest/moorland
Muko	168	Softwood plantation

KABAROLE DISTRICT

Buhungiro	1020	High forest
Butebe	8	Eucalyptus plantation
Butiiti	3	Eucalyptus plantation
Fort Portal	65	Eucalyptus plantation
Ibambaro	3724	High forest
Itwara	8638	High forest
Kagorra	2448	Softwood plantation
Kahunge	5	Eucalyptus plantation
Kakasi	800	High forest
Kasenda	2574	High forest (encroached)
Katente	5	Eucalyptus plantation
Kibale	55800 (now N.P.)	High forest (part encroached)
Kibegu	1269	High forest
Kikumiro	730	Softwood plantation
Kisangi (part)	1288	High forest
Kitechura	5317	High forest
Kyehara	482	Softwood plantation
Matiri	5431	High forest
Mpara	3	Eucalyptus plantation
Muhangi	2044	High forest
Nkera	790	High forest
N. Rwenzori (part)	243	Savannah woodland
Nyakinoni	5	Eucalyptus plantation
Nyntungo	5	Eucalyptus plantation
Oruha	347	Softwood plantation
Rwensambya	671	High forest
Rwenzori	99600 (incl. Bundib. section; now N.P.)	

KALANGALA DISTRICT

Banga	184	High forest
Bufumira	247	High forest
Buga	285	High forest
Bugana	153	High forest
Bukone	130	High forest
Bunjazi	80	High forest
Busowe	1716	High forest
Buturume	181	High forest (encroached)
Buziga	98	High forest
Funve	181	High forest
Gala	894	High forest
Kamera	130	High forest (encroached)
Kampala	124	High forest (encroached)
Kamukulu	5	High forest
Kijogolo	300	High forest/savannah
Kitemu	60	High forest/savanna
Kubanda	207	High forest
Linga	39	Totally encroached
Lujabwa	47	High forest (encroached)
Lukalu	231	High forest
Lutoboka	378	High forest (encroached)
Luwungulu	23	High forest (encroached)
Makoko	36	High forest/savanna
Mugoye	945	High forest

KAMPALA DISTRICT

Banda Nursery	3	Nursery
Nakawa	5	FD HQ

KAMULI DISTRICT

Bulogo	8	Cassia plantation
Buwaiswa	31	Eucalyptus plantation

Kaliro	104	Eucalyptus plantation
Kamuli	5	Eucalyptus plantation
Kidiki	10	Cassia plantation
Mafudu	10	Cassia plantation
Makoka	18	Cassia plantation
Mbulamuti	34	Eucalyptus plantation
Namalemba	54	Maesopsis plantation
Namasagali	54	Eucalyptus plantation
Namukoge	5	Cassia plantation
Ngereka (part)	809	High forest/plantation

KAPCHORWA DISTRICT

Kapchorwa	5	Nursery and offices
(Mount Elgon)	(included under Mbale)	

KASESE DISTRICT

Kanyampara	62	Eucalyptus plantation
Kihabule	1647	
Kisangi (part)	4141	Swamp forest and moist semideciduous forest
Mubuku	1662	Savannah grassland/ woodland
Nyabirongo	16	Eucalyptus plantation

KITGUM DISTRICT

Achwa River	8459	Savannah
Agoro-Agu	23585	Montane forest
Aram	155	Savannah
Aringa River	44	Savannah
Awere	5	Savannah
Jaka	44	Savannah
Kitgum	5	Eucalyptus plantation
Labongo	3	Savannah
Lalak	2212	Savannah
Lamwo	2424	Savannah
Lokung	1427	Cassia plantation
Matidi	236	Eucalyptus plantation
Napono (part)	2018	Savannah
Noam-Okora	3	Savannah
Nyangea-Napore (pt)	14066	Savannah/montane forest
Ogili	5348	Savannah
Ogom	800	Savannah
Orom	5	Cassia plantation
Paenyeme	339	Savannah
Pajimu	158	Savannah
Palabek	5	Eucalyptus plantation
Parabongo	2792	Savannah
Rom	12400	Savannah/montane

KOTIDO DISTRICT
(some of these form the Labwor Hills F.R.)

Akur	6434	
Alerek	7433	
Ating	1318	
Kaabong	41	
Kano	8293	
Lomej	759	
Lopeichubei	1090	
Lotim-Puta	1958	
Lwala	5884	
Morongole	15063 (7500 in N.P.)	
Nangolibwel	20210	
Teiponga	57	Moist savannah

LUWERO DISTRICT

Bombo	65	Eucalyptus plantation
Bowa	10 (not yet gazetted)	Eucalyptus plantation
Kagogo	689	Pine plantation/savanna
Kalagala (Busakwa)	16	Eucalyptus plantation
Kamusenene	6177	Savanna woodland
Kapipini	6242	Savanna woodland
Kasagala	10298	Savanna woodland
Katuugo	2546	Pine plantation
Kyalubanga	4393	Savanna grassland

Napono (part)	1709	
Nyangea-Napore (pt)	27677 (10000 in N.P.)	Savannah/montane forest
Otukei	824	
Timu	11751	
Zulia	12000 (50000 in N.P.)	Savannah/montane forest

KUMI DISTRICT

Aburiburi	36	Eucalyptus plantation
Abuya	117	Eucalyptus plantation
Bukedea	16	Eucalyptus plantation
Kachumbala	21	Eucalyptus plantation
Kamachya	23	Eucalyptus plantation
Koreng	70	Savannah woodland
Kumi	28	Eucalyptus plantation
Ongino	39	Savannah woodland

LIRA DISTRICT

Abako	3	Moist savannah
Abuje	251	Savannah woodland
Abunga	231	Savannah woodland
Acwao	264	Savannah woodland
Adekokwok	8	Moist savannah
Adero	249	Moist savannah
Adwari	13	Savannah woodland
Agwata	8	Moist savannah
Ajuka	262	Moist savannah
Aleptong	13	Savannah woodland
Aliki	8	
Alit	189	Savannah woodland
Aloi	21	Moist savannah
Along-Kongo	150	Savanna woodland
Amaich	47	Moist savannah
Amugo	8	Savanna woodland
Apula	10	Savanna woodland
Aputi	13	Savanna woodland
Atan	13	
Atungulo	189	Savanna woodland
Awor	220	
Bala	18	
Bata	10	Moist savannah
Dokolo	10	Moist savannah
Ekwera	8	Moist savannah
Epor	220	Moist savannah
Kachung	2458	Moist savannah/ plantation
Kangai	16	Moist savannah
Lira	130	Moist savannah
Molitar	26	Moist savannah
Namasale	10	Moist savannah
Ngeta	18	Moist savannah
Ocamo-Lum	246	Moist savannah
Ogur	10	Moist savannah
Ojurango	246	Moist savannah
Olia	212	Savanna woodland
Oliduro	212	Savanna woodland
Olilim	5	
Omoro	8	Savanna woodland
Onekokeo	259	Plantation
Ongom	228	Moist savannah
Orumo	5	
Otukei	1254	

Mbale	1207	Savanna woodland
Nabika	91	Eucalyptus plantation
Wabisi-Wajala	8744	Savanna woodland
Wabuika Mujwalanga	8285	Savanna grassland
Wakweyo	4946	Savanna grassland
Wangu	31	Maesopsis plantation

MASAKA DISTRICT

Bugonzi	386	
Bukakata	16 (not yet gazetted)	
Buyaga Dam	12	
Jubiya	4571	

Kalungu	18	
Kasonke	130	
Kazoba	7423	
Kigona (part)	245	
Kigona River	120	
Kisasa	321	
Kitasi	267	
Kumbu	50	
Kyakumpi	10 (not yet gazetted)	
Kyalwamuka	3023	
Kyamazzi	4848	
Kyirira	96	
Lwengo	21	
Mabukonge	184	
Manwa	326	
Mujuzi	6079	
Mulundu	104	
Nabijoka	54	
Nakitondo	174	
Ntusi	23	
Wabitembe	298	

MASINDI DISTRICT

Budongo (part)	81893	High forest/grassland
Fumbya	425	Savanna
Kaduku	583	Savanna
Kasokwa	73	High forest
Kasongoire	3069	Savanna
Kibeka	9570	Savanna
Kilebe	49	Savanna
Kitonya	293	Savanna
Kyahaiguru	422	Savanna
Kyamugongo	117	Savanna
Maseege	959	Savanna
Masindi	39	Eucalyptus plantation
Masindi Port	18	Eucalyptus plantation
Musoma	16 (not yet gazetted)	Eucalyptus plantation
Nsekuro	132	Savanna
Nyabyeya plantation	347	Pine/eucalyptus
Nyakunyu	466	Savanna
Nyamakere	3898	Savanna
Rwensama	127	Savanna
Sirisiri	492	Savanna

MBALE DISTRICT

Bubulo	21	Plantation
Bukigai	18	Plantation
Busumbu	10	Plantation
Kalonyi	23	Plantation
Mbale Plantation	540	Plantation
Mount Elgon	119200 (part in Kapchorwa; now N.P.)	Montane forest/moorland (part encroached)
Mutufu	21	Plantation

Lufuka	267	
Lukolo	176	
Luwafu	389	
Luwawa	300	
Lwamunda	4696	
Makokolero	104	
Mpanga	453	High forest
Mugomba	725	
Muko	298	
Nakaga	277	
Nakalere	684	
Nakaziba	101	
Nakindiba	142	
Nalubaga	262	
Naludugavu	181	
Namanve (part)	608	Eucalyptus plantation
Nambale	238	
Nambuga	73	
Nanfuka	334	

MBARARA DISTRICT

Bugamba	1210	Softwood plantation
Bwizibwera	28	Eucalyptus plantation
Ibanda	13	Eucalyptus plantation
Kasyoha-Kitomi	4076	High forest
Kinoni	18	Eucalyptus plantation
Kyahi	4090	Eucalyptus plantation
Mbarara	164	Eucalyptus plantation
Rugongi	5	Eucalyptus plantation
Rwoho	9073	High forest/plantation

MOROTO DISTRICT

Kadam	39917	Montane forest/savanna
Moroto	48262	Montane forest/savanna
Napak	20316	Montane forest/savanna

MOYO DISTRICT

Adjumani	484	Plantation
Ayipe	839	Grassland
Era	7281	Grassland
Eria		Grassland
Itiya	166	Grassland
Laropi		Grassland
Lobajo	111	Plantation
Otzi	18800	Grassland/montane forest
Pakelt		Grassland
Uze	438	Grassland
Zoka	6480	High forest

MPIGI DISTRICT

Budugade	60
Buvuma	1096
Buwa	352
Buzimba	21
Degeya	249
Gangu	1054
Gunda	57
Jumbi	342
Kabulego	168
Kabuye	153
Kagongo	127
Kajansi	327
Kalandazi	137
Kalandazi	458
Kalangalo	337
Kalo	78
Kalombi	3836
Kanjaza	332
Kasozi	44
Kaswera	54
Katabalalu	1225
Kavunda	140
Kinyo	259
Kitubulu	70
Kyansozi	704
Kyewaga	223
Navugulu	2714
Nawandigi	3766
Nonve	738
Nsowe	5097
Sembule	44
Semunya	330
Tumbi	513
Wabinyomo	246
Wabirago	65
Wakayenmbe	179
Walumwanyi	399
Wamasega	194
Wantagalala	223
Wantayi	238

MUBENDE DISTRICT

Bulondo	453	High forest
Bumude-Nchwanga	329	Savanna
Bwezigolo-Gunga	5263	High forest/savanna

Goyera	992	Savanna
Kabindo	1474	Savanna
Kabugeza	285	Savanna
Kabukira	342	Savanna
Kagogo	761	Savanna
Kajonde	342	High forest
Kanangalo	2642	Savanna
Kasa	1121	Savanna
Kasana-Kasambya	5141	Savanna
Kasega	109	Savanna
Kasenyi	220	Savanna
Kasolo	3331	Savanna
Katabalalu	28	Savanna
Kaweri	1246	Plantation
Kijwiga	256	Savanna
Kikonda	2046	Plantation/savanna
Kisombwa	3038	Savanna
Kitonya	780	Savanna
Kyampisi	321	
Lukuga	114	Softwood plantation
Lusiba	670	Savanna
Luwunga	9718	Savanna
Mpinve	1810	Savanna
Mubende	85	Savanna
Muinaina	1062	Plantation
Mukambwe	192	High forest
Musambya	746	
Nakwaya	477	Softwood plantation/savanna
Namwasa	8104	
Nfuka-Magobwa	1623	Savanna
Tala	9150	Savanna
Walugondo	161	Plantation/High forest
Zimwa	834	Savannah/plantation

MUKONO DISTRICT

Bajo	3373	
Bira	313	
Buduli	65	
Bugomba	272	
Bugusa	243	
Bukaibale	1137	
Buloba	269	
Buluku	300	
Buuka	308	
Buwanzi	458	
Izinga Island	104	
Kafumbi	365	
Kakonwa	743	
Kalangala Falls	104	
Kande	249	
Kasala	298	
Kasulo	57	
Kerenge	73	
Kifu	1419	
Kifunve	197	
Kirigye	57	
Kisakombe	220	
Kisisita	741	
Kiula	2147	Savannah
Kizinkuba	648	
Koja	231	
Koko	246	
Kuzito	158	
Kyampisi-Bulijjo	371 (not yet gazetted)	
Lukole	383	
Mabira	29954	
Mala Island	3	
Mawanga	10	
Mwola	629	
Nabanga	477	
Nakalanga	1598	
Nakasenyi	21	Eucalyptus plantation
Nakiza	673	
Nakunyi	111	
Namaanyi	456	
Namabowe	130	
Namakupa	280	
Namanve (part)	1208	Eucalyptus plantation
Namatiwa	1611	
Namunyoro	85	
Namwoya	389	
Nandagi	479	Plantation
Natyonko	1435	
Nawaitale	93	
Nazigo	57	Eucalyptus plantation
Ngogwe (Bwema)	62	
Nimu	344	
Nkongwe	311	
Nsese	36	
Olamusa	391	
Sozi	220	
Wamala	1950	Savannah
Yubwe	197	
Zirimiti	935	

NEBBI DISTRICT

Abiba	2007	
Agweci	127	Savannah woodland
Alui	575	
Awang	163	
East Uru	477	
Erusi	21	
Lendu	1487	
Lul Kayonga	114	
Lul Oming	373	
Lul Opio	249	
Omier	2380	
Usi	438	
Wadelai	552	
West Uru	293	

NTUNGAMO DISTRICT

Ntungamo	13	Eucalyptus plantation
Rwotto	9073	Softwood/savannah grassland

PALISSA DISTRICT

Goligoli	44	
Jami	13	
Kabuna	31	
Kanginima	16	
Lumuto	93	
Odurata	88	
Sala	316	

RAKAI DISTRICT

Sango Bay	15100	High forest/swamp forest/grassland

RUKUNGIRI DISTRICT

Bwambara	32	Eucalyptus plantation
Ihimbo	456 (+ 110 proposed)	High forest/savannah
Kabisoni	7 (not yet gazetted)	Plantation
Kagogo	5	Plantation
Kaniabizo	41 (not yet gazetted)	Plantation/savannah
Kihihi	36	Eucalyptus plantation
Kyantuhe	205	Savannah/plantation
Mburamaizi	497 (not yet gazetted)	Savannah/plantation
Rukungiri	26	Plantation
Rushaya	31 (not yet gazetted)	Plantation
Rwengiri	155	Eucalyptus plantation
South Maramagambo	15175	High forest

SOROTI DISTRICT

Achuna	166	
Achwali	376	
Alungamisimosi	4646	
Amorokini	91	
Ananamana	43 (not yet gazetted)	
Angutewere	280	
Anyara	171	

Asuret	57
Atigo	938
Bugombo Hill	1033
Bululu Hill	425
Dakabera	199
Jerere	83
Kabola	36
Kachogogweno	404
Kagwara	370
Katakwi	30 (not yet gazetted)
Kateta	166
Kidetok	10
Kyere	13
Lemutome	177
Madoci	368
Obule	36
Ochomai	243
Ochomil	267
Odudui	197
Ogata-Akimega	526
Ogera Hill	427
Ogwara	10
Omodoi	67
Onyurutu	158
Pigire	658 (not yet gazetted)
Sambwa	282
Soroti	135

TORORO DISTRICT

Achilet	16	Plantation
Apokoli	21	
Monikakinei	163	Savannah/moist forest
Mudakoli	34	Plantation
Nagongera 1	63	Plantation
Nakwiga	111	
Sitambogo	650	Savannah
Tebakoli	23	
Tororo	369	Plantation
West Bugwe	3054	Savannah/moist forest

??

Alito	16
Awebo	10
Ayami	329
Ayer	21
Ayito	231
Ilera	158
Telwa	339

APPENDIX 2

SOME EDIBLE WOODY PLANTS FOUND IN UGANDA

The following list has been compiled from Peters, O'Brien and Drummond (1992), using Howard (1994) to determine whether a species is recorded from Uganda. The uses described are not necessarily known from Uganda, since the source lists uses of species from throughout Africa. Furthermore, inclusion in this list does not imply that the plant is edible in its raw form: many are famine foods, or require careful preparation to remove poisons.

Zamiaceae	
Encephalartos hildebrandti	Fruit-pulp, trunk-pith
Aloaceae	
Aloe schweinfurthii	Nectar
Asparagaceae	
Asparagus flagellaris	Shoot, root
Palmae	
Borassus aethiopum	Fruit-pulp, seed, Terminal leaf-bud, sap
Calamus deeratus	Terminal leaf-bud
Elaeis guineensis	Fruit-pulp, kernel, terminal leaf-bud
Phoenix reclinata	Fruit, terminal leaf-bud, sap
Smilacaceae	
Smilax anceps	Root
Acanthaceae	
Justicia flava	Leaf
Whitfieldia elongata	Nut
Anacardiaceae	
Antrocaryon micraster	Fruit-pulp, kernel
Lannea barteri	Fruit
Lannea edulis	Fruit
Lannea fulva	Fruit
Lannea schimperi	Fruit
Lannea schweinfurthii	Fruit, bark
Lannea triphylla	Root
Pistacia aethiopica	Bark
Pseudospondias microcarpa	Fruit
Rhus longipes	Fruit
Rhus natalensis	Fruit, bark
Rhus ruspolii	Fruit
Rhus vulgaris	Fruit
Sclerocarya birrea	Fruit-pulp, kernel
Annonaceae	
Annona senegalensis	Fruit
Hexalobus monopetalus	Fruit
Monodora myristica	Seed
Uvaria scheffleri	Fruit
Uvaria welwitschii	Fruit
Apocynaceae	
Carissa edulis	Fruit
Landolphia buchananii	Fruit
Voacanga thouarsii	Fruit
Aquifoliaceae	
Ilex mitis	Fruit, root, bark
Araliaceae	
Cussonia arborea	Fruit
Cussonia spicata	Fruit, root
Asclepiadaceae	
Calotropis procera	Flowering shoots
Cryptolepis oblongifolia	Leaf
Balanitaceae	
Balanites aegyptiaca	Fruit-pulp, kernel
Balanites pedicellaris	Fruit
Balanites wilsoniana	Fruit
Berberidaceae	
Berberis holstii	Fruit
Bignoniaceae	
Kigelia africana	Fruit-pulp, seed, bark
Spathodea campanulata	Fruit, flower
Bombacaceae	
Bombax buonopozense	Immature fruit, leaf, flower
Boraginaceae	
Cordia africana	Fruit
Cordia monoica	Fruit
Ehretia cymosa	Fruit, stem
Burseraceae	
Boswellia neglecta	Gum
Canarium schweinfurthii	Fruit-pulp, seed
Commiphora africana	Fruit, leaf, stem,root-pith, bark, gum
Commiphora samharensis	Bark
Commiphora schimperi	Root
Canellaceae	
Warburgia ugandensis	Fruit
Capparidaceae	
Boscia angustifolia	Fruit-pulp, seed, leaf, bark
Boscia coriacea	Fruit
Boscia salicifolia	Leaf, bark, fruit
Cadaba farinosa	Leaf, stem
Capparis erythrocarpos	Fruit
Capparis fascicularis	Fruit
Crateva adansonii	Fruit, leaf
Maerua crassifolia	Fruit
Maerua pseudopetalosa	Fruit, root
Cecropiaceae	
Musanga cecropioides	Fruit, wood-ash
Myrianthus arboreus	Fruit-pulp, leaf
Myrianthus holstii	Fruit

Celastraceae	
Cassine aethiopica	Fruit
Maytenus heterophylla	Aril
Maytenus senegalensis	Root
Chrysobalanaceae	
Parinari curatellifolia	Fruit-pulp, kernel
Parinari excelsa	Fruit-pulp, kernel
Clusiaceae	
Garcinia buchananii	Fruit
Garcinia livingstonei	Fruit, leaf
Harungana madagascariensis	Fruit
Mammea africana	Fruit-pulp, seed
Combretaceae	
Combretum aculeatum	Seed
Combretum collinum	Fum
Combretum hereroense	Fruit, leaf, gum
Combretum molle	Root
Combretum mossambicense	Fruit
Combretum racemosum	Leaf
Terminalia brownii	Fruit
Terminalia glaucescens	Root
Terminalia spinosa	Bark
Compositae	
Vernonia adoensis	Root
Vernonia amygdalina	Leaf, stem, root
Vernonia colorata	Leaf, stem
Convolvulaceae	
Ipomoea longituba	Root
Ipomoea spathulata	Root
Ipomoea verbascoidea	Root
Dichapetalaceae	
Dichapetalum madagascariense	Fruit-pulp
Ebenaceae	
Diospyros kirkii	Fruit
Diospyros mespiliformis	Fruit-pulp, seed
Euclea divinorum	Fruit, leaf
Euphorbiaceae	
Acalypha bipartita	Leaf
Acalypha racemosa	Leaf
Antidesma membranaceum	Fruit
Antidesma venosum	Fruit
Bridelia micrantha	Fruit
Bridelia scleroneura	Fruit
Drypetes gerrardii	Fruit
Erythrococca atrovirens	Pod
Erythrococca bongensis	Leaf
Erythrococca fischeri	Leaf
Flueggia virosa	Fruit
Hymenocardia acida	Fruit, shoot
Margaritaria discoidea	Fruit
Phyllanthus muellerianus	Fruit, leaf
Phyllanthus reticulatus	Fruit
Ricinodendron heudelotii	Kernel
Tetrorchidium didymostemon	Stem
Uapaca sansibarica	Fruit
Flacourtiaceae	
Dovyalis abyssinica	Fruit
Dovyalis macrocalyx	Fruit
Flacourtia indica	Fruit
Oncoba spinosa	Fruit
Rawsonia lucida	Fruit
Scolopia zeyheri	Fruit
Irvingiaceae	
Irvingia gabonensis	Fruit-pulp, seed
Klainedoxa gabonensis	Seed
Leeaceae	
Leea guineensis	Fruit
Leguminosae	
Acacia elatior	Pod
Acacia gerrardii	Bark
Acacia hockii	Bark, gum
Acacia kirkii	Bark
Acacia mellifera	Pod, gum
Acacia nilotica	Gum
Acacia polyacantha	Gum
Acacia reficiens	Gum
Acacia senegal	Gum
Acacia seyal	Gum, bark
Acacia tortilis	Pod, leaf, gum, bark
Afzelia africana	Aril, imm. seed
Albizia anthelmintica	Leaf
Albizia zygia	Leaf
Burkea africana	Gum
Canthormion altissimum	Pulp, seed
Cordyla richardii	Fruit
Crotalaria cleomifolia	Leaf
Crotalaria natalitia	Leaf, flower
Crotalaria recta	Flower
Dalbergia melanoxylon	Leaf
Daniellia oliveri	Seed, gum
Delonix elata	Seed
Dichrostachys cinerea	Leaf, gum
Erythrina abyssinica	Root
Indigofera arrecta	Root
Parkia filicoidea	Pulp, seed
Piliostigma thonningii	Pod, seed, leaf
Prosopis africana	Seed
Pterolobium stellatarum	Leaf
Sesbania sesban	Fruit, leaf, flower
Tamarindus indica	Pod, seed,leaf, flower
Tetrapluera tetraptera	Fruit-pulp
Loganiaceae	
Strychnos innocua	Fruit-pulp
Strychnos spinosa	Fruit-pulp
Strychnos usambarensis	Fruit
Malvaceae	
Hibiscus cannabinus	Fruit, leaf, flower, gum, bark
Hibiscus rostellatus	Leaf
Sida ovata	Leaf
Meliaceae	
Ekebergia capensis	Fruit
Trichilia dregeana	Aril
Trichilia emetica	Aril
Monimiaceae	
Xymalos monospora	Fruit
Moraceae	
Ficus spp.	Fruit
Ficus glumosa	Fruit, leaf
Ficus mucoso	Fruit, leaf
Ficus ovata	Bark
Ficus stuhlmannii	Fruit, leaf
Ficus sur	Fruit, leaf, root, bark
Ficus sycomorus	Fruit, leaf
Ficus thonningii	Fruit, leaf
Morus mesozygia	Fruit
Treculia africana	Seed
Trilepisium madagascariense	Fruit
Myristicaceae	
Pycnanthus angolensis	Seed, aril
Myrsinaceae	
Embelia schimperi	Fruit
Myrtaceae	
Syzygium cordatum	Fruit
Syzygium guineense	Fruit, root, bark
Syzygium owariense	Fruit
Ochnaceae	
Lophira lanceolata	Kernel
Ochna afzelii	Fruit
Olacaceae	
Ximenia americana	Fruit-pulp, root
Ximenia caffra	Fruit-pulp
Oleaceae	
Jasminum abyssinicum	Root
Opiliaceae	
Opilia celtidifolia	Fruit
Phytolaccaceae	
Phytolacca dodecandra	Leaf

Piperaceae	
Piper capense	Fruit
Pittosporaceae	
Pittosporum viridiflorum	Fruit
Polygalaceae	
Carpabolia alba	Fruit
Proteaceae	
Protea madiensis	Nectar
Rhamnaceae	
Berchemia discolor	Fruit
Rhamnus prinoides	Fruit, root
Ziziphus abyssinica	Fruit, leaf
Ziziphus mucronata	Fruit
Ziziphus pubescens	Fruit
Ziziphus spina-christi	Fruit-pulp
Rosaceae	
Rubus apetalus	Fruit
Rubus pinnatus	Fruit
Rubus rigidus	Fruit
Rubus steudneri	Fruit
Rubus volkensii	Fruit
Rubiaceae	
Canthium lactescens	Fruit
Coffea canephora	Seed
Coffea eugenoides	Fruit
Coffea liberica	Seed
Craterispermum schweinfurthii	Bark
Euclinia longiflora	Fruit-pulp
Gardenia erubescens	Fruit
Gardenia ternifolia	Fruit
Gardenia volkensii	Fruit-pulp
Mussaenda arcuata	Fruit
Mussaenda elegans	Fruit
Mussaenda erythrophylla	Root
Oxyanthus speciosus	Stem
Pavetta crassipes	Fruit, leaf
Rothmannia urcellifromis	Fruit
Rutidea orientalis	Fruit
Sherbournia bignoniiflora	Fruit
Tricalysia coriacea	Fruit
Vangueria apiculata	Fruit
Rutaceae	
Clausena anisata	Fruit
Toddalia asiatica	Fruit
Salvadoraceae	
Salvadora persica	Fruit-pulp, leaf, bark
Sapindaceae	
Allophylus africanus	Fruit, leaf
Allophylus macrobotrys	Leaf
Aphania senegalensis	Fruit-pulp
Blighia unijugata	Fruit
Deinbollia kilimandshcarica	Fruit
Lecaniodsicus cupanioides	Fruit-pulp
Lecaniodiscus fraxinifolius	Fruit
Pappea capensis	Fruit, leaf
Zanha golungensis	Fruit
Sapotaceae	
Afrosersalisia cerasifera	Fruit
Aningeria adolfi-friedericii	Fruit
Bequaertiodendron natalense	Fruit
Chrysophyllum albidum	Fruit-pulp
Chrysophyllum delevoyi	Fruit-pulp
Chrysophyllum perpulchrum	Fruit
Chrysophyllum pruniforme	Fruit
Mimusops bagshawei	Fruit, bark
Mimusops kummel	Fruit
Pachystela brevipes	Fruit
Solanaceae	
Solanum aethiopicum	Fruit, leaf
Solanum dasyphyllum	Fruit, leaf
Solanum giganteum	Fruit
Solanum gilo	Fruit
Solanum incanum	Leaf
Sterculiaceae	
Dombeya rotundifolia	Fruit, stem
Sterculia setigera	Seed, gum
Thymelaeaceae	
Gnidia chrysantha	Leaf
Peddiaea fischeri	Fruit
Tiliaceae	
Glyphaea brevis	Stem, flower
Grewia bicolor	Fruit
Grewia floribunda	Fruit
Grewia mollis	Fruit, shoot, flower, bark
Grewia pubescens	Fruit-pulp
Grewia similis	Fruit
Grewia tenax	Fruit
Grewia trichocarpa	Fruit
Grewia villosa	Fruit
Sparmannia ricinocarpa	Leaf
Triumfetta annua	Leaf
Triumfetta cordifolia	Leaf
Triumfetta rhomboidea	Leaf, root
Ulmaceae	
Celtis integrifolia	Fruit, leaf
Celtis wightii	Leaf
Chaetacme aristata	Fruit
Trema orientalis	Leaf
Verbenaceae	
Lantana trifolia	Fruit
Vitex amboniensis	Fruit
Vitex doniana	Fruit
Violaceae	
Rinorea ilicifolia	Fruit

APPENDIX 3

SOME MEDICINAL WOODY PLANTS FOUND IN UGANDA

The following list has been compiled from Iwu (1993), using Howard (1994) to determine whether a species is recorded from Uganda. The uses described are not necessarily known from Uganda, since the source lists uses of species from throughout Africa. The plant name is followed by the main medicinal uses and the parts of the plant used.

Acanthaceae		
Acanthus montanus	Gastrointestinal disorders, laxative	Leaves
Justicia flava	Diarrhoea, dysentery, fevers, yaws	Leaves
Lankesteria elegans	Venereal diseases, coughs, bronchitis	Leaves
Thunbergia erecta	Febrifuge, wound dressings	Leaves
Whitfieldia elongata	Skin diseases, snake bite, love potion	Seeds, stem
Agavaceae		
Dracaena fragrans	Topic fever remedy, anti-infective, anti-inflammatory	Fruits, leaves
Dracaena laxissima	Venereal diseases, skin eruptions	Roots
Anacardiaceae		
Lannea schweinfurthii	Pain relief, tonic, anti-fungal	Leaves, fruits
Rhus vulgaris	Diarrhoea, wound dressings	Leaves, fruits
Annonaceae		
Annona senegalensis	Wound healing, chest colds, diarrhoea, dysentery	Gum, roots
Cleistopholis patens	Haemostatic agent for fresh wounds	Exudate from leaves
Hexalobus monopetalus	Fevers, mouth infections, inflammation	Stem bark, roots
Monodora myristica	Carminative, anti-parasitic	Fruits, leaves
Uvaria angolensis	Liver disorders, tonic, skin diseases	Stem bark, roots
Xylopia aethiopica	Carminative, restorative after childbirth, analgesic	Fruits, whole plant
Xylopia parviflora	Skin infections, colds	Stem bark, fruits
Xylopia staudtii	Headache, colds, sinus decongestant	Stem bark, fruits
Apocynaceae		
Acokanthera schimperi	Weak infusion for syphilis, arrow poison	Stem bark, roots
Alstonia boonei	Fevers, tumours, aphrodisiac	Roots, stem bark
Carissa edulis	Toothache, tonic, aphrodisiac	Leaves, root, latex
Funtumia africana	Wound/burn dressing, incontinence, urethritis	Leaves, roots
Funtumia elastica	Male impotence, tonic, haemorrhoids, skin infections	Stem, twigs
Picralima nitida	Malaria, sleeping sickness, local algesic, arthritis, cough, aphrodisiac, diabetes	Seeds, stem, roots
Plumeria rubra	Laxative, fevers, skin diseases	Leaves, roots, latex
Rauvolfia vomitoria	Fevers, sedative in maniac syndromes, emetic	Roots, stem, leaves
Tabernaemontana holstii	Local pains, fevers	Roots, fruits
Voacanga africana	Diuretic, infanct tonic and convulsion prophylaxis	Root, stem bark
Asclepiadaceae		
Calotropis procera	Externally as embrocation, latex as purgative, juice from leaves used for headaches and catarrh, conjunctivitis, skin diseases, wound dressing, roots used for venereal diseases	Leaves, latex, roots

Balanitaceae		
Balanites aegyptiaca	Tonic, anti-parasitic, fevers, fish poison , abortifacient, molluscicide	Fruits, roots, stem
Balanites wilsoniana	Emenagogue, anhelmintic, fevers, anti-inflammatory	Fruits, leaves
Bignoniaceae		
Kigelia africana	Dysentery, constipation, wound dressing, boils	Roots, stem, leaves
Markhamia platycalyx	Fevers, flu, anti-microbial, coughs, conjunctivitis, stomachic	Leaves, roots
Spathodea campanulata	Fevers, wound dressing, constipation, gastrointestinal disorders	Stem, leaves
Stereosp. kunthianum	Skin eruptions, venereal diseases, wound dressing, cough	Stem bark, pods
Bombacaceae		
Bombax buonopozense	Venereal diseases, constipation, anti-viral	Leaves
Ceiba pentandra	Stimulant, laxative	Roots, leaves
Boraginaceae		
Cordia africana	Tonic for fatigue and exhaustion	Stem bark
Ehretia cymosa	Dysentery, infanti-le convulsion, bath for fevers, laxative	Roots, leaves, juice
Burseraceae		
Canarium schweinfurthii	Coughs, exudate for venereal diseases	Fruits, stem bark
Commiphora africana	Stem chewsticks, stomachic, carminative, colds	Exudate, leaves
Canellaceae		
Warburgia ugandensis	Flu, fevers, pains, stomach ache, gastrointestinal disorders	Stem bark, roots
Capparidaceae		
Cadaba farinosa	Anti-viral, analgesic	Leaves
Crataeva adansonii	Ear-ache, analgesic, wound dressing	Roots, stem bark
Euadenia eminens	Aphrodisiac, ear-ache, conjunctivitis	Seeds, roots
Maerua angolensis	Local pain relief, oral hygiene	Stem
Maerua triphylla	Ear-ache, fevers, anti-infective	Leaves, fruits
Celastraceae		
Catha edulis	Stimulant, anti-depressant	Leaves
Maytenus heterophylla	Viral infections, anti-inflammatory	Leaves, roots
Maytenus senegalensis	Dysentery, colic, anti-microbial	Roots, leaves
Combretaceae		
Combretum molle	Anthelmintic, abortifacient, stomach ache, wound dressing, fevers, colic	Leaves
Compositae		
Vernonia amygdalina	Stomachic, febrifuge, cough, anti-septic	Leaves, stem bark
Vernonia auriculifera	Fevers, medicinal container, tonic	Leaves
Vernonia conferta	Cough, stomach ache, anti-parasitic	Leaves, stem
Cycadaceae		
Encephalartos barteri	Rituals, burial rites, fruits anti-viral	Whole plant, fruits
Ebenaceae		
Diospyros mespiliformis	Fevers, dysentery, skin eruptions, root used as abortifacient, leprosy, vermifuge	Leaves, roots, bark
Ericaceae		
Agauria sailicifolia	Vermifuge, local pain remedy, haemostatic	Leaves
Euphorbiaceae		
Alchornea cordifolia	Malaria mixtures, skin infections, purgative	Roots, leaves
Anti-desma membranaceum	Fevers, treatment of threatened abortion, stomach ache	Leaves

Bridelia micrantha	Cough, laxative, diabetes	Leaves, stem bark
Clutia abyssinica	Anti-viral, anti-pyretic, analgesic	Leaves
Croton dichogamus	Anti-viral, anti-pyretic	Leaves
Discoglypremna caloneura	Purgative, abortion, poisoning	Seeds
Elaeophorbia drupifera	Local pain relief, purgative, scorpion bite	Latex, leaves
Euphorbia candelabrum	Application for eye tumours, solvent for arrow poison	Latex, leaves
Mallotus oppositifolius	Dysentery, haemorrhage	Leaves, fruits
Margaritaria discoideus	Fevers, coughs, inflammatory diseases	Root bark
Microdesmis puberula	Emmenagogue, threatened abortion, diarrhoea, aphrodisiac, skin eruptions	Leaves, whole plant
Ricinodendron heudelotii	Purgative, guinea worm extraction	Latex, leaves
Ricinus communis	Purgative, wound dressing, lactation	Seed, leaves
Synadenium granti-i	Ear-ache remedy, leprosy, fevers	Roots, leaves
Tetrorchidium didymostemon	Purgative, fevers, oedema	Stem bark, leaves
Uapaca paludosa	Bronchitis, coughs, parasitic skin diseases, male impotence	Stem bark, roots
Flacourtiaceae		
Flacourtia indica	Cough, headache, skin diseases	Leaves, fruits
Oncoba spinosa	Colds, fever, female infertility	Fruits, leaves
Hamamelidaceae		
Trichocladus ellipticus	Indigestion, laxative, anti-inflammatory	Stem bark
Hypericaceae		
Allanblackia kimbiliensis	Local pain relief, cosmetics application, anti-viral	Fruits, leaves
Garcinia livingstonei	Coughs, fevers, parastic diseases	Fruits, stem
Harungana madagascariensis	Acute stomach and toothaches, dysentery, haemorrhoids	Leaves, roots, stem
Mammea africana	Fevers, skin infections, diarrhoea, bronchitis	Fruit, leaves, bark
Psorospermum febrifugum	Leprosy, skin diseases, mouth infections	Roots
Irvingiaceae		
Irvingia gabonensis	Leaf decoction for fevers	Fruit rind, roots
Leeaceae		
Leea guineensis	Anti-infective, analgesic, anti-diabetic, aphrodisiac	Leaves, roots
Leguminosae		
Acacia albida	Childbirth, fevers, coughs, diarrhoea	Leaves, fruits
Acacia senegal	Dysentery, diarrhoea, gonorrhoea, anti-inflammatory	Fruits, bark, latex
Albizia adianthifolia	Filariasis, anodyne	Stem, fruits
Albizia anthelmintica	Fevers, skin diseases	Stem bark
Cassia sieberiana	Laxative, febrifuge	Leaves
Daniellia oliveri	Tonic, fevers	Stem bark, leaves
Dichrostachys cinerea	Analgesic, anti-viral	Fruits, leaves
Entada abyssinica	Hypotensive, analgesic	Leaves
Erythrina abyssinica	Anti-microbial, toothache, hepatitis	Leaves, stem bark
Erythrina mildbraedii	Muscular pains, sore throat	Leaves, fruits
Erythrophleum suaveolens	Rodenticide, local analgesic, poisoning	Leaves, stem bark
Leptoderris fasciculata	Cough remedy, dysentery, hiccup	Bark
Parkia filicoidea	Ointment for inflammation, eyewash, astringent	Fruits, leaves
Piptadeniastrum africanum	Aphrodisiac, tonic, enaema, urethritis, abortifacient	Fruits, leaves
Prosopis africana	Anxiety states, analgesic	Leaves
Sesbania sesban	Local application for inflammation, increased lactation in cows, stomachic	Leaves
Tamarindus indica	Tonic, cardiac disorders, laxative, fevers	Leaves, fruits
Tetrapleura tetraptera	Flatulence, jaundice, fevers, convulsions	Fruits, whole plant
Liliaceae		
Asparagus racemosus	Anti-inflammatory, diuretic, laxative	Leaves, fruits

Loganiaceae		
Anthocleista vogelli	Anti-inflammatory, anti-diabetes, wound dressing, venereal diseases	Stem bark, leaves
Nuxia floribunda	Fevers, cough, indigestion, influenza, infanti-le convulsions, rituals	Leaves
Strychnos spinosa	Fruit used as tonic, fevers, wound dressing	Fruits, leaves
Strychnos usambarensis	Local pain relief, tonic	Stem bark, leaves
Malvaceae		
Sida rhombifolia	Demulcent, emmolient, phthisis, snake bite	Whole plant, leaves
Meliaceae		
Ekebergia senegalensis	Bronchitis, fevers, urinary tract infections, epilepsy, fish poison	Roots, leaves
Entandrophragma utile	Diabetes, dressing of chronic sores	Stem bark
Guarea cedrata	Fevers, haemorrhoids	Stem bark
Khaya senegalensis	Malaria, vermifuge	Leaves, stem bark
Trichilia roka	Anti-parasitic, tonic, anti-epileptic	Stem bark, roots
Trichilia heudelotii	Febrifuge, diuretic, aphrodisiac, cardiac	Stem, roots, leaves
Trichilia prieureana	Gonorrhoea, fevers, enaema	Stem bark
Turraea robusta	Fevers, diarrhoea	Stem
Turraea vogelii	Filariasis, tonic, rituals	Leaves, stem, fruits
Melianthaceae		
Bersama abyssinica	Fever, general body pain, headache	Root
Moraceae		
Ficus asperifolia	Cough, haemorrhoids, urethral anti-septic, fever	Leaves, fruits
Ficus exasperata	Cough, venereal diseases	Leaves
Ficus natalensis	Pains, venereal diseases	Fruits, leaves
Ficus thonningii	Bronchitis, urinary tract infection	Leaves, fruits
Milicia excelsa	Tonic, inflammation	Roots, leaves, fruit
Musanga cecropioides	Facilitates childbirth, emmenagogue, fevers, abortifacient	Leaves, stem
Myrianthus arboreus	Dysentery, skin infections, anthelmintic	Leaves, root, stem
Treculia africana	Laxative, chronic cough, skin infections, anthelmintic	Fruits, leaves
Moringaceae		
Moringa oleifera	Poultice for inflammation, gonorrhoea	Roots, leaves
Myristicaceae		
Pycnanthus angolensis	Skin diseases, mouth sores, fevers	Seed fat, stem bark
Myrsinaceae		
Embelia schimperi	Anti-spasmodic, anthelmintic, stomach disorders	Leaves, stem bark
Myrsine africana	Chest pains, anthelmintic, arthritis	Fruits
Myrtaceae		
Syzigium guineense	Carminative, tonics after childbirth, abdominal pain	Buds, fruits
Ochnaceae		
Lophira lanceolata	Fevers, anti-viral, anti-inflammatory, venereal infections	Stem bark, roots
Olacaceae		
Ximenia caffra	Conjunctivitis, syphilis, toothache, headache, malaria, sleeping sickness, purgative, abscess	Roots, stem, leaves
Oleaceae		
Jasminum dichotomum	Wound dressing, parasitic skin infection, fever	Leaves, berries
Opiliaceae		
Opilia celtidifolia	Fever, flu, analgesic, anthelmintic, sleeping sickness, diuretic, purgative, psychiatry	Roots, leaves

Palmae		
Borassus aethiopicum	Bronchial complaints, coughs, asthma	Fruits, sap
Elaeis guineensis	Root analgesic, leaves anti-bacterial	Leaves, roots, fruits
Phoenix reclinata	Tonic drink, thorn ingredient in remedy for pleurodynia and pleurisy	Sap, juice
Passifloraceae		
Barteria nigritana	Fevers, aches, stomach disorders	Leaves, fruits
Phytolaccaceae		
Phytolacca duodecandra	Sponges, fish poison, purge teniafuge	Fruits, leaves
Piperaceae		
Piper capensis	Coughs, anhelmintic, fevers, insecticide	Leaves, fruits
Pittosporaceae		
Pittosporum viridiflorum	Emetic, chest complaints, malaria	Stem bark
Plumbaginaceae		
Plumbago zeylanica	Parasitic skin diseases, haemorrhoids, fevers, anthelmintic, vesicant, abortifacient, anti-inflammatory	Root, leaves, stem
Polygalaceae		
Carpabolia alba	Cough, indigestion, tapeworm, syphilis, purgative	Leaves, stem bark
Proteaceae		
Faurea saligna	Fevers, diarrhoea	Leaves, stem
Rhamnaceae		
Maesopsis eminii	Bronchitis, mouth sores, venereal diseases	Leaves, stem bark
Zizyphus mucronata	Tonic, colds, anti-pyretic	Fruits, leaves
Zizyphus mauritiana	Carminative, colds, diarrhoea	Leaves, fruits, stem
Rhizophoraceae		
Alangium chinense	Mental illness, coughs	Leaves, fruits
Rosaceae		
Hagenia abyssinica	Diarrhoea, fevers, wound dressing	Leaves
Parinari excelsa	Diarrhoea, dysentery, tonic, wound dressing	Stem, fruit
Prunus africana	Inflammation, prostate gland and kidney diseases	Roots, stem
Rubus pinnatus	Gum bleeding, diarrhoea	Roots
Rubiaceae		
Aidea micrantha	Skin diseases, fevers, parasitic infections	Stem bark, roots
Canthium rubrocostatum	General tonic, coughs, influenza, vermifuge	Roots, fruits
Crossopteryx febrifuga	Anti-pyretic, anti-viral	Roots, stem bark
Feretia apondanthera	Sedative, pain, anti-pyretic	Roots, stem bark
Gardenia erubescens	Venereal diseases, cosmetic applications, tonic, aphrodisiac	Fruit
Hallea stipulosa	Malaria, fevers, skin diseases, venereal infections	Roots, stem bark
Morinda lucida	Anti-malarial, fevers, pains	Roots, leaves
Mussaenda elegans	Colds, anti-pyretic, gonorrhoea	Roots
Nauclea diederrichii	Malaria, febrifuge	Roots, stem bark
Nauclea latifolia	Fever teas, malaria, inflammation	Roots, stem bark
Oxyanthus speciosus	Fevers, teeth cleaning	Stem, flowers
Rothmannia whitfieldii	Dysmenorrhoea, check perspiration, dye	Fruits, roots
Rothmannia longiflora	Cosmetic paint, measles, jaundice	Fruits, leaves
Uncaria africana	Cough, aphrodisiac	Stem bark, roots
Rutaceae		
Clausena anisata	Fever, headache	Roots, leaves
Zanthoxylum chalybeum	Stomach ache, skin infections, general pain relief	Roots, twigs
Zanthoxylum gilletii	Toothache, chewing stick, fevers, bacterial infections	Roots, stem, leaves

Zanthoxylum rubescens	Urinary anti-septic, venereal diseases, mouth infections	Roots, stem bark
Toddalia asiatica	Fevers, inflammation, cough, insect bites	Leaves, roots
Salicaceae		
Salix subserrata	Body pains, anti-infective	Leaves
Salvadoraceae		
Azima tetracantha	Snake bite, wound dressing, body pains	Roots
Salvadora persica	Tooth cleaning, venereal diseases, catarrh	Stem, root bark
Santalaceae		
Osyris abyssinica	Wound dressing, galactogogue, menorrhoea, infertility, venereal diseases	Leaves, roots
Sapindaceae		
Allophyllus africanus	Diarrhoea, arthritis, headache, nasal congestion, anthelmintic, colic, infanti-le fevers, haemorrhoids, lactation induction	Fruits, leaves, root
Blighia unijugata	Haemostatic, especially in childbirth, anthelmintic, tonic, fish poison	Roots, pods, leaves
Dodonaea viscosa	Febrifuge, cough	Fruits, leaves
Lecaniodiscus cupanioides	Fevers, hepatomegaly, dressing for burns, measles	Leaves, root, stem
Sapotaceae		
Bequaertiodendron natalense	Abdominal pains, tonic	Roots
Butyrospermum paradoxum	Emolient, rheumatic aches, facilitates childbirth, headache, eye bath	Seed fat, leaves
Chrysophyllum albidum	Anti-emetic, anti-malarial, anti-diarrhoeal	Fruits
Pachystela brevipes	Jaundice, nausea	Fruits, stem bark
Simaroubaceae		
Brucea anti-dysenterica	Diarrhoea, dysentery, parasitic skin diseases	Leaves
Harrisonia abyssinica	Fevers, general pain relief, dyspnea	Leaves, roots
Harrisonia occidentalis	Skin diseases, laxative	Root bark
Solanaceae		
Solanum incanum	Skin diseases, fevers, stomach ache, expulsion of placenta	Fruits, leaves, root
Sterculiaceae		
Dombeya rotundifolia	Syphilis, rituals	Stem root
Sterculia rhynchocarpa	Stomach ache, fevers	Stem bark
Tiliaceae		
Glyphaea brevis	Vermifuge, venereal diseases, aphrodisiac, analgesic, indigestion	Fruit, juice, root
Grewia bicolor	Sedative, insanity, anti-infective	Roots
Grewia mollis	Wound dressing, sweetening agent	Stem bark, leaves
Triumfettia cordifolia	Dysentery, diarrhoea, fevers	Leaves
Ulmaceae		
Celtis wightii	Diarrhoea	Roots
Trema orientalis	Cough, bronchial congestion, asthma, anthelmintic, anti-spasmodic, female infertility	Stem bark, leaves
Umbelliferae		
Steganotaenia araliaceae	Carminative, toothache, diarrhoea, abortifacient, sore throat, asthma, colds	Leaves, fruits, roots, stem
Verbenaceae		
Clerodendrum myricoides	Analgesic, anti-pyretic	Leaves
Duranta repens	Anti-fungal, skin diseases, insecticide	Fruit juice
Vitex doniana	Cough, skin infections	Leaves, fruits
Vitaceae		
Cissus quadrangularis	Anti-viral, analgesic	Leaves

REFERENCES

Abe, E. and Pomeroy, D. 1988. *Native trees and their uses.* Makerere University, Kampala.

Abura-Ogwang, D. 1994. *The national tourism development plan and its relevance for the Forest Department.* In: Springall, H. (ed.). 1994. Proceedings of a workshop on nature conservation for senior forest officers. Forest Department, Kampala.

Alexandre, D.Y. 1978. Le rôle disseminateur des éléphants en forêt de Taï, Côte d'Ivoire. *La Terre et la Vie* Vol. 32: pp47-72.

Anderson, D. 1987. *The economics of afforestation: a case study in Africa.* Johns Hopkins University Press, Baltimore.

Arnold, J.E.M. and Campbell, J.C. 1985. *Collective management of hill forests in Nepal: the community forestry project.* National Academy of Sciences, Washington, D.C.

Atlas of Uganda. 1967. *Atlas of Uganda.* Department of Lands and Surveys, Entebbe.

Aylward, B.A. 1993. *The economic value of pharmaceutical prospecting and its role in biodiversity conservation.* 76 pp. IIED, London.

Bawa, K.S. and Hadley, M. 1990. *Reproductive ecology of tropical forest plants.* UNESCO/Parthenon, Paris.

Beeby, A. 1993. *Applying ecology.* Chapman and Hall, London.

Belshaw, R. and Bolton, B. 1993. The effect of forest disturbance on the leaf litter ant fauna in Ghana. *Biodiversity and conservation*, Vol. 2: pp656-666.

Bennett, J. 1993. *The use of benefit-cost analysis in the assessment of conservation projects in developing countries.* 15 pp. University of New South Wales.

Bennun, L., Dranzoa, C. and Pomeroy, D. (unpubl.). *The forest birds of Kenya and Uganda.* Unpublished draft.

Berg, A., Ehnstrom, B., Gustafson, L., Hallingback, T., Jonsell, M. and Weslien, J. 1994. Threatened plant, animal and fungus species in Swedish forests: distribution and habitat associations. *Conservation Biology* 8: pp718-731.

Bibby, C.J., Collar, N.J., Crosby, M.J., Heath, M.F., Imboden, Ch., Johnson, T.H., Long, A.J., Stattersfield, A.J. and Thirgood, S.J. 1992. *Putting biodiversity on the map: priority areas for global conservation.* International Council for Bird Preservation, Cambridge.

Binggeli, P. 1989. The ecology of *Maesopsis* invasion and dynamics of the evergreen forest of the East Usambaras, and their implications for forest conservation and forestry practices. In: Hamilton, A.C. and Bensted-Smith, R. *Forest Conservation in the East Usambara Mountains, Tanzania.* IUCN, Gland.

Blockhus, J.M., Dillenbeck, M., Sayer, J.A. and Wegge, P. 1992. *Conserving biological diversity in managed tropical forests.* IUCN, Gland.

Brooks, D.J. 1993. *Market conditions for tropical timber products.* IIED, London.

Brown, G. and Henry, W. 1989. *The economic value of elephants.* IIED, London.

Budowski, G. 1984. Applicability of agroforestry systems. In: Gregersen, H.M. and Elzi, D. *Readings on social forestry projects.* World Bank, Washington , D.C.

Buechner, H.K. and Dawkins, H.C. 1961. Vegetation change induced by elephants and fire in Murchison Falls National Park, Uganda. *Journal of Ecology*, Vol. 42 (4): pp752-766.

Cachan, P. 1963. Signification ecologique des variations microclimatiques verticales dans la forêt sempervirante du basse Côte d'Ivoire. *Ann. Fac. Sci. Univ. Dakar*, 8: pp89-155.

Caldecott, J. 1988. *Hunting and wildlife management in Sarawak.* IUCN, Gland.

Carlson, A. 1986. A comparison of birds inhabiting pine plantation and indigenous forest patches in a tropical mountain area. *Biological Conservation* 35: pp195-204.

Chadwick, D.H. 1994. *The fate of the elephant.* Viking, London.

Chadwick, D.H. 1991. *Elephants: out of time, out of space.* National Geographic, May 1991.

Charter , J.R. and Keay, R.W.J. 1960. Assessment of the Olokemeji fire-control experiment (investigation 254) 28 years after institution. *Nigerian Forestry Information Bulletin*, 3: pp1-32.

Child, G. 1984. Managing wildlife for people in Zimbabwe. In: McNeely, J. and Miller, K. (eds.). 1984. *National Parks, conservation and development.* Smithsonian Institution, Washington, D.C.

Clark, C. 1992. Empirical evidence for the effects of tropical deforestation on climate change. *Environmental Conservation*, Vol. 19(1): pp39-47.

Collar, N.J. and Stuart, S.N. 1985. *Key forests for threatened birds in Africa.* International Council for Bird Preservation and IUCN, Cambridge.

Collar, N.J., Crosby, M.J. and Stattersfield, A.J. 1994. *Birds to watch 2: the world list of threatened birds.* Birdlife International, Cambridge.

Collins, N.M. 1980. The effect of logging on termite (Isoptera) diversity and decomposition processes in lowland dipterocarp forests. *Tropical Ecology and Development* (1980): pp113-121.

Collins, N.M. 1983. Termite populations and their role in litter removal in Malaysian rainforests. In: Sutton, S.L., Whitmore, T.C. and Chadwick, A.C. (eds.). *Tropical rainforest: ecology and management. Blackwell, Oxford.*

Collins, N.M. 1989. Termites. In: Lieth, H. and Werger, M.J.A. *Tropical rainforest ecosystems.* Elsevier, Amsterdam.

Collins, N.M. and Morris, M.G. 1985. *Threatened swallowtail butterflies of the world: the IUCN Red Data Book.* IUCN, Gland.

Connell, J.H. 1978. *Diversity in tropical rainforests and coral reefs.* Science 199: pp1302-1310.

Cunningham, A.B. 1992. *People, park and plant use: research and recommendations for multiple-use zones and development alternatives around Bwindi-Impenetrable National Park, Uganda.* CARE-International, Kampala.

Curry-Lindahl, K. 1981. *Bird migration in Africa.* Academic Press, London.

Davidson, J. 1987. *Bioenergy tree plantations in the tropics: ecological implications and impacts.* IUCN, Gland.

Dawkins, H.C. 1956. *Interim results from research plot Bunyoro RP 41.* Uganda Forest Department Technical Note no. 14/56.

Dawkins, H.C. 1958. *The management of tropical high forest with special reference to Uganda.* Imperial Forestry Institute, Oxford.

Denslow, J.S. 1980. Patterns of plant species diversity during succession under different disturbance regimes. *Oecologia* 46: pp18-21.

Deshmukh, I. 1986. *Ecology and tropical biology.* Blackwell, Palo Alto.

Diamond, J.M. 1975. The island dilemma: lessons of modern biogeographic studies for the design of natural preserves. *Biological conservation*, 7, pp. 129-146.

Diamond, A.W. and Hamilton, A.C. 1980. The distribution of forest passerine birds and quarternary climatic change in tropical Africa. *Journal of Zoology (London)* 191: pp379-402.

Dixon, J.A. and Sherman, P.B. 1990. *Economics of protected areas: approaches and applications.* East-West Center, Washington, D.C.

Earl, D.E. 1991. Introduction. In: Howard, P.C. (ed.) 1991. *Nature conservation in tropical forests: principles and practice.* Proceedings of a symposium for district and regional forest officers, Makerere, Kampala.

Earl, D.E. 1992. Wise management of natural tropical forest for timber production, tourism and wildlife. In: Miller, F.R. and Adam, K.L. (eds.). *Wise management of tropical forests. Proc. Oxford Conference on Tropical Forests.* Oxford Forestry Institute, University of Oxford.

Eggeling, W.J. 1947. Observations on the ecology of the Budongo rainforest, Uganda. *Journal of Ecology* 34 (1), 20-87.

Eggeling, W.J. 1948. Epiphytes in the Budongo Forest. *Uganda Journal*, vol. 12 (1), 106-114.

Eggleton, P., Bignell, D.E., Sands, W.A., Waite, B., Wood, T.G. and Lawton, J.H. 1995. The species richness of termites (Isoptera) under differing levels of forest disturbance in the Mbalmayo Forest Reserve, southern Cameroon. *Journal of Tropical Ecology*, Vol. 11: pp85-98.

Ehrlich, A.H. and Ehrlich, P.R. 1990. Extinction: life in peril. In: Head, S. and Heinzman, R. *Lessons of the rainforest.* Sierra Club, San Francisco.

Emmons, L.H. 1980. Ecology and resource partitioning among nine species of African forest squirrels. *Ecological monographs*, Vol. 50: pp31-54.

Erwin, T.L. 1982. Tropical forests: their richness in Coleoptera and other arthropod species. *Coleopterists' bulletin* 36, 74-45.

FAO. 1986. *Data book on endangered tree and shrub species and provenances.* FAO, Rome.

FAO. 1989a. *Management of tropical moist forests in Africa.* FAO, Rome.

FAO. 1989b. *Household food security and forestry: an analysis of socio-economic issues.* FAO, Rome.

FAO. 1992. *The state of food and agriculture 1992.* FAO, Rome.

FAO. 1993. *The challenge of sustainable forest management. What future for the world's forests?* FAO, Rome.

FAO. 1994. Forest development and policy dilemmas. In: *The state of food and agriculture 1994*. FAO, Rome.

Farnsworth, N. and Soejarto, D. 1985. Potential consequences of plant extinction in the United States on the current and future availability of prescription drugs. *Economic Botany*, Vol. 39(3): pp231-240.

Farrow, C. 1994. The people problem. *WWF News*, Summer 1994. WWF-UK, Godalming.

FFPS. 1994. International Gorilla Conservation Programme. *Fauna and Flora News*, Oct. 1994. FFPS, London.

Flatley, G. and Bennett, J. 1994. *The value of Vanuatu forest protection to Australian tourists.* 35 pp. University of New South Wales.

Gautier-Hion, A. 1990. Interactions among fruit and vertebrate fruit-eaters in an African tropical rainforest. In: Bawa, K.S. and Hadley, M. *Reproductive ecology of tropical forest plants.* UNESCO/Parthenon, Paris.

Gillis, M. 1986. *Non-wood forest products in Indonesia.* Department of Forestry, University of North Carolina.

Glowska, L., Burhene-Guilmin, F. and Synge, H. 1994. *A guide to the convention on biological diversity.* IUCN, Gland. 161 pp.

Grainger, A. 1986. *The future role of the tropical rainforests in the world forest economy.* Unpublished PhD dissertation, Oxford University, Oxford.

Hall, J.B. and Swaine, M.D. 1976. Classification and ecology of closed canopy forest in Ghana. *Journal of Ecology* 64: pp913-951.

Hambler, C. and Speight, M.R. 1995. Biodiversity conservation in Britain: science replacing tradition. *British Wildlife* 6(3): pp137-147.

Hamilton, A.C. 1974. Distribution patterns of forest trees in Uganda and their historical significance. *Vegetatio* 28: pp21-35.

Hamilton, A.C. 1969. The vegetation of south-west Kigezi. *Uganda Journal*, Vol. 33(2).

Hamilton, A.C. 1989. Climatic change on the East Usambaras. In: Hamilton, A.C. and Bensted-Smith, R. *Forest Conservation in the East Usambara Mountains, Tanzania.* IUCN, Gland.

Hamilton, A.C. 1975. A quantitative analysis of altitudinal zonation in Uganda forests. *Vegetatio* 30: pp99-106.

Hamilton, C.A. 1984. *Deforestation in Uganda.* Oxford University Press, Nairobi.

Hamilton, C.A. 1993. *The vital wealth of plants.* World-wide Fund for Nature, Gland.

Hamilton, C.A., Taylor, P. and Vogel, J.C. 1986. Early forest clearance and environmental degradation in south-west Uganda. *Nature* 320, 164-167.

Harrison, P. 1994. Not just a numbers game. *Our Planet*, Vol. 6(3).

Hawthorne, W. 1993. *Forest regeneration after logging: findings of a study in the Bia South Game Production Reserve, Ghana.* Overseas Development Administration, London.

HBEW. 1994. *Draft proceedings of Household Bio-energy Workshop held in Masindi, Uganda.* Forest Department, Kampala.

Herd, C. and Langoya, C.D. 1994. *Budongo Forest Ecotourism Development Plan.* Forest Department, Kampala.

Hobbs, R.J. and Huenneke, L.F. 1992. Disturbance, diversity and invasion: implications for conservation. *Conservation Biology* 6(3).

Holloway, J.D., Kirk-Spriggs, A H. and Khen, C.V. 1992. The response of some rainforest insect groups to logging and conversion to plantation. *Philosophical transactions of the Royal Society (B)*, Vol. 335: pp425-436.

Holmgren, P., Masakha, E.J. and Sjoholm, H. 1994. Not all African land is being degraded: a recent survey of trees on farms in Kenya reveals rapidly increasing forest resources. *Ambio*, Vol. 23 (7): pp390-395.

Hopkins, B. 1974. *Forest and savannah.* Heinemann, London.

Howard, P.C. 1991. *Nature conservation in Uganda's tropical forest reserves.* IUCN, Gland.

Howard, P.C. 1994a. *An annotated checklist of Uganda's indigenous trees and shrubs.* Forest Department, Kampala.

Howard, P.C. 1994b. Buffer zones: where do we go from here? In: Springall, H. (ed.). 1994. *Proceedings of workshop on nature conservation for senior forest officers, 19th-23rd September 1994.* Forest Department, Kampala.

Howard, P.C. 1994c. Forest conservation: a planning perspective. In: Springall, H. (ed.). 1994. *Proceedings of workshop on nature conservation for senior forest officers, 19th-23rd September 1994.* Forest Department, Kampala.

Howard, P.C. and Viskanic, P. 1994. *Biodiversity assessment for the planning of Forest Nature Reserves in Uganda.* Paper presented at IUFRO Forest Biodiversity Symposium on Measuring and Monitoring Biodiversity in Tropical and Temperate Forests, Chiang Mai, Thailand, 28th August - 2nd September 1994.

Howe, H.F. and Smallwood, J. 1982. Ecology and seed dispersal. *Annual Review of Ecology and Systematics*, 13: pp201-228.

Hughes, J.F. 1950. The influence of forests on climate and water supply. *Forestry Abstracts*, Vol. 11 (2/3).

Hungerford, H.R., Volk, T.L. and Ramsey, J.M. 1994. *A prototype environmental education curriculum for the middle school.* UNESCO, Paris.

Huntley, B.J. 1988. Conserving and monitoring biotic diversity: some African examples. In: Wilson, E.O. (ed.). *Biodiversity.* National Academic Press, Washington, D.C.

Hurtado, M.E. 1994. Changing consumerism. *Our planet*, Vol. 6 (2): pp18-20. UNEP, Nairobi.

Hutchinson, D.E. 1965. *The ecological theater and the evolutionary play.* Yale University Press, New Haven.

ITTO. 1990. *Guidelines for the sustainable management of natural tropical forests.* International Tropical Timber Organisation, Yokohama.

ITTO. 1991a. *Pre-project study on the conservation status of tropical timbers in trade.* International Tropical Timber Organisation/World Conservation Monitoring Centre, Cambridge.

ITTO. 1991b. *ITTO guidelines on the conservation of biological diversity in tropical production forests.* International Tropical Timber Organisation, Yokohama.

ITTO. 1992. *Criteria for the measurement of sustainable tropical forest management.* ITTO, Yokohama.

ITTO. 1993. *Final version of ITTO guidelines on the conservation of biological diversity in tropical production forests: a supplement to ITTO guidelines for the sustainable management of natural tropical forests.* ITTO, Yokohama.

ITTO. 1995. Global initiatives in forest policy. *ITTO Tropical Forest Update*, 5(1): pp16-17.

IUCN. 1988. *Uganda: conservation of biological diversity.* World Conservation Monitoring Centre, Cambridge.

IUCN. 1993. *Status of multilateral treaties in the field of environment and conservation.* IUCN, Bonn.

IUCN. 1994. *Guidelines for protected area management categories.* IUCN, Gland.

IUCN/UNEP/WWF. 1980. *World conservation strategy: living resource conservation for sustainable development.* IUCN, Gland.

IUCN/UNEP/WWF. 1991. *Caring for the earth: a strategy for sustainable living.* IUCN, Gland.

Iwu, M.M. 1993. *Handbook of African medicinal plants.* CRC Press, Boca Raton.

Jackson, D. 1994. Certification and the search for sustainable timber. *Oryx*, Vol. 28(4): pp216-219.

Johns, A.D. 1985. Selective logging and wildlife conservation in tropical rain-forest: problems and recommendations. *Biological Conservation* 31: pp355-375.

Johns, A.D. 1992. Species conservation in managed tropical forests. In: Whitmore, T.C. and Sayer, J.A. *Tropical deforestation and species extinction.* Chapman and Hall, London.

Johns, A.D. and Skorupa, J.P. 1987. Responses of rainforest primates to habitat disturbance: a review. *Int. J. Primatology*, Vol. 8: pp157-191.

Johnson, K.R. 1993. *Local use of Budongo's forest products.* Unpublished MSc thesis, University of Oxford.

Jonsson, T. and Lindgren, P. 1990. *Logging technology for tropical forests - for or against?* Skogsarbeten, Kista.

Kagenda, A. 1975. A factor analytic approach for the delimitation of the rainfall regions of Uganda. *East African Geographical Review*, 13: pp9-36.

Kamugisha, J.R. 1993. *Management of natural resources and environment in Uganda: policy and legislation landmarks, 1890-1990.* Regional Soil Conservation Unit, Nairobi: 100 pp.

Kanowski, P.J. and Savill, P.S. 1992. Sustainable practice. In: Sargent, C. and Bass, S.(eds.). *Plantation politics: forest plantations in development.* Earthscan, London.

Karani, P.K. 1994. *Sustainable management of tropical rainforest in Uganda.* Commonwealth Secretariat, London.

Kasenene, J.M. 1980. *Plant regeneration and rodent populations in selectively felled and unfelled areas of the Kibale Forest in south-west Uganda.* MSc thesis, Makerere University, Kampala.

Kazoora, C. 1995. Unpublished transcript of Bwindi case study given to the author by C.D. Langoya.

Keay, R.W.J. 1961. Increment in the Okomu Forest Reserve, Benin. *Nigerian Forestry Information Bulletin (New Series)* 11. Federation of Nigeria, Lagos.

Kiernan, V. 1993. US counts cost of alien invaders. *New Scientist*, 23rd October: p9.

Kingdon, J. 1990. *Island Africa: the evolution of Africa's rare animals and plants.* Collins, London.

Kingdon, J. 1973. Endemic mammals and birds of western Uganda: measuring Uganda's biological wealth and a plea for supra-economic values. *Uganda Journal* 37: pp1-7.

Kisubi, A. 1991. *Abundance and response of wild primates to forest habitats in western Uganda.* Unpublished MSc thesis, Makerere University, Kampala.

Kivumbi, C.O. and Newmark, W.D. 1991. The history of the half-mile forestry strip on Mount Kilimanjaro. In: Newmark, W.D. *The conservation of Mount Kilimanjaro.* IUCN, Gland.

Klem, C. de and Shire, C. 1993. *Biological diversity conservation and the law.* IUCN, Gland. 292 pp.

Knoch, K. and Schulze, A. 1956. *Niederschlag, Temperatur und Schwülle in Afrika.* Hamburg.

Krebs, C.J. 1985. *Ecology: the experimental analysis of distribution and abundance.* HarperCollins, New York.

Langdale-Brown, I., Osmaston, H.A., and Wilson, J.G. 1964. *The vegetation of Uganda and its bearing on land-use.* Government of Uganda.

Langdale-Brown, I. 1960. *The vegetation of the western province of Uganda.* Department of Agriculture, Kampala.

Laws, R.M., Parker, I.S.C. and Johnstone, R.C.B. 1975. *Elephants and their habitats: the ecology of elephants in North Bunyoro, Uganda.* Clarendon, Oxford.

Lea, J. 1988. *Tourism and development in the third world.* Routledge, London. 88 pp.

Lee, P.C., Thornback, J. and Bennett, E.L. 1988. *Threatened primates of Africa: the IUCN Red Data Book.* IUCN, Gland.

Lepage, M. 1983. Structure et dynamique des peuplements de termites tropicaux. *Acta Oecologia/Oecologia Generalis* 4: pp65-87.

Lindberg, G. and Hawkins, D.E. 1993. *Ecotourism: a guide for planners and managers.* The ecotourism society, Vermont.

Lockwood. 1973. *Forest resource development study: Republic of Uganda.* Lockwood Consultants, Toronto.

Longmann, K.A. and Jenik, J. 1974. *Tropical forest and its environment.* Longman, London. 196 pp.

Lundgren, L. 1993. *Twenty years of soil conservation in Eastern Africa.* Regional Soil Conservation Unit, Nairobi.

Mabberley, D.J. 1992. *Tropical rainforest ecology.* Blackie, Glasgow.

MacArthur, R.H. and Wilson, W.O. 1967. *The theory of island biogeography.* Princeton University Press, New Jersey. 203pp.

MacKinnon, J., MacKinnon, K., Child, G. and Thorsell, J. 1986. *Managing protected areas in the tropics.* IUCN, Gland.

Makombe, K. (ed.) 1994. *Sharing the land: wildlife, people and development in Africa.* IUCN, Harare.

Malaise, F. 1978. The miombo ecosystem. In: *Tropical forest ecosystems.* UNESCO, Paris.

Margules, C. and Usher, M.B. 1981. Criteria used in assessing wildlife conservation potential: a review. *Biological Conservation*, Vol. 21: pp79-109.

Mather, A.S. 1991. *Global forest resources.* Bellhaven, London.

McNeely, J.A. 1988. *Economics and biological diversity: developing and using economic incentives to conserve biological resources.* IUCN, Gland.

McNeely, J.A., Miller, K.R., Reid, W.V., Mittermeier, R.A. and Werner, T.B. 1990. *Conserving the world's biological diversity.* IUCN, Gland.

Miller, T.B. 1981. Growth and yields of logged-over mixed dipterocarp forest in East Kalimantan. *Malayan Forester*, Vol. 44: pp419-424.

Ministry of Energy, Minerals and Environment Protection. 1991. *National report on the environment and development (prepared for UNCED).* Kampala.

Mittermeier, R.A. and Bowles, I.A. 1994. Reforming the approach of the Global Environmental Facility to biodiversity conservation. *Oryx* 28 (2), 101-106.

Moench, M. 1994. *Training and planning for joint forest management.* Ford Foundation, New Delhi.

Morrisson, E. and Bass, S. 1992. What about the people? In: Sargent, C. and Bass, S. (eds.). Plantation politics: forest plantations in development. Earthscan, London.

Murnyak, D.F. 1981. Censusing gorillas in Kahuzi-Biega National Park. *Biological Conservation* 21: pp163-176.

Myers, A.A. and Giller, P.S. 1988. *Analytical biogeography: an integrated approach to the study of animal and plant distributions.* Chapman and Hall, London.

National Biodiversity Unit. 1992. *Uganda: country study on costs, benefits and unmet needs of biological diversity conservation.* Department of Environment Protection, Kampala.

NEAP. 1992. *Issues paper on terrestrial biodiversity: forestry, wildlife, tourism.* National Environmental Action Plan, Kampala.

Nicholson, J.W. 1930. *The influence of forests on climate and water supply in Kenya.* Forest Department, Entebbe.

Nisbet, E.G. 1991. *Living earth: a short history of life and its home.* Chapman and Hall, London.

Norton-Griffiths, M.N. and Southey, C. 1994. The opportunity costs of biodiversity conservation in Kenya. *Ecological Economics.*

Nummelin, M. and Hanski, I. 1989. Dung beetles of the Kibale Forest, Uganda: comparison between virgin and managed forest. *Journal of Tropical Ecology*, Vol. 5: pp349-352.

Oates, J.F., Whitesides, G.H., Davies, A.G., Waterman, P.G., Green, S.M., DaSilva, G.L. and Mole, S. 1990. Determinants of variation in tropical forest primate biomass: new evidence from West Africa. *Ecology*, Vol. 71: pp328-343.

ODA. 1992a. *Environmental synopsis of Uganda.* IIED, London.

ODA. 1992b. *Manual of environmental appraisal.* ODA, London.

Offutt, M. 1992. Tourism as a conservation strategy in the Nyungwe Forest, Rwanda. In: Sayer, J.A., Harcourt, C.S. and Collins, N.M. 1992. *The conservation atlas of tropical forests: Africa.* IUCN/World Conservation Monitoring Centre, Cambridge.

OTA. 1984. *Technologies to sustain tropical forest resources.* Office of Technology Assessment, Washington, D.C.

Palo, M. and Salmi, J. 1987. *Deforestation or development in the third world?* Finnish Forest Research Institute, Helsinki.

Panayotou, T. and Ashton, P.S. 1992. *Not by timber alone: economics and ecology for sustaining tropical forests.* Island Press, Washington, D.C.

Paterson, J.A. 1991. The ecology and history of Uganda's Budongo Forest. *Forest and Conservation History* 35.

Payne, J.B. and Davies, A.G. 1982. *A fauna survey of Sabah.* WWF-Malaysia, Kuala Lumpur.

Pearce, D.W. 1987. *Forest policy in Indonesia.* Unpublished memorandum, World Bank, Washington, D.C.

Pearce, D.W. 1988. Natural resource management and anti-desertification policy in the Sahel-Sudan zone: a case study of gum arabic. Paper presented to the UNESCO international task force on human investment and resource use, Paris. In: Pearce, D.W., Barbier, E.B. and Markandya, A. 1988. *Environmental economics and decision-making in sub-Saharan Africa.* 25 pp. IIED, London.

Pearce, D.W. and Moran, D. 1994. *The economic value of biodiversity.* Earthscan, London. 172 pp.

Pearce, D.W., Barbier, E.B. and Markandya, A. 1988. *Environmental economics and decision-making in sub-Saharan Africa.* 25 pp. IIED, London.

Pearson, D.J. and Lack, P.C. 1991. Migration patterns and habitat use by passerine and near-passerine migrant birds in eastern Africa. *Ibis* 134 (suppl. 1): pp89-98.

Peters, C.R., O'Brien, E.M. and Drummond, R.B. 1992. *Edible wild plants of sub-Saharan Africa.* Royal Botanic Gardens, Kew.

Philip, M.S. 1962. *Management of tropical high forest with special reference to the introduction of monocyclic felling in Uganda.* Forest Department, Entebbe.

Pickett, S.T.A. and White, P.S. 1985. *The ecology of natural disturbance and patch dynamics.* Academic Press, San Diego.

Pierlot, R. 1966. Structure et composition des fõrets denses d'Afrique Centrale, spécialement celles du Kivu. *Acad. R. Sci. Outre-Mer, Classe Sci. Nat. Médic., n.s.* Vol. 16. 367 pp.

Plumptre, A.J., Reynolds, V., and Bakuneeta, C. 1994. *The contribution of fruit eating primates to seed dispersal and natural regeneration after selective logging.* Budongo Forest Project, Oxford.

Plumptre, A.J. and Reynolds, V. 1994. The effect of selective logging on the primate populations in the Budongo Forest Reserve, Uganda. *Journal of Applied Ecology*, Vol. 31: pp631-641.

Plumptre, R.A. and Carvalho, J. 1991. *The marketing of Uganda hardwoods.* CMF Forst-Consult report.

Pomeroy, D.E. and Dranzoa, C. (unpublished). *Quantifying the effects of deforestation on birds: census methods and some preliminary results.* Makerere University, Kampala.

Pomeroy, D.E. 1993. Centers of high biodiversity in Africa. *Conservation Biology*, Vol. 7(4). 901-907.

Pomeroy, D.E. and Lewis, A.D. 1987. Bird species richness in tropical Africa: some comparisons. *Biological Conservation* 40: pp11-28.
Pomeroy, D.E. and Service, M.W. 1986. *Tropical ecology.* Longman, Harlow.
Poore, D. 1989. *No timber without trees.* Earthscan, London.
Poore, D. and Sayer, J.A. 1991. *The management of tropical moist forest lands: ecological guidelines.* IUCN, Gland.
Postel, S. and Heise, L. 1988. *Reforesting the earth.* Worldwatch Institute, Washington, D.C.
Rabinowitz, D. 1981. Seven forms of rarity. In: Synge, H. (ed.). *The biological aspects of rare plant conservation.* Wiley, Chichester.
Raintree, J.B. 1991. *Socio-economic attributes of trees and tree planting practices.* FAO, Rome.
Redhead, J.F. 1960. Analysis of logging damage in lowland rainforest. *Nigerian Forestry Information Bulletin (New Series),* Vol. 10: pp5-16.
Regal, P.J. 1982. Pollination by wind and animals: ecology of geographic patterns. *Annual Review of Ecology and Systematics* 13: pp497-524.
Repetto, R. and Gillis, M. 1988. *Public policies and the misuse of forest resources.* Cambridge University Press, Cambridge.
Rhodes, S. 1994. *Environmental education booklet: a guide for the DEP Programme.* Kyambogo, Kampala.
Rodgers, A. 1994. Joint forest management: experience from India and Tanzania. In: Springall, H. (ed.) *Proceedings of a workshop on nature conservation for senior forest officers.* Forest Department, Kampala.
Rogers, D. 1979. Tsetse population dynamics and distribution: a new analytical approach. *Journal of Animal Ecology* 48: pp825-849.
Rohner, U. 1978. *Comparison of pit sawing and mechanical sawmills.* Kibuye, Rwanda. Unpublished.
Ruitenbeek, H.J. 1990. *Economic analysis of tropical forest conservation initiatives: examples from West Africa.* WWF, Godalming.
Sale, J.B. 1981. *The importance and values of wild plants and animals in Africa.* IUCN, Gland.
Sanford, W.W.. 1968. Distribution of epiphytic orchids in semi-deciduous tropical forest in Southern Nigeria. *Journal of Ecology,* 56: pp697-705.
Sayer, J.A. 1991. Using non-timber forest products to support forest conservation programmes. In: Wegge, P. (ed.). *Status and potential of non-timber products in the sustainable development of tropical forests.* ITTO, Yokohama.
Sayer, J.A. 1991. *Rainforest buffer zones: guidelines for protected area managers.* IUCN, Gland.
Sayer, J.A., Harcourt, C.S. and Collins, N.M. 1992. *The conservation atlas of tropical forests: Africa.* IUCN/World Conservation Monitoring Centre, Cambridge.
Scott, P. 1994. Joint forest management: the Ugandan experience. In: Springall, H. (ed.). 1994. *Proceedings of workshop on nature conservation for senior forest officers, 19th-23rd September 1994.* Forest Department, Kampala.
Sheil, D. 1994. Naturalised and invasive plant species in the evergreen forests of the East Usambara Mountains, Tanzania. *African Journal of Ecology* 32: pp66-71.
Sheppard, S. 1995. *Recreation in forest reserves: objectives of the Forest Department.* Unpublished draft. Forest Department, Kampala. 185 pp.
Skorupa, J.D. and Kasenene, J.M. 1983. Tropical forest management: can rates of natural treefalls help guide us? *Oryx* 18(2): pp96-101.
Skorupa, J.P. 1986. Responses of rainforest primates to selective logging in Kibale Forest, Uganda: a summary report. In: Benirschke, K. (ed). *Primates: the road to self-sustaining populations.* Springer-Verlag.
Soulé, M.E., Wilcox, B.A. and Holtby, C. 1979. Benign neglect: a model of faunal collapse in the game reserves of East Africa. *Biological Conservation* 15: pp259-272.
Soulé, M.E (ed.). 1986. *Conservation biology: the science of scarcity and diversity.* Sinauer, Massachusetts.
Speight, M.C.D. 1989. *Saproxylic invertebrates and their conservation.* Council of Europe, Strasbourg.
Struhsaker, T. 1987. Forestry issues and conservation in Uganda. *Biological Conservation* 39: pp209-234.
Stuart, S.N. and Adams, R.J. 1990. *Biodiversity in sub-Saharan Africa and its Islands.* IUCN, Gland.
Swanson, T.M. 1991. *Wildlife utilisation as an instrument for natural habitat conservation: a survey of the literature and of the issues.* IIED, London.
Swanson, T.M. and Barbier, E.B. 1992. *Economics for the wilds: wildlife, wildlands, diversity and development.* Earthscan, London.
Swift, M.J., Heal, O.W. and Anderson, J.M. 1979. *Decomposition in terrestrial environments.* Blackwell, Oxford.
Swynnerton, C.F.M. 1924. *Report on the control of elephants in Uganda.* Uganda Government.

Synnott, T.J. 1975 *Factors affecting the regeneration and growth of seedlings of* Entandrophragma utile *(Dawe and Sprague) Sprague.* Unpublished PhD thesis, Makerere University, Kampala.
Synnott, T.J. 1985. *A checklist of the flora of Budongo Forest Reserve, Uganda, with notes on ecology and phenology.* Commonwealth Forestry Institute, Oxford.
Tabor G.M., Johns, A.D. and Kasenene, J.M. 1990. Deciding the future of Uganda's tropical forests. *Oryx* 24 (4): pp208-214.
Tacconi, L. and Bennett, J. 1994. *The socio-economic assessment of the Erromango Kauri protected area.* 25 pp. University of New South Wales.
Taiga Rescue Network. 1992. Forests and forestry in Scandinavia: a status report. *Taiga News*, July 1992.
Terborgh, J. 1986. *Keystone plant resources in the tropical forest.* In: Soulé, M.E (ed.). 1986. Conservation biology: the science of scarcity and diversity. Sinauer, Massachusetts.
Thiollay, J.-M. 1992. Influence of selective logging on bird species diversity in a Guianan rainforest. *Conservation Biology* 6(1).
Thomas, S.C. 1991. Population densities and patterns of habitat use among anthropoid primates of the Ituri Forest, Zaire. *Biotropica*, Vol. 23: pp68-83.
Tickell, O. 1995. Trees of life: not-so-sterile plantations. *BBC Wildlife magazine*, Jan. 1995: p12.
Tindyebwa, N.B. 1992. *Budongo Forest inventory.* Forest Department, Kampala.
Trenaman, K.W. 1955. *Working plan for the Budongo, Siba and Kitigo Central Forest Reserves, second revision period, 1955-1964.* Forest Department, Entebbe.
Tukahirwa, E.M. 1992. *Uganda: environmental and natural resource management policy and law: issues and options.* Makerere University, Kampala.
Turner, B.J. 1967. Ecological problems of cattle ranching in Combretum savannah woodlands in Uganda. East *African Geographical Review* 5: pp9-19.
Turyahikayo, G. 1994. *Energy and environmental policy.* Presentation at Uganda Household Bio-Energy Workshop, Masindi, 19/4/94.
Udarbe, M.P., Glauner, R., Kleine, M. and Uebelhor, K. 1994. Sustainability criteria for forest management in Sabah. *ITTO Tropical Forest Update*, Vol. 4(4): pp13-17.
Uganda Household Bio-Energy Workshop. 1994. Draft document of proceedings, Masindi, 19/4/94.
UNEP. 1993. Harvesting nature's diversity: indigenous knowledge and biodiversity. *Nature et Faune/Wildlife and Nature*, 9(3): pp22-28.
UNESCO. 1993. World population. *All of us*, vol. 3. Centre UNESCO de Catalunya, Barcelona.
UNESCO/UNEP. 1984. *Conservation, science and society: contributions to the first international biosphere reserve congress, Minsk.* UNESCO, Paris.
Vanclay, J. (unpublished manuscript). *Tropical forestry: challenges and prospects.*
Warren, M.S. and Key, R.S. 1989. Woodlands: past, present and potential for insects. In: Collins, J.M. and Key, R.S. 1991. The conservation of insects and their habitats. Academic Press.
Watson, D. 1988. The evolution of appropriate resource management systems. In: Berkes, F. (ed.). 1989. *Common property resources: ecology and community based sustainable development.* Bellhaven, London.
Watt, A.D. 1995. Unpublished information from presentation given to Royal Entomological Society of London Conference on Forests and Insects, London, September 1995.
WCMC. 1990. *1990 IUCN red list of threatened animals.* IUCN, Cambridge.
WCMC. 1992. *Global biodiversity: status of the earth's living resources.* World Conservation Monitoring Centre/Chapman and Hall.
Western, D. 1984. Amboseli National Park: human values and the conservation of a savannah ecosystem. In: McNeely, J.A. and Miller, K.R. (eds.). *National Parks, conservation and development: the role of protected areas in sustaining society.* Smithsonian Institution, Washington, D.C.
White, L.J.T. 1992. *The effects of mechanised selective logging on the flora and mammalian fauna of the Lopé reserve, Gabon.* Unpublished PhD thesis, University of Edinburgh.
White, F. 1983. *The vegetation map of Africa.* UNESCO, Paris. 35 pp.
Whitmore, T.C. 1978. Gaps in the forest canopy. In: Tomlinson, P.B. and Zimmermann, M.H. (eds.). *Tropical trees as living systems.* Cambridge University Press.
Whitmore, T.C. 1990. *An introduction to tropical rainforests.* Clarendon, Oxford.
Whitmore, T.C. and Sayer, J.A. 1992. *Tropical deforestation and species extinction.* Chapman and Hall, London.
Wilcove, D.S., McLellan, C.H. and Dobson, A.P. 1986. Habitat fragmentation in the temperate zone. In: Soulé, M.E. (ed.). 1986. *Conservation biology: the science of scarcity and diversity.* Sinauer, Massachusetts.
Wilson, E.O. 1988. *Biodiversity.* National Academy Press, Washington D.C.

World Bank. 1994. Forestry values: much more than meets the eye. *Environment Dissemination Notes*, No. 1. World Bank, Washington, D.C.
Wright, M. 1995. Death by a thousand cuts. *New Scientist*, 11th Feb.: pp36-40.
WWF. 1991a. *Tropical forest conservation.* WWF-International, Gland.
WWF. 1991b. *WWF fact sheets: tropical forests; endangered species.* WWF-UK, Godalming.
WWF/IUCN. 1992. *Beyond the green horizon: a discussion paper on principles for sustainable tourism.* WWF/IUCN, Gland.
Wyatt-Smith, J. 1987. *The management of tropical moist forest for the sustained production of timber: some issues.* IUCN, Gland.
Zimmermann, R.C. 1982. *Environmental impact of forestry: guidelines for its assessment in developing countries.* FAO, Rome.

PERSONAL COMMUNICATIONS

Mr. C. Bakuneeta. Director, Budongo Forest Project, Masindi, Uganda.
Dr. P.C. Howard. Senior Nature Conservation Adviser, EC Natural Forests Management and Conservation Project, Uganda Forest Department HQ, Kampala.
Mr. P. Musamali. MSc student, Makerere University Department of Zoology/Institute of Environment and Natural Resources.
Mr. I. Owiunji. MSc student, Makerere University Department of Zoology/Institute of Environment and Natural Resources.

GLOSSARY

Abiotic	Non-living.
Afrotropical	The biogeographical region covering the whole of the African continent south of the Sahara.
Albertine Rift	The western rift valley and associated mountains and lakes, running through western Uganda.
Biodiversity	The total variety of life on earth.
Biogeography	The study of distribution patterns of life on earth.
Biological Diversity	The total variety of life on earth.
Biological Inventory	A quantitative or semi-quantitative survey of plants and/or animals.
Biomass	Live weight.
Biome	A large-scale ecosystem type, defined on the basis of vegetation.
Biosphere	The thin portion of the planet, between the earth's crust and upper atmosphere, that can sustain life.
Biosphere Reserve	A protected area designated by UNESCO, whose management objectives include not only preservation but also some degree of human use, usually in defined zones.
Biotic	Living.
Bryophyte	Lower, non-flowering, plants including mosses and liverworts.
Buffer Area	A loosely-defined area outside a protected area, where it is intended that management will be influenced to favour the conservation of the protected area.
Buffer Zone	A zone within a protected area, protecting particularly sensitive areas such as strict nature reserves, from undue human pressure that may exist outside the protected area, usually by allowing some limited and controlled human use within the buffer.
Carnivore	A meat-eater.
Clear-felling	Felling the mature trees in a forest all at one time.
Climax community	The end-point of a succession.
Climax Species	Plant species that are adapted to live and reproduce in a climax community.
Community	A group of co-existing plants and animals.
Complementarity	Degree of overlap.
Conservation	Management of human use of organisms or ecosystems so that it may yield the greatest sustainable benefit to present generations, while maintaining its potential to meet the needs and aspirations of future generations.
Consumer	An organism that gets its nutrients and energy through eating others.
Consumptive Use Value	The economic value derived from using a resource and changing it in the process.
Corridor	A physical link connecting two otherwise separated areas.
Cost Benefit Analysis	A process whereby economic costs and benefits for a given situation or proposal are compared, so that the net values associated with these can be compared on a level footing.
Dbh	Diameter at breast height.
Deciduous	Loosing its leaves at certain times of the year, such as the dry or cold season.
Decomposer	An organism that gets its nutrition and energy by eating the remains of other organisms.
Deforestation	The process of replacement of forest by other land-use or vegetation types.
Degradation	The process of forest or ecosystem deterioration through inappropriate use.
Development	The process of change in human societies that is supposed to result in greater prosperity and productivity.
Discount Rate	The degree to which societies or individuals value the present over the future.
Diversity	Comprises a measure of richness (e.g. number of species) with a measure of evenness (e.g. how many individuals of species A there are compared to species B, C. etc.).
Ecology	The study of the processes and interactions between organisms and their environment.
Ecosystem	A functioning, interacting system composed of one or more living organisms and their effective environment.
Ecotone	A gradation between two ecosystems or vegetation types.
Ecotourism	A form of special-interest tourism that aims to be environmentally sustainable.
Ecotourist	A tourist who seeks pleasure from experiencing the natural environment at close quarters, without changing it significantly.
Endangered	So rare and declining that extinction is inevitable if the factors causing the decline continue to operate.
Endemic	Restricted to a certain area or geographical areas.

Endemism	The phenomenon whereby some species are found only in certain geographical areas.
Enrichment Planting	Improving the timber potential of a natural forest by underplanting it with selected seedlings of timber trees.
Environmental Conservation	The design and protection of productive and sustainable land-use systems.
Environmental Economics	Economics that seeks to incorporate many of the real economic values relating to the environment and its human use, which would otherwise be ignored.
Environmental Impact Assessment	A formal process of examining the possible impacts that a project may have on the environment, allowing the project to be modified to reduce harmful impacts or increase benefits, or scrapped altogether if necessary.
Epiphyte	An organism, usually a plant, that grows on another plant.
Equilibrium	An active balance between two states of being.
Evaporation	Loss of water (or other liquids) to the atmosphere by diffusion.
Evergreen	Plants that retain living leaves throughout the year.
Ex situ Conservation	Conservation that is carried out away from the natural environment of the species concerned, such as in a zoo or botanical garden.
Existence Value	The economic value derived from something's existence, regardless of whether it has a use to humanity or not.
Exotic	Not native to a given area.
Extant	Still existing.
Externality	An economic attribute of a system that is not normally included in an economic analysis of that system.
Extinct	No longer in existence.
Faunal Collapse	The process of extinction of animal species associated with an ecosystem that is no longer large enough to support all the extant species.
Feral	Gone back to the wild having escaped or been released from captivity, and able to establish a breeding population there.
Flowering Plant	Taxonomic group of higher plants comprising those orders whose members produce true flowers.
Food Chain	Organisms connected in series through their feeding relationships, in that each feeds on the organism forming the previous link in the chain.
Food Web	A group of organisms forming a common pool, various members of which are connected to others in the pool through their feeding relationships, in that each feeds on or is fed on by others in the same pool.
Forest Reserve	A government land designation the purpose of which is to retain that land as forest or other natural vegetation, or to encourage its conversion to forest.
Forest Stewardship	Looking after forest in a way that is environmentally sustainable over the long term.
Forestry	The science and art of managing forests and trees.
Fragmentation	The process of breaking up large and contiguous units into smaller, separated ones.
Fuelwood	Any wood whose ultimate use is for burning, whether as wood or charcoal.
Fundamental Niche	The niche of an organism whose limits are defined by the organism's responses to various attributes of its abiotic environment.
Game	Animals (including mammals, reptiles, birds and fish) which are, or have the potential to be, quarry species.
Game Reserve	A government-protected area designed to control human use of game animals.
Gap-phase Dynamics	The process of forest renewal through the natural processes of the forest cycle, especially the phase when a treefall gap appears in the canopy, allowing other tree seedling species to compete and ultimately close the gap.
GEF	Global Environment Facility, a World Bank-based mechanism for funding environmental projects in developing countries, especially in the areas of biodiversity conservation and pollution control.
Generalist	An organism that can survive and reproduce under a wide range of environmental conditions.
Genetic diversity	The degree of variation that exists at the level of genes within any species.
Global Warming	The process of gradual warming of the world's climate, brought about by human-induced changes to the biosphere, especially increased carbon dioxide in the atmosphere.
Greenhouse Effect	The heating effect associated with a rise in the level of carbon dioxide, methane and other so-called greenhouse gases in the lower atmosphere, brought about by human use of the biosphere, especially the burning of fossil fuels and the clearance of forests.
Grid Trail	A regular system of paths running at right angles to each other such that they intersect at standard intervals, hence forming a regular grid.
Guild	A group of organisms related by behaviour, or niche, rather than by evolution.

Gymnosperm	A group of higher plants including the conifers and cycads but not including most other flowering plants.
Habitat	The place or environment where an organism lives.
Herbivore	An animal that gets its nutrition and energy by eating plants.
In situ Conservation	Conservation of a species in its natural environment.
Incidental Loss	Loss of, or damage to, non-target trees in the process of extracting other trees for timber or other uses.
Indicator Group	A group of species whose presence or absence, either jointly or singly, provides information about the ecological status of the area sampled or recorded.
Integrated Forest Management	Management which maintains indefinitely, without unacceptable impairment, the productive and renewal capacities as well as the species and ecological diversity of forest ecosystems.
Interspecific	Between species.
Intraspecific	Within a single species.
Introduced	Not native to a given area, and brought there, intentionally or otherwise, by humans.
Invasive Exotic	A species that is not native to a given area and which, once established in that area, has the potential to increase out of all proportion to its abundance in its own native area, often in the process excluding species native to the area in which it is invasive.
Inventory	A quantitative or semi-quantitative survey.
Invertebrate	Any species of animal that does not have a backbone.
Island Biogeography	The theory that the species complement in any area is dynamic, and maintained by an equilibrium between immigration and local extinction. The theory states that large blocks of single ecosystem types will tend to support more species than smaller blocks, and that isolated areas will tend to have fewer species than contiguous areas of the same size.
ITTO	International Tropical Timber Organisation.
IUCN	International Union for the Conservation of Nature: The World Conservation Union.
Joint Forest Management	Management of forest reserves that is shared between the government body (such as the Forest Department) and the local community living near the forest reserve, to the benefit of both stakeholders.
Light-demander	A tree species whose seeds can only germinate in gaps in which full sunlight impinges at ground level for at least part of the day.
Logging	The process of felling forest trees and removing them as logs rather than converting them on site.
Loop Trail	A path system comprising one or more paths that start and finish in the same place, forming a loop.
Mammal	The group of backboned animals whose members have fur and suckle their young.
Management Plan	A document outlining the management proposed for a given area, and also including other sections, such as background information, that are relevant to that area's management.
Mass Tourism	Tourism that is aimed at, and appeals to, large numbers of relatively undiscriminating tourists.
Mechanical Logging	The process of extraction and primary conversion of timber trees using machines.
Microhabitat	The place where a small (to the human eye) organism lives, especially the very small details that distinguish that place from others where that organism does not live.
Minimum Viable Population	The smallest population of a species which can survive on its own at its present size in the long term.
Monitoring	Checking progress periodically.
Monocyclic	A form of natural forest silviculture whereby the forest is only entered to carry out fellings once over the time that it takes for trees of the target species to grow from sapling to commercial maturity.
Montane	Referring to, or coming from, a mountain environment, where conditions differ markedly from those in the lowlands.
Mosaic	A patchwork of two or more clearly-defined vegetation types.
National Park	A government designation of protected area, established normally for the conservation of biodiversity or wilderness, often with no or little human use.
Native	Belongs in an area and natural to it.
Natural forest	Forest that has not been extensively modified by humans, and owes it general appearance and species composition to natural processes.
Naturalised	A species that is exotic to an area, but has successfully colonised it without necessarily displacing too many native species in the process.

Nature All the plants, animals and other organisms that exist on earth, plus the natural processes acting on the earth and its inhabitants.

Nature conservation Measures taken by humans to ensure the long-term survival of plants, animals and other organisms.

Nature Reserve A designation applied to land so that its management is designed to ensure the survival of the plants, animals and other organisms that live there.

Niche The role of an organism in its community; its relationship with other organisms and with the non-living components of the ecosystem.

Non-consumptive Use Value An economic attribute which is determined on the basis of its value to humanity for uses that do not destroy or change that attribute.

Occult Precipitation Condensation derived from fog or clouds as air currents cause them to make contact with branches and other objects on which water can condense.

Opportunity Cost The value of benefits foregone by not carrying out a specific action.

Option Value The value associated with retaining the option to carry out a specific action in the future, even if it transpires that the action is never actually carried out.

Organism A living individual.

Orographic Rainfall Rainfall brought about when moist air is forced to rise over land-masses (such as mountains), cooling as it does so and thereby causing water to condense out of it.

Parasite An organism that gets its nutrients and energy by feeding on the living tissue of another organism, and not necessarily killing it in the process.

Parasitoid An organism that gets its nutrients and energy by feeding within or on the living tissue of another, invariably ultimately killing the host in the process.

Permanent Sample Plot A small area marked out in a forest, and studied intensively at intervals over a number of years to assess and quantify any changes in the structure or species composition brought about by management or by natural processes.

Pest Any organism that is living where humans do not want it to live, and causing a nuisance to humans in the process.

Photosynthesis The process whereby plants assimilate the energy in sunlight by fixing it into chemical energy in sugars.

Phytochoria Large-scale plant communities that are distinguished on the basis of high endemism, that is, few of the species contained in one of them are also found in adjacent ones.

Pioneer Species Species that are adapted to colonising disturbed areas, and which generally cannot survive in an area without disturbance.

Pit Sawing The process of cutting timber trees and converting them to planks in the forest, involving at least two people operating a large manual saw. The log is rolled onto a frame over a pit; for cross-cutting, one sawyer operates one end of the saw from within the pit below the log while the other operates the other end from on top.

Plantation A crop, normally of woody plants, where all the plants to be harvested have been deliberately planted and have not arisen through natural regeneration.

Pleistocene Ice Age A period covering tens of thousands of years, ending about ten thousand years ago, during which global temperatures were a few degrees cooler than today's, resulting in the spread of ice outwards from the poles, and the contraction of tropical forests to small pockets as rainfall declined.

Policy The framework in which an institution's activities are carried out. Often formulated into a written document.

Polycyclic A form of natural forest silviculture whereby the forest is entered to carry out fellings more than once over the time that it takes for trees of the target species to grow from sapling to commercial maturity, so that mature trees of a relatively standard size are harvested frequently but in small numbers.

Population Any group of individuals of a given species that exist together in a given area and can interbreed, yet are isolated from other similar groups of the same species.

Predator An animal that gets it nutrition and energy by feeding on other animals.

Preservation Protection without any form of human use.

Prey An organism that is eaten by another.

Primary Forest Forest that is thought to be in its natural form, unchanged by humans, and mature enough to be composed of a climax vegetation type.

Producer An organism that gets it nutrition and energy from sources other than consuming other organisms. Plants are the main producers, fixing energy from the sun and nutrients from the soil.

Production Forest Forest designated for use in producing timber or other forest products.

Production Zone A zone within a forest designated for use in producing timber or other forest products.

Protected area A general term for any area officially designated to protect the natural or semi-natural features that exist there.

Protection Forest Forest designated to serve non-exploitative functions, such as protection of watersheds, climate amelioration, or nature conservation.

Ranking The process of ordering a series according to predefined criteria.

Rarity The degree to which a species or population is comprised of relatively few individuals.

Realised Niche The extent of an organism's niche in the presence of the influence of other organisms competing with, predating on, or otherwise living in the same environment as, the organism in question.

Refugium/a A hypothetical geographical area/areas where environmental conditions are such that, due to climate or other environmental change, they provide the only suitable living area/areas for a given species that once occupied a much wider area when environmental conditions were more favourable for it.

Regeneration The process of renewal and recolonisation of an area by organisms.

Renewable Resource A resource that, if used wisely, can go on providing indefinitely because it is not finite.

Residual Stand The trees remaining standing after logging or other forms of silviculture.

Richness How many species live in an area.

Saproxylic Species which are dependent, during some part of their life cycle, upon the dead or dying wood of moribund or dead trees (standing or fallen), or upon the presence of other saproxylics.

Savannah Tropical grassland ecosystem, with or without trees.

Sawnwood Wood that has been converted into planks or other products through sawing.

Secondary Forest Forest that has regenerated or recolonised following a recent period when the area was not substantially forested.

Selective Logging Logging whereby only a few trees are selected for felling at any one time.

Semi-deciduous Forest in which a proportion of the trees shed their leaves during the dry or cold season; or trees that shed a proportion of their leaves during the dry or cold season.

Shade-bearer Tree species whose seeds can germinate under forest shade and whose seedlings can establish and survive in shade at least for a year or two.

Shade-intolerant Tree species whose seeds can only germinate in gaps in which full sunlight impinges at ground level for at least part of the day.

Shade-tolerant Tree species whose seeds can germinate under forest shade and whose seedlings can establish and survive in shade at least for a year or two.

Shadow Pricing The process of determining the value of something by extrapolation from something else whose value is thought to be comparable but is easier to measure.

Silviculture The science and art of growing and managing trees.

Skid Trail The rough track along which mechanical skidders (or draft animals) haul out logs from a forest to a loading area, for onward transport to the sawmill.

Specialist One who can only survive under a relatively limited set of environmental conditions, under which it flourishes.

Strict Nature Reserve A designation applied to land of high nature conservation value so that it can be managed to ensure the survival of the species that live there with minimal disturbance from humans.

Succession The non-seasonal, directional and continuous pattern of colonisation and extinction on a site.

Sustainable development Development that meets the needs and aspirations of people today without compromising the ability of future generations to meet their own needs.

Sustainable use Using renewable resources at rates within their capacity for renewal.

Synconium The flower-head and fruiting body of a fig plant which consists of an inrolled inflorescence so that the individual flowers line the inside of a chamber, whose only connection with the outside world is a small pore called the ostiole.

Tenure Rights associated with land, ranging from outright ownership to rights of use.

Threatened A general term for any organism whose future survival is in jeopardy because of human activities, regardless of the degree of threat.

Tourism The practice of travelling for pleasure, together with the business of providing services for such travellers.

Tourist A voluntary, temporary traveller, travelling in the expectation of pleasure for the novelty and change experienced on a relatively large and non-recurrent round-trip.

Transition Gradual change from one state to another.

Transpiration The process whereby water evaporates from the pores in the leaves of plants, and in so doing allows the plant to take up more water and nutrients from the soil.

Tropical forest A general term for vegetation types dominated by trees and growing in the tropics.

Tropical moist forest	Tropical forest that receives sufficient rainfall (total and spread) to support semi-deciduous or evergreen trees.
Tropical rainforest	Tropical forest that receives sufficient rainfall (total and spread) to be dominated by evergreen trees.
Ubiquitous	So widespread as to be found almost anywhere.
UNCED	United Nations Conference on Environment and Development, Rio de Janeiro, 1992.
UNDP	United Nations Development Programme.
UNEP	United Nations Environment Programme.
UNESCO	United Nations Education and Science Organisation
Vascular Plant	A broad category of higher plants, comprising all plants that possess a vascular system for transport of water, from ferns to flowering plants.
Vertebrate	Animals with backbones.
Vulnerable	Threatened with extinction, not imminently, but to such an extent that if the causal factors continue to operate, the species will become endangered.
Wildlife	All plants, animals and other organisms.
Woody Plant	A category that includes all plants which use lignin to strengthen their tissues, such as trees, shrubs and woody climbers.
Working Plan	Another name for the type of management plan that has a long history of use in forest departments.
WWF	World Wildlife Fund/Worldwide Fund for Nature.
Zoning	The process of dividing up a protected area geographically into different management categories, so that different parts of that area can serve different functions and conflict can be minimised.

A NATURE CONSERVATION SOURCE-BOOK FOR FORESTRY PROFESSIONALS

This volume is part of a series of reports which describe forest resources in selected Commonwealth countries.

ISBN 978-1-84859-653-5

9 781848 596535