CHAPTER 7
BIODIVERSITY

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REGIONAL SYNTHESIS

Biodiversity offers multiple opportunities for development and improving human well-being. It is the basis for essential environmental services upon which life on Earth depends. Thus, its conservation and sustainable use are of critical importance.

The opportunities and challenges associated with biodiversity typically apply over large geographical extents, although one or two issues may be more important at any given location. To avoid repetition, particular issues are highlighted in the sub-regional sections, not because they are restricted to those areas, but because they are best illustrated there. Deforestation is discussed under Central Africa, while relations between protected areas and adjacent populations are dealt with under Eastern Africa. Riparian biodiversity is discussed in Northern Africa, climate change and invasive alien species (IAS) in Southern Africa, desertification in Western Africa, and endemism in the Western Indian Ocean (WIO) islands. Habitat degradation and resource overexploitation are discussed in this regional synthesis, because they are overwhelmingly important as drivers of biodiversity loss throughout Africa.

INVENTORY OF RESOURCES

Africa is well endowed with both variety and abundance of living things, together referred to as biological diversity, or biodiversity. That biodiversity, with some exceptions, is currently in a better condition than in many parts of the world. Biodiversity can be considered at three major levels:

- The genetic variation within populations;
- The number, relative abundance and uniqueness of species; and
- The variety, extent and condition of ecosystems.

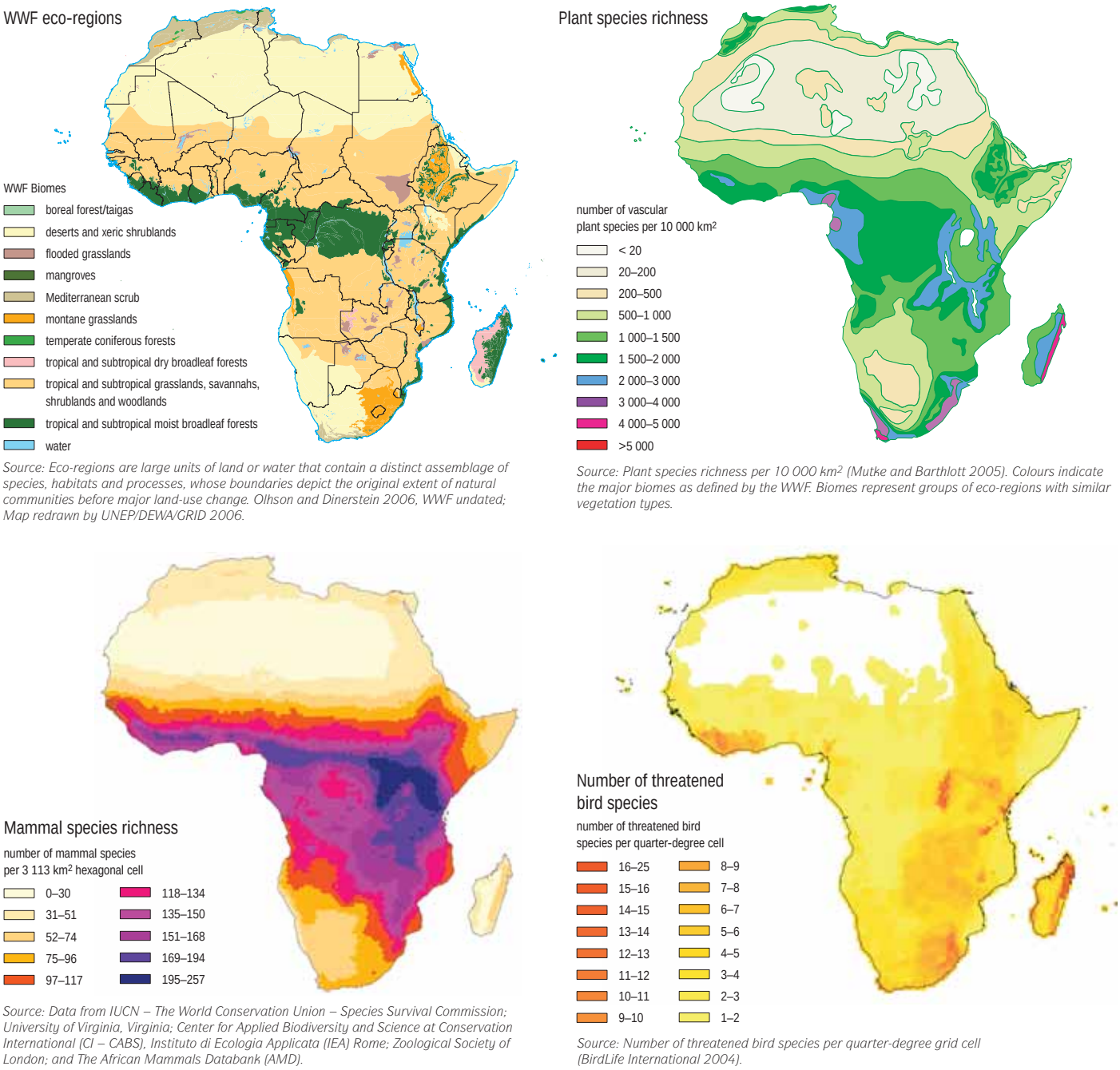
Broad geographical patterns

Ecosystems are broadly arranged in a latitudinal pattern (White 1983), with increasing species richness towards the equator (Mutke and Barthlott 2005). However, plant species richness is also high in the winter-rainfall Mediterranean climate regions of Northern Africa and the southern Cape (Cowling and others 1996). In between are the subtropical deserts, which are generally a zone of lower diversity: for example, a vast part of the Sahara, the Ténéré, is home to only 20 plant species in an area of about 200 000 km^2. Overlaid on these latitudinal patterns are pockets of rich biodiversity with small distribution ranges, particularly in tropical montane areas (Rahbek 1995). From Ethiopia to the Cape, mountains contain several centres of endemism for birds, mammals, and plants (Fjeldsa and Lovett 1997, de Klerk and others 2002). One of the most globally important centres of endemism is the coastal mountain range in the eastern part of Madagascar (Goodman and Benstead 2003).

The increasing richness of plants and vertebrates toward the equator is related primarily to climatic factors, such as water availability (Mutke and others 2001), however the diversity of land variations, such as topographic, is also important. There are exceptions to this: some areas with harsh climates including, the Namib Desert and the Karoo in the west of South Africa have an estimated 4 500 plant species, a third to one-half of which are endemic (Davis and others 1994).

Spatial patterns of diversity vary for different species, and the diversity and abundance of different species influence each other. For example, the Cape is a centre of plant diversity of global importance, but not a centre of diversity for mammals, birds, snakes and amphibians (Figure 1). The Central Zambezian Miombo

Figure 1: The distribution of biodiversity



Source: Eco-regions are large units of land or water that contain a distinct assemblage of species, habitats and processes, whose boundaries depict the original extent of natural communities before major land-use change. Olhson and Dinerstein 2006, WWF undated; Map redrawn by UNEP/DEWA/GRID 2006.

Source: Plant species richness per 10 000 km² (Mutke and Barthlott 2005). Colours indicate the major biomes as defined by the WWF. Biomes represent groups of eco-regions with similar vegetation types.

Source: Data from IUCN – The World Conservation Union – Species Survival Commission; University of Virginia, Virginia; Center for Applied Biodiversity and Science at Conservation International (CI – CABS), Instituto di Ecologia Applicata (IEA) Rome; Zoological Society of London; and The African Mammals Databank (AMD).

Source: Number of threatened bird species per quarter-degree grid cell (BirdLife International 2004).

woodlands located in Zambia, the Democratic Republic of the Congo (DRC) and Tanzania is a centre of bird diversity, but not of plant diversity.

Species richness and endemism

About 1 000 vertebrate species occur in just 4 of the 119 eco-regions (covering about 8 per cent of Africa's total area): Northern Acacia-Commiphora bushlands and thickets, Northern Congolian forest-savannah mosaic, Albertine Rift montane forests and Central Zambezian Miombo woodlands (Burgess and others 2004).

A quarter (1 229 species) of the world's approximately 4 700 mammal species occur in Africa (Brooks and others 2001), including about 960 species in sub-Saharan Africa (SSA) and 137 species in Madagascar. The eastern and southern savannahs host large populations of mammals, including at least 79 species of antelope (Klopper and others 2002).

More than 2 000 bird species occur, constituting more than a fifth of the approximately 10 000 bird species in the world, (Burgess and others 2004, BirdLife International undated). About 1 600 bird species are endemic to SSA (Jetz and Rahbek 2001). Bird species richness is highest in Eastern Africa around the Albertine Rift montane forests, the Victoria basin forest-savannah mosaic, East African montane

Box 1: Plant Diversity: Kupe-Bakossi

The area of Kupe-Bakossi, 100 km north of Cameroon's second city of Douala, is a highly diverse region, with two extinct volcanoes (Mwanenguba and Edib), river valleys, grassland and some of the wettest forest in Africa. It is also the top centre for documented plant diversity in mainland tropical Africa, with a total of 2 440 species of which 82 are strictly endemic and 232 are threatened with extinction according to IUCN 2001 criteria. This richly diverse area has been under threat both from illegal logging and encroaching farmland. Among recently documented species is a new Cola species, an orchid species and genus not seen since it was discovered around 30 years ago on a tree that had just been felled in a logging operation, *Ossiculum aurantiacum*, a new mint specific to waterfalls, *Plectranthus cataractarum*, a new shrimp plant, *Justicia leucoxiphus*, as well as three new species of coffee.

Source: RBG 2005

Ossiculum aurantiacum is a highly attractive and critically endangered orchid, endemic to Cameroon.

Source: H. Beentje

forests, Northern Congolian forest-savannah mosaic, and then into the *Acacia-Commiphora* bushlands and thickets and the Central Zambezian Miombo woodlands. The large size of these eco-regions, their high level of habitat heterogeneity, and their presence on a migratory flyway explain this pattern. The next highest band of species richness is found across the remainder of the tropical belt, with the exception of the western portion of the Upper Guinea forests and the centre of the Congo basin. The eco-regions of Madagascar and other offshore islands all have much lower bird species richness than the continental mainland (Burgess and others 2004).

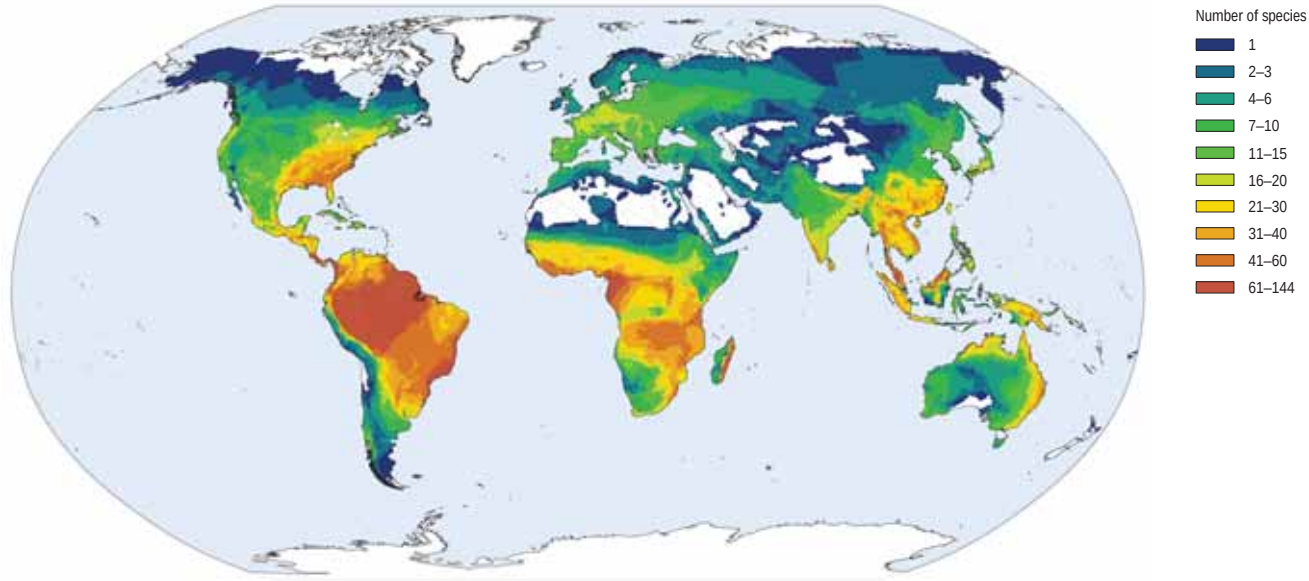
Africa has about 950 amphibian species (GAA 2004); however numerous new species and even genera are described every year. The highest levels of amphibian species richness occur in the DRC (210), Cameroon (189) and Tanzania (157); these countries are also ranked among the 20 countries with the highest level of diversity and endemism (GAA 2004). The fauna of Madagascar are particularly undersampled: from 1990 to 1999 discoveries of new amphibian and reptile species increased the number of known species by 25 per cent and 18 per cent, respectively (Goodman 2004). The Congo basin is also under-represented due to inadequate surveys (GAA 2004).

Overall plant richness at species, genus and family level is lower than that of other tropical areas. The African mainland has between 40 000 and 60 000 plant species (Beentje and others 1994, Beentje 1996), of which approximately 35 000 are endemic. South America, by comparison, has about 90 000 plant species (Frodin 2001) in an area 40 per cent smaller. Parts of the Congo basin have moderate levels of plant species richness, comparable to many parts of Central Europe (Barthlott and others 2005). This is a consequence of major extinction events due to historic climate variations (Hamilton and Taylor 1991, Davis and others 1994) and fewer major tectonic events, which are thought to having triggered the evolution of many species in the South American Andes (Burgess and others 2004). Five of the 20 global centres of plant diversity are located in Africa. More than 3 000 plant species per 10 000 km^2 occur in the Cameroon-Guinea centre, the Capensis centre, the Maputaland-Pondoland centre, the Albertine Rift centre and the Madagascar centre (Barthlott and others 2005).

At least a sixth of the world's estimated 270 000 plant species (Groombridge and Jenkins 2002) are endemic to Africa. The Cape Floral Kingdom, a global centre of plant endemism (Barthlott and others 2005) has about 9 000 vascular plant species occurring in an area of 90 000 km^2 (Goldblatt and Manning 2000) of which about 69 per cent are endemic. More than 12 000 plant species occur in Madagascar, at least 81 per cent of which are endemic (Davis and others 1994), which is an exceptionally high proportion by global standards. More recent studies suggest that these figures for species richness and endemism in Madagascar may be underestimates (Goodman 2004).

Southern Africa has a rich and varied insect and arachnid fauna, with at least 580 families and about

Figure 2: Global diversity of amphibians



Source: GAA 2004

100 000 species recorded (Barnard 1998).There is a high diversity of butterflies in the rainforests of the upper Guinea, the Albertine Rift, and the Congo basin, as well as in the Central Zambezian Miombo woodlands (Burgess and others 2004). Namibia is thought to be one of the global centres of arachnid richness (Barnard 1998) and about one-third of the Southern African insect species are believed to occur in Namibia, although less than a quarter of these species are described.

Africa has several global centres of freshwater biodiversity (Groombridge and Jenkins 2002) and many of these are also centres of intensive fishing activity. Centres of species richness and endemism for freshwater fish, molluscs and crustacea are located in the upper Guinea river region (mainly Guinea and Liberia), Cabinda (DRC), and the eastern part of Madagascar. It is conservatively estimated that Africa has at least 2 000 fish species, which is thought to be the highest species richness in the world (Klopper and others 2002). The explosive diversification of certain types of fish, such as the Cichlidae in the Great Lakes, has contributed to this richness. Fish species richness in the Congo basin is second only to that of the Amazon basin. Data on endemism is inadequate (Groombridge and Jenkins 2002). Fish diversity at the family level is somewhat lower than in southern America and Southeast Asia.

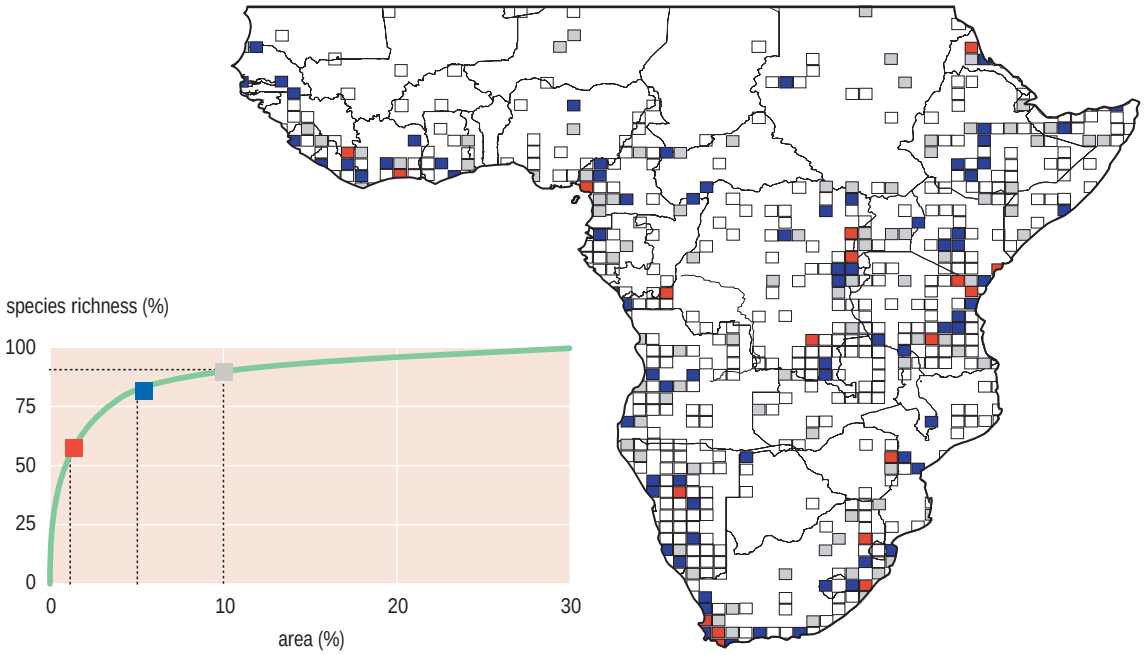
The coastal and marine ecosystems along Africa's 40 000 km coastline contain a high marine biodiversity, with overlapping centres of endemism of, for example, fish, corals, snails and lobsters at the coast of eastern South Africa and in the Red Sea (Roberts and others 2002). See also Chapter 5: *Coastal and Marine Environments*.

Centres of biodiversity

Biodiversity information is patchy for many organisms. Centres of biodiversity are located in the following eco-regions: Mt Cameroon and Bioko montane forests, overlapping with the Cross-Sanaga-Bioko coastal forests; the Cameroon highlands' forests; the Eastern Arc forests and the northern Zanzibar-Inhambane coastal forest mosaic; the Guinea montane forests and the western Guinea forests; the Drakensberg montane grasslands and forests; the Albertine Rift montane forests and the upper Guinea lowland rain forests.

Nearly two-thirds (62 per cent) of SSA species of plants and vertebrates can be represented (though not necessarily adequately protected) in approximately 1 per cent of its land area, as shown in Figure 3. This 1 per cent area includes key taxon-specific centres of diversity (such as the Cape for plants) and a few multi-taxon centres of biodiversity such as, for example, Mt Cameroon, East Usambaras, Mt Nimba, Western Ruwenzori, Mt Elgon and parts of the upper Guinea lowland forests. Many of the represented species are endemic to these areas. To include all vertebrate and plant species occurring in SSA in protected areas, about a third of its total area would need to be included into conservation strategies. Hence, identifying locations of high biodiversity in several major groups, so that a high proportion of biodiversity can be protected in a comparatively small area, is an important research goal.

Figure 3: Plant and vertebrate diversity



The figure shows the proportion of plants, birds, mammals, snakes and frogs species in SSA that can be represented by hypothetical sets of areas of varying size. The solid black curve indicates the proportion of species represented by successively cumulating areas that cover a maximum number of species for each of the groups. The map indicates the location of one-degree grid cells that are part of selected area sets. For example, within 1 per cent of SSA (red one-degree grid cells), 58 per cent of all 9 692 included species can be represented in at least one grid cell. To represent all species, approximately 30 per cent of SSA is needed (represented by all coloured grid cells plus the open cells framed in grey).However, areas which represent many species are not necessarily priority areas for conservation.

Sources: Plant distribution data: Biogeographic Information System on African Plant Diversity (Küper and others 2004). Vertebrate distribution data: Zoological Museum, University of Copenhagen (Fjeldsa and others 2004)

Ecosystem change and conservation

In comparison with most other parts of the world, such as eastern Europe, North America and Southeast Asia, Africa's biodiversity is still in good condition (Hoekstra and others 2005, Scholes and Biggs 2005). Contemporary biodiversity patterns are strongly influenced by land-use patterns of mammalian herbivores and people. However:

- Approximately half of Africa's terrestrial eco-regions have lost more than 50 per cent of their area to cultivation, degradation or urbanization (Burgess and others 2005).
- Eco-regions that have gone through more than a 95 per cent transformation include the Mandara Plateau mosaic, Cross-Niger transition forests, Jos Plateau forest-grassland mosaic, and Nigerian lowland forests.
- Nine other eco-regions have lost more than 80 per cent of their habitat, including the species-rich lowland Fynbos and Renosterveld and the forests and grasslands of the Ethiopian Highlands.
- The Mediterranean woodlands and forests have lost more than 75 per cent of their original habitat, and the few remaining blocks of habitat are highly fragmented (Burgess and others 2005).

Africa has over 2 million km² of protected areas.

IUCN-WCPA undated

The challenges and opportunities associated with human activities are also considered in relation to specific themes in the other chapters of this section.

Africa has over 2 million km² of protected areas (an area four times the size of Spain) (IUCN-WCPA undated). The eco-regions under the best protection tend to be the savannah habitats, particularly those of Eastern and Southern Africa (Burgess and others 2005). Charismatic animals, such as large mammals, are much better covered by the current network of protected areas (de Klerk and others 2004, Fjeldsa and others 2004) than, for example, plants (Burgess and others 2005). Many range-restricted species are not adequately included in these areas (Rodrigues and others 2004).

The least protected areas are found in Northern Africa, Madagascar, the drier parts of South Africa, and in the most heavily deforested parts of Western and Eastern Africa (Tables 1-6). Of the 119 ecoregions, 89 have less than the 10 per cent of their area officially protected, which is the guideline suggested by the 2010 biodiversity targets of the Convention on Biological Diversity (CBD). Some of the least well-protected eco-regions are also those with high biodiversity values, including Mt Cameroon and the

Bioko area, the Eastern Arc forests, the Succulent Karoo, the Ethiopian montane forests, the lowland Fynbos and Renosterveld, the western Guinean lowland forests, the east African montane forests, the Albertine Rift montane forests, and the Northern Zanzibar-Inhambane coastal forest mosaic.

Endowments and opportunities

There is a considerable overlap between historic cultural centres and centres of biodiversity. Some factors promoting high biodiversity, such as perennial water availability, environmental heterogeneity and fertile soils have also favoured human settlement (Balmford and others 2001). In general, patterns of biodiversity and language diversity coincide (Moore and others 2002), and show parallel extinction risks (Sutherland 2003), suggesting that cultural cohesion and biodiversity sustainability are closely linked.

The most important centres of vertebrate and plant diversity are inhabited by more than 100 million people (Balmford and others 2001) and are areas of intensive land use. These have been identified as "hotspots" (Myers and others 2000). In Africa, these are the Cape Floristic Region, the Coastal Forests of Eastern Africa, the Eastern Afromontane, the Guinean Forests of West Africa, the Horn of Africa, Madagascar and the Indian Ocean Islands, Maputaland-Pondoland-Albany and the Succulent Karoo (CI 2006). Despite their proximity to metropolitan areas and despite often being completely surrounded by transformed land, many sites of primary vegetation remain within hotspots (for example, the Taï and Banco national parks of Côte d'Ivoire, the Table Mountain National Park of South Africa, and parts of the coastal forests of Eastern Africa); these areas contain irreplaceable habitats for endemic species. For example, the Taï National Park currently represents at least 40 per cent of the total remaining forest area of Côte d'Ivoire (Poorter and others 2004).

There are at least two fundamental reasons for Africa's biodiversity richness:

- First, it has occupied its position astride the equator for hundreds of millions of years. Its life forms have not, during this period, been wiped clean by glaciers or inundated by oceans, and have been able to gradually accumulate new varieties.
- Second, perhaps because Africa has been occupied by humans for longer than any other continent, it has not suffered the mass extinctions that followed the arrival of the human species elsewhere.

In this place where humans evolved, people coexisted with other living things, at least until the modern era. That situation is rapidly changing. Major increases in the human population and rising wealth create pressures on land, and on freshwater and marine ecosystems. Global trade has intensified the demand for animal products, tropical timbers, cash crops and seafood. At the same time, global connectedness has brought new problems, such as global climate change, IAS, the spread of viral diseases, and the introduction of new technologies. The result is that biodiversity, so persistent for millions of years, is now under unprecedented threat. These human drivers and pressures are discussed more fully in Chapter 1: *The Human Dimension*.

Biodiversity underlies the provision of a large variety of benefits that people obtain from ecosystems (MA 2006). These include environmental goods, such as food and wood for energy, and ecosystem functions that depend on particular organisms, for example pollination by bees, or nitrogen fixation by symbiotic bacteria in the roots of legumes. Living organisms are critical in creating the environmental conditions on Earth that make it habitable to humans and many other species by, for instance, regulating the climate and atmospheric composition (Lovelock 1979, Steffen and others 2004, MA 2006).

Women collecting NTFPs in a forest, Cameroon.

Source: J. Nguieburi/CIFOR

Environmental goods

Many important food crops originate in Africa, including several species of millet and sorghum, one species of rice, the grain crop teff, and the oil palm. Globally, about 7 000 of the 270 000 known plant species have been used as food (FAO 1997), but only about 200 have been domesticated, and just 20 of these are of major economic importance (Groombridge and Jenkins 2002). About two-thirds of the overall calorie intake is provided by ten crops (FAOSTAT 2005). Globally, only 30-40 species (0.25 per cent of 15 000 species of mammals and birds) have been used extensively in livestock production, and fewer than 14 account for over 90 per cent of livestock production (FAOSTAT 2005). African biodiversity is closely linked to nutrition and achieving food security. Nearly three-quarters of the recorded protein consumption in Africa is derived from plant sources (FAOSTAT 2005). In rural areas, essential micronutrients are derived from eating a large variety of plant foods. Foods from the wild are particularly important in times of stress – drought, ill-health and economic change – and, as discussed in Chapter 9: *Genetically Modified Crops*, shifts to monoculture may present threats to biodiversity, human health and food security. Much of the animal protein consumed is either directly harvested from wild populations (fisheries and bushmeat), or produced through grazing of natural ecosystems by domestic livestock. Freshwater fish is a key source of protein. For example, in hyper-arid Mali, fish makes up 60 per cent of the total animal protein consumed annually (Quensière 1994, MA 2006). In Central and Western Africa, bushmeat (wild animals and birds) is a major source of animal protein, making up more than 80 per cent of consumption in some areas (Robinson and Bennett 2000). Milk, often in sour form, is also an important protein source (FAOSTAT 2005).

Freshwater fisheries, such as those at lakes Victoria, Tanganyika and Malawi, support subsistence livelihoods and enterprises at multiple levels. Wetland systems, including those of Lake Banguelu, the Kafue floodplain and the Okavango delta, are also important sources of food. Important commercial marine fisheries are located off the west coast of Southern Africa (South Africa, Namibia and Angola), the Horn of Africa, and off the coast of Mauritania in Western Africa; collectively these provide about half of the total catch. These fisheries are centred on commercially important species such as hake, anchovy and pilchard, and the associated industries are an important source of employment. Chapter 5: *Coastal and Marine Environments* considers the importance of fisheries.

Forests and woodlands provide a wide range of environmental goods and an overview of these is given in Chapter 6: *Forests and Woodlands*. Over 80 per cent of people rely on wood or charcoal for domestic cooking and heating (IEA 2002), as processed fossil fuels are too expensive. Charcoal tends to be preferred in most urban areas, as the energy content per unit mass is about double that of wood. Charcoal is also cleaner-burning at the point of consumption than wood, so that the health impacts of charcoal are about four times lower than that of wood (IEA 2002), but the total greenhouse gas (GHG) emissions (including the making of the charcoal using earth kilns which are not efficient) are higher. Forests and woodlands also provide poles,

Box 2: Livestock production, biodiversity and human well-being

Most domestic livestock is grazed in natural or semi-natural ecosystems, rather than on planted pastures. Domestic livestock consists primarily of cattle in areas that receive more than 450 mm mean annual rainfall, and of sheep and goats in drier areas (Scholes and Biggs 2004). The natural grass and tree growth provides feed at almost no direct input cost to the livestock owners and, provided that the stocking rates are within the productive capacity of the land, at relatively low cost to biodiversity (Scholes and Biggs 2005). In contrast, raising livestock on planted pastures, or on grain-based feeds in feedlots, as practised in many western agricultural systems, entails substantial input costs, and has major on- and off-site impacts on biodiversity.

The services provided by livestock extend beyond food. In many rural agricultural societies, cattle are important assets and status symbols. In the absence of a banking system, animals are sold when large expenses need to be met (WRI and others 2005). Oxen, and donkeys in poorer communities, provide transport and draught power for ploughing.

The genetic diversity of indigenous cattle breeds has proven invaluable over the past 50 years in providing disease resistance and climate tolerance to imported European breeds (see for example OSU 1996 and ARC-AII undated), and the conservation of traditional livestock diversity is receiving belated attention through the research of organizations such as the International Livestock Research Institute (ILRI) based in Nairobi, Kenya.

Sources: Scholes and Briggs 2004, WRI and others 2005, OSU 1996, ARC-AII undated.

bark string and thatch for houses and livestock pens. Especially in rural areas with only a partial cash economy, natural ecosystems are the main source of building material, which would be unaffordable if it had to be purchased. Several forest and woodland species are important as commercially traded timber, especially for the furniture industry. These include species such as *Pterocarpus angolensis* and *Melia*. Most of these species are harvested from natural ecosystems, although some are now being established as plantations.

Natural ecosystems provide a wide variety of plants and animals that are important for traditional medicines and modern pharmaceutical products. Up to 80 per cent of people make some use of traditional medicine (WHO 2003), which draws on a wide variety of indigenous plants and animals, and especially on rare or unusual organisms. Important modern pharmaceutical products are derived from certain plants, as discussed in Chapter 1: *The Human Dimension* and Chapter 6: *Forests and Woodlands*. For example, the Namibian devil's claw (*Harpagophytum procumbens*) is used locally for digestive problems, arthritis and low back pain, and supports lucrative trade. The bark of the afromontane tree *Prunus africana* is the source of a commercial prostrate remedy. Pharmaceutical bioprospecting is likely to increase in coming years, especially as new methods that utilize evolutionary and ecological knowledge enhance productivity. The 2004 global market for herbal medicines, including herbal products and raw materials, was estimated to be US$65 000 million (Lambert and others 2005). As a source of income, medicinal plants compare favourably with coffee, oil palm, cocoa and cotton, and they do not appear to be affected by the Organisation for Economic Cooperation and Development's (OECD) market and trade barriers which affect other commodities from developing countries (Lambert and others 2005). Rural communities have a great opportunity to effectively use their local knowledge to become serious players in the global herbal medicine market.

Many plants and animals originating in Africa are important commercial trade products. Coffee (*Coffea arabica* and *Coffea robusta*) originates in Ethiopia and ranks among the five most valuable agricultural exports from developing nations (FAOSTAT 2005), employing about 25 million people worldwide (O'Brien and Kinnaird 2003). *Aspalathus linearis* (*Rooibos* tea), originating from South Africa, is now traded globally in the fast-growing speciality tea industry. The world's ornamental flower market includes a substantial number of species derived from Africa: *Gladiolus*, *Pelargonium*, *Geranium*, *Strelitzia*, *Viola*, *Protea*, *Kniphofia* and *Zantedescia*. The growing international pet trade includes several African species, including many endemic cichlid fish species from Africa's rift valley lakes for aquariums. Key trade-related concerns include: the illegal (and often wasteful) harvesting from wild populations of often rare species; the accrual of benefits to individuals, whereas the costs are borne by society as a whole; and international intellectual property rights and patent agreements which can deprive local people of benefits. Currently, relatively little of the value derived from species originating in Africa accrues to Africa. Ensuring that such benefits are captured in future represents a major opportunity for expanding biodiversity-based development. Some of the problems associated with realizing these opportunities are discussed in Chapter 1: *The Human Dimension*.

Prunus africana is a valuable medicinal plant, Cameroon.

Source: O. Ndoye/CIFOR

Environmental services

Biodiversity has "intrinsic value" – or value for its own sake – but it also has significant value in all cultures for the things that it provides: food, medicine, building and craft materials and spiritual, cultural and aesthetic services. Less obvious, but just as important, are the services that allow natural and human-altered ecosystems (such as agricultural and urban landscapes) to function properly – regulating the climate, soil fertility, and the outbreak of pests and diseases. Some level of biodiversity – the exact amount is at this stage unknown – is a necessary condition for the delivery of ecosystem services, but it is especially important for

maintaining functional ecosystems (MA 2006). The value of ecosystem services can sometimes be expressed in monetary terms (Costanza and others 1997, UNEP 2002) but these estimates are very contentious, and are not the only way of expressing importance. Value can, for instance, be measured in terms of other aspects of human well-being, such as health, security or good social relations. Other aspects related to value and livelihoods are considered in Chapter 1: *The Human Dimension*.

Ecosystem services depend not so much on the absolute number of species present, but on the diversity of the functions performed by different members of the ecological community. The preservation of the natural biodiversity of an area and genetic diversity of crop species can enhance resistance to invasion by pests and diseases thus reducing agricultural losses. Planting a variety of crop species and varieties, and preserving their wild relatives, increases crop resistance to pests and diseases and thus the probability of meeting food needs. Ethiopia and the Upper Nile are recognized as global centres of crop plant genetic diversity (Hawkes and Worede 1991). Agro-biodiversity farming practices can enhance biological control and reduce the dependency and costs associated with biocides in monocropping systems (MA 2006). Similarly, natural and semi-natural ecosystems, both terrestrial and marine, appear to be more resistant to IAS if the number, types and relative abundance of native species are preserved (MA 2006).

Biodiversity can provide pollution detoxification and control. Certain aquatic and marine organisms provide water filtration services that significantly reduce the impacts of pollution on water quality. For example, the hydrological processes in wetlands, and particularly the slowing down of water-flow by vegetation and the creation of anaerobic zones, bring about the deposition of heavy metals from streams and rivers, reduction in nitrogen loading through denitrification, and reduction of pathogens through predation by other micro-organisms. Well-vegetated watersheds significantly reduce the volume of sediment flowing down rivers. Protecting the ecosystems and organisms that provide such services is generally far more cost-effective than the alternative of building and operating water filtration plants. In the context of the oceans, some marine microbes can degrade toxic hydrocarbons such as those released in an oil spill, providing valuable pollution processing services.

Ecosystem biodiversity – both terrestrial and marine – influences climate at local, regional and global scales. The type and distribution of habitats and the functional

• Some level of biodiversity – the exact amount is at this stage unknown – is a necessary condition for the delivery of ecosystem services, but it is especially important for maintaining functional ecosystems. •

MA 2006

Africa's biodiversity is remarkably intact. Miombo woodlands in eastern Zimbabwe.

Source: Y Katerere

diversity of terrestrial plants influence the reflection of incoming radiation from the sun back to space, evapotranspiration, air temperature, fire regime and carbon sequestration, all of which influence climate (MA 2006). It has been suggested that human-induced changes to the vegetation in the semi-arid Sahel has contributed to decreased precipitation since the 1970s and to desertification (Thomas and Middleton 1994). Marine biodiversity plays a major role in climate regulation, particularly through its effects on nitrogen cycling and carbon sequestration. If there were no life in the ocean, transfer of carbon dioxide from the atmosphere to the sea floor would cease, and atmospheric carbon dioxide levels would rise (MA 2006).

Recreational and spiritual values

People of all cultures and income levels value the cultural, spiritual, religious, educational and aesthetic benefits of biodiversity (Biggs and others 2004, MA 2005). Traditional societies express these values in the form of sacred species, ecosystems and landscapes, while urban and developed societies express this in the form of protected areas and heritage sites. Many religions attach spiritual values to ecosystems or components of ecosystems, such as trees, hills, rivers or groves. Loss or damage to ecosystems can therefore harm social relations by, for example, impeding religious and social ceremonies that bind people (MA 2003, MA 2005). Biodiversity also has intrinsic value for many people: it is valued as an end in itself, apart from any use value that it provides to people.

Nature-based tourism

Nature-based tourism is one of the fastest-growing tourism sectors worldwide and in Africa (Scholes and Biggs 2004). It depends on the conservation of natural landscapes and wildlife, so that using ecosystems in this way can jointly promote human well-being and biodiversity conservation if well managed. International tourism represents about 7 per cent of the worldwide export of goods-and-services, ranking fourth after exports of chemicals, automotive products and fuels (Christ and others 2003). Nature-based tourism makes up approximately half of the total tourism market

Box 3: Increasing the opportunities associated with nature-based tourism

Nature-based tourism is sometimes the most profitable use of the land for the individual land-user, particularly in arid areas or areas with poor agricultural soils (Barnes 1995; Barnes and others 2001). Taking costs and benefits as a whole, its net social benefit is often positive, especially when compared to highly-subsidized land uses(Scholes and Biggs 2005). For example, the effective management of a protected-area network in Madagascar would cost approximately US$18 million annually in management, but would generate more than US$20 million annually in net local benefits from nature-based tourism, watershed production and direct payments for biodiversity conservation (Carret and Loyer 2003). Nature-based tourism tends to be labour-intensive, and in the context of the high unemployment rates, this is a significant development advantage.

Several significant challenges remain to increasing Africa's share of the world's tourism market:

- Tourism is highly sensitive to political and economic instability and increasing the opportunities for peace through regional cooperation is important.
- Poor infrastructural development, both in terms of air and road transport, affect markets.
- The threat of diseases, such as malaria, also affects potential markets.

A second set of challenges centres on the distribution of costs and benefits between foreign and local recipients, and between local people and urban elites. In the worst cases, the brunt of the costs, such as denial of access to grazing land and wild food sources, are borne by the local people, while the bulk of the benefits are enjoyed by foreign owners and middlemen in the tourism market chain. In best practice examples, the costs to local people are minimized by negotiated access, and the benefits are spread by joint ownership, profit-sharing, preferential employment, associated enterprises (eg craft industries) or outsourcing schemes (eg vegetable growing, transport services). Africa has a number of successful ventures based on cooperation with communities, including the Campfire programme in Zimbabwe, initiatives with the Himba people in Namibia and the Makuleke and Mier communities in South Africa, and Wilderness Safaris in Botswana.

Sources: Scholes and Briggs 2004, WRI and others 2005, OSU 1996, ARC-All undated.

(Christ and others 2003). The significance of this sector is discussed more fully in Chapter 3: *Land* and Chapter 5: *Coastal and Marine Environments*.

Adding value to genetic resources

Genetic resources include all chemical and genetic information of substances that could be used as biochemical precursors in the synthesis of pharmaceutical or agricultural products. Selecting substances for investigation often depends on traditional knowledge about which plants or animals are used for specific purposes.

There is a substantial global market for pharmaceutical value-addition to genetic resources. Global sales of pharmaceuticals amounted to US$300 000 million in 1998. Of the 25 per cent best-selling drugs worldwide in 1997, 42 per cent of sales came from biological or natural products, or entities derived from natural products, with a total value of US$17 500 million (Newman and Laird 1999). Despite the technical progress in the development of fully synthetic drugs, 11 per cent of the 252 drugs considered as basic and essential by the World Health Organization (WHO) originate exclusively from flowering plants (Rates 2001). The pharmaceutical industry is highly research-intensive. Of the average expenditure of US$500 million on the development of a new drug, about 37 per cent is spent during the "discovery phase" (Laird 2002). Of the approximately 120 pharmaceutical products derived from plants in 1985, 75 per cent were discovered by studying their traditional medical use (Farnsworth and others 1985). Traditional African cultures have a deep knowledge of their natural environment, sometimes accumulated over thousands of years. Chapter 1: *The Human Dimension* and Chapter 6: *Forests and Woodlands* look at specific examples of the value of commercializing this knowledge.

A second important market for genetic resources is the agro-industry. Responding to global and regional market and financial pressures, farmers now grow a limited number of high-yielding varieties of food crops. This may result in higher income in the short term, but makes production more susceptible to disease or environmental problems, and more dependent on fertilizers and pesticides. Cultivars of many of the world's most important economic plants stem from a very narrow genetic base. For example, plantations of oil palm in Malaysia are based on material from only four specimens of this plant from Western Africa (Groombridge and Jenkins 2002). Considerable efforts are therefore underway to broaden the genetic bases of crops through the introduction of varieties to increase resilience and maximize productivity. Typically, the development and release of a new, modern variety takes 8-15 years and costs in the range of US$1-2.5 million, for a traditionally bred variety, and US$25-75 million to develop a transgene for genetically modified (GM) varieties (Laird 2002). However, the wild relatives of many important food crops are fast disappearing. For example, Ethiopia, which is the geographic origin of coffee and is a centre of

Box 4: The fair and equitable use of genetic resources

Currently, the legal framework for fair and equitable exchange of genetic resources is very complex and made up of a combination of international and national law, contractual agreements, researcher codes of ethics, institutional or corporate policies, and indigenous people's declarations, which are often in conflict.

At a global level, it is now accepted that collecting genetic resources and related knowledge requires the "prior informed consent" of the custodians or owners and the fair and equitable sharing of benefits (UNEP 1992). There is also growing appreciation that what is fair and equitable is likely to differ substantially across industry sectors, and individual research and development programmes, and that successful benefit-sharing arrangements are those tailored to the specific circumstances of an individual case. The CBD envisages the use of genetic information as a source to generate income for providers of genetic material and, therefore, to create incentives to protect biodiversity. Chapter 9: *Genetically Modified Crops* considers, among other things, the approach of the AU to the use of genetic resources.

A major challenge for global legal frameworks is that large parts of the global economic benefits arising from the use of genetic resources currently accrue in regions different from where the respective resources originate. In addition, genetic resources can commonly be supplied by many different, often competing, suppliers at varying scales (communities, regions or nations), and defining the group to whom benefits should accrue can be very contentious.

Sources: Posey and Dutfield 1996, UNEP 1992, Yamin 2003

genetic diversity, is one country whose biodiversity has been least explored, but has only 4 000 km^2 of land containing populations of wild coffee remaining (Groombridge and Jenkins 2002). Many other populations of wild species are increasingly restricted in distribution and fragmented, and nine species for mainland Africa were listed as threatened in 1998.

Challenges faced in realizing opportunities for development

The imperative to improve human well-being can place multiple and often competing demands on ecosystems. Difficult trade-offs may have to be made, for instance between the protection of habitat for biodiversity, and the transformation of ecosystems for human needs. Some ecosystem transformation is inevitable if the Millennium Development Goals (MDGs) are to be met, but the impact on biodiversity will depend on how development activities are carried out. Significant opportunities exist to generate wealth through activities that draw on environmental goods-and-services, and at the same time promote the conservation of these resources. These activities include a range of moderate intensity extractive uses, such as livestock or wildlife ranching, wild plant harvesting, low-impact logging, and sustainable fisheries, as well as non-extractive uses, such as nature-based tourism and the exploitation of genetic resources.

As already discussed, despite significant environmental change, Africa still has a significant store of biodiversity. The key challenge in promoting sustainable natural resource use is to ensure that the rate of extraction (including the incidental damage caused during the harvest process) remains within the limits of sustainability. Strategies to ensure sustainability may rely on a combination of protection strategies including protected areas and conservation measures within "used-and-lived-in" spaces. Important challenges are how to:

- Determine the sustainable extraction rate and practices; and
- Establish and maintain institutions that are able to regulate natural resource use within the limits without placing undue constraints on their legitimate use.

Habitat degradation and loss

Habitat refers to the range of resources that a species needs to maintain a viable population including sufficient territory, necessary food and water, and required physical features such as tree cover, rocky hills or deep pools, as well as the organisms and ecosystem disturbances that must be present for it to complete its life cycle. The major current cause of biodiversity loss in Africa is habitat loss and that is likely to remain true for the first third of the 21st century (Sala and others 2000).

Expanding agriculture is an important cause of habitat loss. Newly planted fields, Morocco.

Source: J.C. Mohamed-Katerere

Habitat is lost when land cover (or its aquatic equivalent) is changed, usually as a result of changing use by humans. Common examples are the conversion of near-natural vegetation to temporary or permanent croplands; the replacement of forest by pastures; the expansion of human settlements; and the alteration of river habitats by dams, pollution and removal of water for human use. Forests and woodland cover is declining at a rate more or less equivalent to the increase in cropland (Scholes and Biggs 2005). The terrestrial ecosystem type where the greatest degree of habitat loss has occurred is grasslands, which have been converted to cereal agriculture (Scholes and Biggs 2005).

Habitat fragmentation – the division of continuous patches into smaller pieces which are partly or fully disconnected from one another by infrastructure, agricultural fields or human settlements – can have similar outcomes for biodiversity as outright habitat losses. First, the "edge effect" disrupts biodiversity for a considerable distance into the remnant patches. Second, the number of species that can be supported in the long term depends on habitat size.

Overexploitation of resources

If renewable resources are harvested at a rate greater than their regeneration rate, the long-term flow of benefits is reduced, and they are said to be overharvested. When natural capital is drawn down too

> The major current cause of biodiversity loss in Africa is habitat loss and that is likely to remain true for the first third of the 21st century.
>
> Sala and others 2000

far, fundamental ecosystem changes can occur which make ecosystem recovery to full service delivery potential very slow or impossible, and degradation is said to have occurred. Degraded ecosystems support half or less of the biodiversity of non-degraded used ecosystems (Scholes and Biggs 2005).

Much overharvesting is the unintended side effect of activities aimed at harvesting just one or a few components of the ecosystem. The discarded "by-catch" in fisheries and the habitat destruction caused by logging are examples of this. Regulatory policies that pay no heed to anything other than the target species encourage this kind of damage.

Overharvesting is a problem in many localities. For example, about 9 per cent of rangelands south of the equator are grazed by domestic livestock at unsustainable rates (Scholes and Biggs 2004). The fish stocks in the Great Lakes (Lake Victoria in particular) show classic symptoms of overfishing, and marine fish stocks in Western and Eastern Africa are at risk of overfishing.

The CBD has three objectives: the conservation of biodiversity, the sustainable use of its components, and the equitable sharing of benefits arising from the use of biodiversity.

Strategies for enhancing opportunities from biodiversity

While significant challenges for researching and managing biodiversity in Africa remain, there is enough information available to give broad but concrete direction to the development of national, sub-regional and regional biodiversity policy.

Multilateral agreements

Many multilateral environmental agreements (MEAs) exist to promote biodiversity protection. Most African countries have ratified the Ramsar Convention (protecting wetlands of international importance), the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES), the Convention on the Conservation of Migratory Species of Wild Animals (CMS), the Convention Concerning the Protection of the World Cultural and Natural Heritage (the World Heritage Convention), the United Nations Convention to Combat Desertification (UNCCD), the United Nations Framework Convention on Climate Change (UNFCCC), and the CBD. These global MEAs are complemented by sub-regional and regional agreements, such as the African Convention on the Conservation of Nature and Natural Resources (ACCNNR) and the New Partnership for Africa's Development (NEPAD) Environmental Initiative. The 2002 World Summit on Sustainable Development (WSSD) saw convergence on a shared vision of sustainable development as a way of alleviating poverty, raising human well-being, and simultaneously meeting biodiversity protection objectives. Recognition of the administrative burden that the multiplicity of environmental agreements places on resource-constrained governments has prompted a desire to rationalize their implementation. Among the conclusions of the WSSD was that the link between the

The sustainable use of natural resources is a priority for many African countries. Handicrafts from *Raphia farinifera* provide income opportunities in Madagascar.

Source: V. Rabesahala

Box 5: Collaboration and conservation

Biodiversity gains are best made through the avoidance of ecosystem degradation. This may demand inter-state collaboration or state-community collaboration.

The Central African Forest Treaty is an example of a successful inter-state collaboration. The area of Congo forest that is formally protected has increased by 36 per cent (an addition of 46 000 km^2) since the Yaoundé Declaration of 1999. At the national level, the Declaration triggered re-evaluation of protected area networks. In Gabon, 13 new national parks covering 30 000 km^2 were established in 2003, making up about 10 per cent of the national land area. A similar process is under way in Cameroon. The DRC and Central African Republic (CAR) are planning similar reviews of their protected area networks. In February 2005, at the second Congo Basin Forest Summit, the Central African Forest Treaty, Africa's first region-wide conservation treaty was signed. It creates a single organisation, the Central African Forests Commission (COMIFAC), to oversee forest conservation activities in the Congo basin. Future efforts will focus less on opening new parks and more on implementing sustainable forestry in the areas outside the parks.

Collaboration between the state, representing the needs of society as a whole and those of future generations, and those people and groups that get all or part of their livelihoods from use of the resources, may also be important in protecting biodiversity. Experience in several parts of Africa and elsewhere is that when use rights for biodiversity are devolved to groups of people who have a vested interest in the maintenance of the resource in the long term, the outcome for biodiversity and livelihoods is favourable and reduces the burden on governments (Hulme and Murphree 2001). In Il Ngwesi, Kenya, a community partnership with a private-sector ecotourism operator and a government parastatal, the Kenya Wildlife Service (KWS) saw a reversal in the rate of biodiversity decline and a reduction in the vulnerability of a pastoral community within a period of six years (UNEP 2004a). The community established a conservancy area of 8 700 ha to restore plant biodiversity in order to attract wildlife back to a group ranch for ecotourism. They also formed a group of scouts to control poaching and cattle rustling. Household incomes increased from almost zero to US$800 annually over the same period (UNEP 2004a).

Sources: COMIFAC 2005, Hulme and Murphree 2001, UNEP 2004a

conservation of natural resources and economic development in Africa is particularly close.

The CBD is particularly focussed on biodiversity. It has three objectives:

- The conservation of biodiversity;
- The sustainable use of its components; and
- The equitable sharing of benefits arising from the use of biodiversity.

Realizing any one of these objectives is dependent upon the other. This requires adequate political and legal instruments to appropriately allocate access, benefits and costs and to make linkages between different environmental sectors as well as with development sectors. Such an approach is discussed in Chapter 8: *Interlinkages: The Environment and Policy Web*. Partnerships with non-governmental organizations (NGOs), community-based organizations, and the technical and scientific community play an important role in conservation planning and policy. Such partnerships are also critical to the success of implementation efforts.

Biodiversity policy

A cost-efficient and robust strategy for biodiversity conservation may have two pillars. The first pillar is the classical approach of identifying those parts of the land, waters and sea where the conservation value exceeds any other use value, and requires strict protection. The second pillar recognizes that, even with such a safety net in place, most wild organisms live in places that are used primarily for purposes other than biodiversity conservation. Adjustments to the way in which these ecosystems are used can lead to a high degree of biodiversity preservation, without unacceptable decreases in the output of other services.

The key issues for establishing an effective protected area network are prioritization of levels of protection and use. Identifying protected areas should not be arbitrary. Sufficient knowledge exists to apply more refined techniques to identify locations that are critical for many species, robust to climate change, and have a good chance of being economically viable. In general, consolidated reserves are more viable than the equivalent area of isolated patches. In some instances transboundary parks are important for habitat protection.

There are known priority areas for conservation in every country, but overall, the greatest current urgency relates to multitaxon centres of endemism, such as the Eastern Arc mountains and Mt Cameroon. As shown in Box 5, adopting collaborative approaches at multiple levels can be important for achieving biodiversity conservation objectives.

Improving science

About US$245 million is currently spent annually by the international community for protected area management in SSA (James and others 2001). The efficacy of these investments depends partly on the availability and reliability of information on the spatial distribution and condition of biodiversity (Balmford and Gaston 1999). The currently available information on biodiversity is inadequate in several respects:

- It is biased towards terrestrial biodiversity, and towards large mammals and birds. The greatest proportion of Africa's biodiversity, invertebrates, is not well known to science.
- For most species, only parts of their distribution ranges are documented. In many areas there is inadequate documentation, including in Ethiopia, the Congo basin, Angola and Mozambique.
- Information on the biodiversity actually conserved in protected areas (eg in the form of species inventory lists) is widely lacking but is essential to document the success of conservation measures currently undertaken and to guide further conservation activities.
- A vast amount of locally and regionally available biodiversity information is not connected and standardized, which is a significant impediment to making priorities comparable at regional to global scales.
- Data on biodiversity condition (ie population size and trend, rather than simple presence or absence) is virtually absent. This information is essential for effective conservation of viable populations (Gaston and Rodrigues 2003) and for giving warning of impending problems well before they are irremediable.
- Biodiversity measures are still commonly restricted to how many species there are, while there is very little information on qualitative aspects of biodiversity such as phylogenetic or functional diversity.

Other important areas of research that would support effective biodiversity policy include: quantification of the current and potential economic benefits provided by ecosystem services, and the consequences and costs of ecosystem destruction; understanding the link between ecosystem diversity and ecosystem integrity; methodologies for the integration of climate change adaptation strategies into conservation planning; and the development of a conceptual basis and methodology to incorporate biodiversity sustaining and generating processes and functional biodiversity into conservation strategies.

SUB-REGIONAL OVERVIEW

The sub-regional overviews focus on selected issues and thus need to be read in the context of the regional synthesis and in relation to the issues covered in the other sub-regions.

CENTRAL AFRICA

Overview of resources

The vast equatorial forests of the Congo basin, which dominate Africa's tropical realm, contain a huge variety of life (Table 1). Due to its inaccessibility and a history of conflict, its ecology remains poorly studied. Within Central Africa, only Chad does not contain tropical rain forest, while in Cameroon, CAR and the DRC rain forest transitions from evergreen forest to deciduous forest, to wooded, open, and Sahelian savannahs, each transition signifying a huge shift in species composition and diversity. Plant diversity is high, with well over 10 000 species, 8 000 of which are found in the forest zone, of which 80 per cent are endemic (White 2001).

Three of the four species of great ape, the closest evolutionary relative to humans, still occur. The sub-region has the highest primate diversity in Africa (Harcourt 2000).

The Congo River is the second largest river system on Earth, containing at least 669 species of fish (Champan 2001), many of which are important sources of protein for the local population.

Challenges faced in realizing opportunities for development

Biodiversity faces various threats, including increasing trade. Although forest elephants, gorillas, forest buffalo, bongo, okapi and giant forest hogs continue to live in large numbers in Central Africa's forests, these species and their habitat face an uncertain future. Forest

Forest leopards (*Panthera pardus*) hold a vital ecological role as the sole large mammalian predator in Gabon's forest habitats.

Source: P. Henschel/WCS

Table 1: The biodiversity features of Central Africa

		Biodiversity opportunity						Threat	Response
		Mammals		Birds		Plants		% of land	% of land
Country	Area km²	Endemic	Total	Endemic	Total	Endemic	Total	transformed	protected
Cameroon	475 440	14	409	8	690	156	8 260	9	7
Central African Republic	622 980	2	209	1	537	100	3 602	2	12
Chad	1 284 000	1	134	0	370		1 600	14	9
Congo	342 000	2	200	0	449	1 200	6 000	3	14
DRC	2 344 860	not known	not known	not known	not known	1 100	11 007	3	5
Equatorial Guinea	28 050	1	184	3	273	66	3 250	7	17
Gabon	267 670	3	190	1	466		6 651	3	0
São Tomé and Príncipe	960	4	8	25	63	134	895		
All countries	5 365 960	27		38		2 756		6	7

Sources: Biodiversity information taken from Groombridge and Jenkins (2002). Calculation of the proportion of transformed land was based on the reclassification by Hoekstra and others (2005) of the GLC3 Global Landcover Classification (Mayaux and others 2004). Hoekstra and others (2005) defined four classes of transformed land: 1) Artificial surfaces and associated areas, 2) Cultivated and managed areas, 3) Mosaic: cropland/treecover, and 4) Mosaic: cropland/ other natural vegetation. In this chapter, all four classes have been integrated into the calculation of the proportion of transformed land. The area covered by classes 3 and 4 was divided by two, assuming that this reflects their mosaic character with a certain proportion of land remaining untransformed. Note that this method does not account for the degree of fragmentation within the mosaic landcover classes. Data on protected areas (IUCN class I-V) were obtained from WRI 2005

elephants once roamed over most of the nearly 2 million km² of the Congo basin forest. Considerable evidence, including that from landscape scale inventories by the Monitoring of the Illegal Killing of Elephants program (MIKE) of CITES, suggests that the elephant range has been dramatically reduced due to illegal killing for ivory and bushmeat, as well as increasing human encroachment into forest lands. Elephants may be increasingly confined to protected areas and their immediate peripheries (Blake 2002). Great apes face similar challenges, with the added spectre of disease, such as Ebola, reducing populations to a fraction of their original abundance (Walsh and others 2004).

The logging industry dominates land use and the economy in forested areas. Since its coastal beginnings, in colonial times, logging has spread to the deep interior of the forest (Bikié and others 2000, Collomb and others 2000). Logging is mostly selective due to high production costs. Canopy damage is typically 10-20 per cent, meaning that forest cover remains post-logging, but the forest ecology is significantly modified. Furthermore, logging and logging roads bring immigration into formerly remote areas, opening up the interior to use, stimulating the development of cash economies, and allowing access to distant markets (Wilkie and others 2000).

The expansion of bushmeat hunting is a major threat: between 1 and 5 million tons is harvested annually, well above sustainable levels (Robinson and Bennett 2002, Robinson and Bennett 2004). Casualties of the bushmeat trade include the great apes (gorillas, chimpanzees, and bonobos), which coupled with the real and growing threat from the Ebola virus could be driven to the verge of extinction within a decade (Walsh and others 2004). With limited national capacity for sustainable land-use planning and law

The bushmeat trade comes with both costs and benefits. It offers nutrition for many poor people, but at times threatens biodiversity. Cameroon.

Source: CARPE

enforcement, logging has become a major vehicle for a dramatically expanding illegal bushmeat trade to supply local, national and international commercial markets. Recognizing the seriousness of the threat, efforts are underway toward sustainable management of the main bushmeat species, and to promote alternative sources of protein in logging concessions and other rural and urban settings, and to diversify incomes for bushmeat hunters (CBFP 2005).

The use of bush fires in the clearing of land for agriculture and settlement as well as a hunting technique is the second major threat to biodiversity resources. Slow-growing species at the edge of the forests are disappearing and gradually being replaced by pioneer species. Regeneration of slow-growing species, which have high value timber, requires long fallow periods, which is often not allowed by the bush fires (UNEP 2004a). There is therefore a risk of forest areas disappearing and being replaced by savannah.

Inter-basin transfers of water pose several threats to biodiversity. For example, proposals have been made to divert large volumes of water from the Ubangui River (part of the Congo River basin) northwards through the CAR and Chad, and to discharge this water into the Logone-Chari rivers feeding Lake Chad (Kuwairi 2004). The proposed water transfer would have the effect of dramatically increasing the flooded extent of Lake Chad and restoring livelihoods of residents living along its shorelines, most of whom subsist on products from their livestock and on blue-green algae and fish harvested from Lake Chad, but runs the risk of transferring an unrelated set of species into the Lake Chad basin. These proposals (Kuwairi 2004) also suggest that a scheme to divert water from the Ubangui River could be enlarged sufficiently so that additional water could be diverted via a pipeline further northwards into southern Libya. Whilst such water transfers could enhance the biodiversity of Lake Chad and its immediate surroundings, there is a strong possibility that such a scheme could have significant adverse effects on the Congo River system to the south.

Strategies to enhance the opportunities for development

Sustainable and equitable natural resource management is the key not just to the maintenance of biodiversity but equally to human development and well-being. Conservation and wildlife management has lagged behind the rest of the region, though one of Africa's first national parks, the Virunga National Park, was created here in 1925. The costs of conservation are far from trivial. It is estimated that successful management of a minimal network of protected areas in forests alone would require an investment of over US$1 000 million over 10 years, followed by recurrent costs of nearly US$90 million per year; current investment is probably about US$15 million per year (Blom 2004).

Much of the remaining biodiversity is held outside national parks (Sayer and others 1992). Thus, broad-scale resource management systems which combine protected areas with areas of increasing human use can be an important intervention. Initiatives such as the Yaoundé Process, which led to the Yaoundé Declaration in 1999, made a formal commitment to the conservation and sustainable management of tropical forests, and helped catalyse the *Plan de Convergence* (COMIFAC 2005), the creation of Gabon's network of 13 national parks (Gabon National Parks undated), and the Congo Basin Forest Partnership (CBFP), consisting of 27 public and private partners (CBFP undated). USAID's Central Africa Regional Project for the Environment (CARPE) and the European Commission's Ecosystems *Forestiers d'Afrique Centrale* (ECOFAC) contribute to this partnership. An important task for the CBFP is the development of a monitoring system to provide a periodic assessment of the forest and biodiversity of the Congo basin (see Box 5).

EASTERN AFRICA

Overview of resources

Eastern Africa's biological diversity reflects its position astride the equator and the high variability of landscapes and aquatic ecosystems. These conditions provide suitable habitat for a large variety of living organisms,

Nectophrynoides viviparus is one of the few frogs that give birth to live young. This vulnerable species occurs in the Uluguru and Udzungwa mountains in the southern highlands of Tanzania.

Source: D. Moyer/WCS

some with very limited ranges. For instance, the Bonga Forest in Ethiopia contains more than 15 species of highland birds; the Metu-Gore-Tepi forest has more than 16 species of birds of which at least two are endemic, while the Tiro Boter-Becho forests have more than 32 highland biome species of birds (EWNHS 1996). Owing to its combination of semi-arid savannahs, lowland and montane rain forests, vast wetlands, and an Afro-alpine zone which ranges in altitude from 650 to 5 000 m, Uganda has over 1 000 species of birds (Carswell and others 2005), a significant percentage of Africa's 2 313 bird species (BirdLife International undated). From its scorching sub-desert flatlands to its mist-enshrouded evergreen montane forests, Eritrea's diverse habitats hold a wide variety of birds, many of which are confined to the Horn of Africa. To date, a total of 107 mammal species have been recorded in Burundi (Groombridge and Jenkins 1994). The Masai Mara in Kenya is world-famous for big game. A total of 277 species of mammals are known in Ethiopia, of which 29 are endemic and almost exclusively confined to the central plateaus (Yalden and others 1986). In the semi-desert grasslands and shrublands of Djibouti, *Acacia nilotic* sub species, *tomentosa* forms nearly pure stands on silty-clay soils subjected to seasonal inundation in association with *Ziziphus abyssinica* as a minor associate (White 1983). Although Djibouti does not have any endemic mammals, the following threatened terrestrial and marine species occur: *Lycaon pictus* (African wild dog), *Dorcatragus megalotis* (Beira antelope), *Gazella dorcas* (Dorcas gazelle), *Dugong dugon* (dugong), *Otomops martiensseni* (large-eared free-tailed bat) and *Gazella soemmerringii* (Soemmerring's gazelle) (Baillie and Groombridge 1996).

Challenges faced in realizing opportunities for development

Maintaining biodiversity is essential for ensuring that the environmental goods-and-services are maintained.

Eastern Africa contains some of the world's oldest and richest protected areas (Table 2), such as the Tsavo, Queen Elizabeth and Serengeti national parks. The principle which guided establishment of most protected areas was that strict protection was essential for effective conservation of biological resources and therefore the exclusion of humans, livestock and fire was considered necessary. This protectionist approach was based on the USA's Yellowstone National Park (McNeely and others 1994). These protected areas were established in the hope that they would continue to exist in pristine state and effectively conserve the inherent biological diversity, especially the characteristic large mammal aggregations. This idea was enshrined in such notable MEAs as the London Convention of 1933 and the ACCNNR of 1968 (McNeely and others 1994). While the present distribution of protected areas embraces a more modern view of the broader biodiversity concept, it still reflects a preoccupation with the large mammal concentrations. The long-term viability of the ecological systems and processes on which such areas depend remains questionable. The exclusion of humans and most of their activities notwithstanding, species loss has continued. In nearly all cases, park boundaries were established with little regard for the year-round needs of resident fauna. For example, the Nairobi National Park and Masai Mara reserve in Kenya were originally designed to conserve

Table 2: The biodiversity features of Eastern Africa

		Biodiversity opportunity						Threat	Response
		Mammals		Birds		Plants		% of land	% of land
Country	Area km²	Endemic	Total	Endemic	Total	Endemic	Total	transformed	protected
Burundi	27 830	0	107	0	451	not known	2 500	37	5
Djibouti	23 200	0	61	1	126	6	826	1	1
Eritrea	117 600	0	112	0	319	not known	not known	19	4
Ethiopia	1 104 300	31	277	28	626	1 000	6 603	39	5
Kenya	580 370	23	359	9	844	265	6 506	13	6
Rwanda	26 340	0	151	0	513	26	2 288	52	8
Somalia	637 660	12	171	11	422	500	3 028	6	0
Uganda	241 040	6	345	3	830	not known	4 900	36	7
All countries	2 758 340	72		52		1 797		24	4

Source: Methodology and sources as for Table 1

populations of migratory mammals whose movements have since been severely restricted. Land conversion and encroachment of these areas, and virtually all other protected areas, have led to serious ecological isolation with negative effects on species richness, abundance and genetic vigour.

In several areas, such as the Nairobi and Mkomazi parks, large mammal populations have become more compressed, and animal and plant species diversity has decreased. Rapid biodiversity loss in some of Kenya's protected areas is also closely linked with the explosion of tourism, rapid coastal development, and spread of human settlements since the 1970s. The large mammal populations of Uganda's Murchison Falls National Park came under heavy pressure during the years of civil strife, leading to huge species declines and directional vegetation change. In Ethiopia's Awash, Abijata Shalla and Nechisar national parks, encroachment and settlement forced many wildlife species out of the park due to increased competition for forage (Hilman 1991, GebreMichael and others 1992, Jacobs and Schloeder 2001).

Although biodiversity loss can be attributed to multiple causes, a large part is accounted for by the real and widespread conflict between people and wildlife. Eastern Africa has a high human population (FAO 2003). The spread of cultivation and settlement has meant that pastoralists and their livestock have been squeezed into increasingly smaller areas. There is increasing competition between people, and between people and wildlife, for grazing land and water resources. Local people and their livestock are still viewed by the national law and policy as alien to parks, reserves and sanctuaries. The loss of key dispersal areas for wildlife leads to greater pressure within the protected areas, and heightened human-wildlife conflict. Hostilities have built up as consecutive governments ignore the hardship that wildlife causes people (Yeager and Miller 1986, Western 1997). Despite the obvious economic benefits that wildlife brings, many farmers, herdsmen and ranchers living adjacent to parks look upon wild animals with considerable disdain (Kaltenborn and others 2003). Wildlife periodically decimates crops,

Wandering mountain gorilla (*Gorilla spp*.). The Bwindi Forest, Uganda, can be seen in the background.

Source: C. Lambrechts/UNEP

causes injuries or death to people and livestock, and spreads diseases.

Strategies to enhance the opportunities for development

Since the early 1990s, there has been a growing policy change focus on sustainable use and increased local participation. There is a realization that a "fences-and-fines" approach leads to even more conflicts, unacceptable social inequity, and ultimately the destruction of the resources themselves. A "use it or lose it" philosophy has taken root (Swanson 1992). The various community-based natural resource management (CBNRM) approaches have yielded mixed results (Agrawal and Gibson 1999, Gibson 1999, Songorwa and others 2000). Nearly all countries are providing greater legitimacy for the involvement of people in natural resources management. A slow but steady change in focus is under way, shifting from the biological challenges to confronting the social and economic issues. In Kenya, for instance, a national land policy is being formulated through a consultative and participatory process. This should open up new opportunities for people wishing to invest in conservation and the sustainable use of biological diversity.

NORTHERN AFRICA

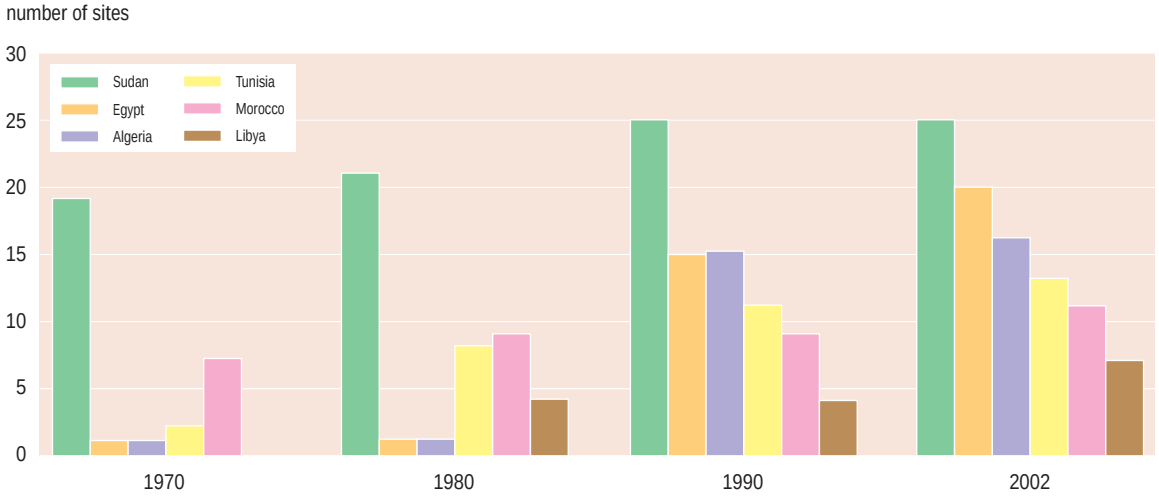
Northern Africa falls within the arid belt extending from the Atlantic to central Asia. Aridity and the geographical location of its six countries determine its biodiversity. The occurrence of long shores with vast coastlines, oases in the Sahara and the different landforms create considerable habitat and species diversity.

The sub-region is vulnerable to desertification and drought. However, due to particular climatic conditions, it is rich in biodiversity, with many species being endemic. The total number of known endemic species of flora is 1 129, of mammals 22, of birds 1, of reptiles 20, and of amphibians 4. At the country level, the highest numbers of endemic biota are mostly found in Morocco, with recorded higher plant species ranging from 1 875 in Libya to 3 675 species in Morocco. Mammals range from 76 species in Libya to 267 species in Sudan. The number of bird species varies from 80 in Libya to 938 in Sudan. Reptiles and amphibians are still underinvestigated in most of the countries, but the numbers of known reptile and amphibian species in Egypt are 83 and 6, respectively.

The major part of the biodiversity of Northern Africa is drawn from the pool of species broadly represented in the Mediterranean basin. There are locations of endemism in the Atlas Mountains of Morocco, Algeria and Tunisia accounting for about a fifth of the plant species in the sub-region (Table 3). Since Northern Africa has been the location of successive civilizations over a period of up to eight millennia, the landscape and its biodiversity are highly transformed in the areas of human settlement.

Hundreds of plant species are used in traditional medicine and represent a wealth of genetic resources rarely found elsewhere (IUCN undated – b). Pharmacopoeial plants include *Hyoscyamus muticus*, *Urginea maritima*, *Colchicum autumnale*, *Senna alexandrina*, *Plantago afra*, *Juniperus communis*, *Anacyclus pyrethrum*, and *Citrullus colocynthis*. Endemic plants, some of which are endangered, include *Argania spinosa*, *Arbutus pavari*, *Cedrus atlantica*, *Euphorbia echinus*, *Euphorbia resinifera*, *Senecio*

Figure 4: Protected areas (IUCN Categories 1-VI): Northern Africa



Source: UNEP 2005b

Table.3: The biodiversity features of Northern Africa

		Biodiversity opportunity						Threat	Response
		Mammals		Birds		Plants		% of land	% of land
Country	Area km²	Endemic	Total	Endemic	Total	Endemic	Total	transformed	protected
Algeria	2 381 740	2	92	1	192	250	3 164	1	5
Egypt	1 001 450	7	98	0	153	70	2 076	4	5
Libya	1 759 540	5	76	0	91	134	1 825	0	0
Morocco	446 550	4	105	0	210	625	3 675	20	1
Sudan	2 505 810	11	267	1	680	50	3 137	17	4
Tunisia	163 610	1	78	0	173		2 196	9	0
All countries	8 258 700	30		2		1 129		7	3

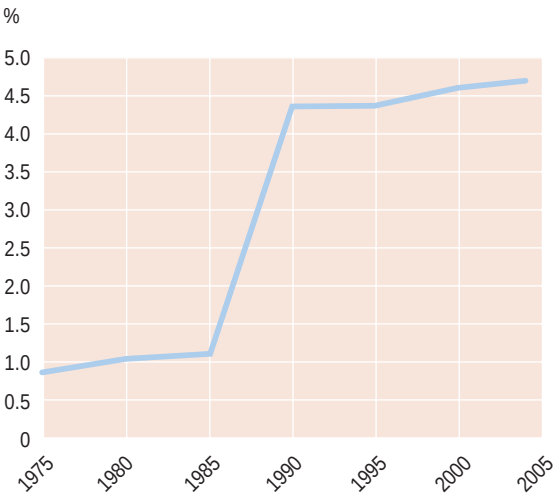
Source: Methodology and sources as for Table 1

antieuphorbium, *Thymus algeriensis*, and *Thymus broussonettii* (Batanouny 1999). To date, they have not been studied in detail or valued. About 70 per cent of wild plants are known to be useful in more than one context, of which 35 per cent are under-utilized.

Challenges faced in realizing opportunities for development

The major underlying threats to biodiversity include population growth, agricultural and urban expansion to ecologically important areas, poverty, unsustainable use of biota, and macro-scale stresses such as drought. Emerging factors threatening biodiversity include IAS and the use of GM species, which may result in an increasing homogenization of the biota (Hegazy and others 1999). Chapter 9: *Genetically Modified Crops* and Chapter 10: *Invasive Alien Species* consider some of these challenges. The depletion of underground water level in many countries has led to the deterioration and loss of unique water springs and wetlands with their associated biota.

Figure 5: Protected areas (IUCN Categories I-IV): percentage of total area in Northern Africa



Source: UNEP 2005b; data from World Database of Protected Areas 2004

Human settlement patterns and activities are located close to available water resources and compete with biodiversity. In such a dry landscape, perennial rivers, oases and ephemeral moist areas, such as *wadis*, are inevitably the focus of people and biodiversity. Northern Africa straddles the migratory bird flyways between Europe and SSA and is an important stopping-off point for an estimated billion migratory raptors, passerines and Palaearctic waterbirds.

The Nile is a key biodiversity corridor across the arid Sahara and Sahel belt, but is highly impacted by human actions in its lower reaches. The functioning of this system (specifically the periodic flooding and discharge to the sea, which brought large amounts of sediment and nutrients to the river banks and delta) was substantially altered by completion of the Aswan Dam in 1934 and the subsequent construction of the Aswan High Dam in 1965. As a result of the intensive water use in Egypt, there is virtually no discharge into the Mediterranean Sea, and only small pockets of relatively undisturbed coastal marshland remain in the delta. New irrigation schemes may further diminish water supplies in the lower Nile system and impose additional threats to the biodiversity. Similarly other development projects, including those related to hydropower, will increase demands on the existing water resources and this, in turn, will exert additional pressures on the basin's ecosystems and biodiversity.

In the coming decade, the abuse of agrochemicals and uncontrolled fishing and hunting are expected to

put more pressure on the fragile ecosystems and the threatened endemic species, particularly in hotspots. Protection of critical sites is imperative. The growing need for transborder conservation is also an emerging issue in some areas, such as the borders between Egypt and Sudan, and between Morocco and Algeria.

Strategies for enhancing biodiversity values

There are ongoing schemes to establish protected areas and biosphere reserves throughout the sub-region. The total area of official protected areas remains less than 5 per cent of the land area, which is below the CBD standard of 10 per cent. Nevertheless, some countries aim to increase their protected areas to more than 15 per cent within the next three decades. Currently, Northern Africa has over 90 protected areas and 12 biosphere reserves. Many other sites are proposed for protection (Hegazy and others 2001).

SOUTHERN AFRICA

Southern Africa is a globally recognized centre of biodiversity richness and endemism, as shown in Table 4. The Western Cape, the Karoo and the Miombo woodlands are of particular significance (Burgess and others 2004).

Biodiversity underpins the economy, including tourism. (Krug and others 2002). Southern Africa has placed increasing importance on conservation and sustainable use and has invested in several initiatives in support of those objectives, notably the transfer of ownership of biodiversity from the state to the private and community sectors, and the development of transboundary parks.

The coelacanth, a 400 million year-old "living fossil" fish, occurs in the waters of the WIO islands.

Source: Estate of J. Metzner/Still Pictures

The current condition and trend of biodiversity has recently been assessed as part of the Millennium Ecosystem Assessment (MA): averaged across all terrestrial species of plants and vertebrates, it is estimated that about 84 per cent of the pre-colonial populations of wild organisms persisted in the year 2000 (Biggs and others 2004, Scholes and Biggs 2004, Scholes and Biggs 2005). The rate of decline in "biodiversity intactness" is about 0.8 per cent per year for the 1990s (Scholes and Biggs 2005). Most of the organisms that persist occur outside the comprehensive and generally well-run system of protected areas.

Table 4: Biodiversity richness and endemism in Southern Africa

		Biodiversity opportunity						Threat	Response
		Mammals		Birds		Plants		% of land	% of land
Country	Area km²	Endemic	Total	Endemic	Total	Endemic	Total	transformed	protected
Angola	1 246 700	7	276	12	765	1 260	5 185	4	4
Botswana	581 730	0	164	1	386	17	2 151	9	18
Lesotho	30 350	0	33	0	58	2	1 591	16	0
Malawi	118 480	0	195	0	521	49	3 765	29	9
Mozambique	801 590	2	179	0	498	219	5 692	11	4
Namibia	824 290	3	250	3	469	687	3 174	2	4
South Africa	1 221 040	35	247	8	596		23 420	22	5
Swaziland	17 360	0	47	0	364	4	2 715	0	2
Tanzania	945 090	15	316	24	822	1 122	10 008	25	15
Zambia	752 610	3	233	2	605	211	4 747	9	8
Zimbabwe	390 760	0	270	0	532	95	4 440	32	8
All countries	6 930 000	65		50		3 666		13	7

Source: Krug and others 2002

Table 5: Average prices of live game (2000)

Species	Price (US$)
Grey duiker	75
Impala	150
Kudu	370
Blue wildebeest	450
Zebra	580
Springbok	670
Red hartebeest	700
Waterbuck	1 000
Bushbuck	1 000
Giraffe	2 700
Hippo	4 000
Sable antelope	10 300
Roan antelope	14 200
Buffalo	16 700
White rhino	25 000

Source: SADC and others 2005

The various species of fauna and flora found in the vast range of terrestrial, freshwater and marine ecosystems are also an important source of food, medicines, research and regional integration through transboundary conservation. They are also an important source of income for communities through CBNRM programmes.

Land-use systems that are based on wildlife utilization are more ecologically sustainable than other uses. For example, wildlife makes better use of vegetation compared to livestock, and has many marketable uses in addition to meat production. Income from wildlife is significant. One of Southern Africa's most prestigious and largest wildlife auctions for live game is organized by the KwaZulu Natal Conservation Service in South Africa. Excess animals from public parks are sold to private wildlife areas predominantly in Southern Africa. Table 5 provides average auction prices for live game in 2000, during which the prices ranged from US$75 for a grey duiker to US$25 000 for a white rhino (SADC and others 2005).

Safari hunting is the main income generating form of consumptive wildlife utilization. However, the most common and widespread use of wildlife is non-consumptive tourism, which takes place in areas where densities of wildlife are high.

Since the 1970s, several initiatives in Mozambique, Namibia, South Africa and Zimbabwe began to transfer use rights and responsibilities to the landholders. In most Southern African countries, wildlife historically belonged to the government, and not to the people who owned or lived on the land. Thus there was little incentive for landholders to conserve or enhance wildlife stocks. In Zimbabwe, the Communal Areas Management Programme for Indigenous Resources (CAMPFIRE) programme targeted sparsely populated communal land adjacent to national parks or hunting areas. It demonstrated that economic returns from sustainable use of wildlife (largely through trophy hunting) exceeded the returns from marginal cultivation or cattle ranching, and schemes were devised to return the proceeds of wildlife utilization to the local communities. In South Africa, a simple change in the provincial wildlife protection legislation lifted many of the restrictions relating to the use of wildlife for those landholders who erected a game-proof fence around their land. Large parts of the country that had been used unprofitably for livestock ranching rapidly began to farm wildlife, initially for the trophy hunting market, and later for the wildlife tourism market (Scholes and Biggs 2004). In Namibia, many experiments in CBNRM have been launched, and several have proven sustainable for long periods.

Transboundary parks have been a "peace dividend" following the achievement of political stability in Southern Africa. Established examples include the Greater Limpopo Transfrontier Park initiative between Mozambique and South Africa, the Kgalagadi Agreement establishing a park between South Africa and Botswana, and the Tuli Park between South Africa, Botswana and Zimbabwe (Mohamed-Katerere 2001). Several more are in advanced stages of implementation. While many of the drivers and benefits of transboundary protected areas are political and economic, there are also significant biodiversity advantages: large parks have lower operational costs; bigger wildlife populations are less prone to loss when conditions fluctuate; and ecosystems seldom follow national jurisdictions.

Given that the biodiversity of Southern Africa is remarkably intact, the most immediate challenge is to avoid degradation of habitat in the extensive areas which are used for activities such as livestock ranching, while simultaneously maintaining viable livelihoods for the people who live in these areas.

Challenges faced in realizing opportunities for development

The invasion of ecosystems by alien species has caused significant economic losses. Such species have been deliberately or accidentally introduced by humans. Only a fraction of such introductions become problem

Lantana camara, an IAS, first introduced as an ornamental plant. invades various habitats, decreasing agricultural productivity and transforming many forest ecosystems.

Source: V. Rabesahala

species, but when they do the consequences can be severe for local biodiversity, ecosystem services and human well-being. For instance, it has been calculated that the additional water use by alien trees in South Africa (excluding those in plantations and orchards) is between 1 400 and 3 300 million m^3/year (Görgens and van Wilgen 2004). Chapter 10: *Invasive Alien Species* looks at these issues more closely.

Climate change is also emerging as a major threat to biodiversity in Southern Africa, with some symptoms already manifest (Rutherford and others 1999). While extreme climate variation is not new, the magnitude and rapidity of climate change likely to occur in the 21st century is greater than the capacity of many organisms to respond by adaptation or migration. Migration to areas with a suitable climate is severely hampered by barriers such as roads, fences, urban areas and cultivated fields. The highly diverse and unique succulent flora of the winter-rainfall regions in the southwest of Africa is projected to be particularly threatened (Rutherford and others 1999). There is emerging evidence that the effects of climate change are already apparent there (Foden and others 2003). Chapter 3: *Land* examines some of the challenges associated with climate change.

WESTERN AFRICA

The wide range of ecosystems – forests, savannahs, deserts, rivers, mountains, mangroves and seas – makes the sub-region rich in biodiversity. The Sahelian zone has several wetlands, including the Niger and Senegal rivers, Lake Chad and floodlands in Senegal and Niger which are very important for migratory birds. The inner Niger delta is a vast floodplain (more than 30 000 km^2) situated in the middle of the Sahelian landscape, rich in natural resources and featuring varied ecosystems (lakes, forest floodplains, flooded grasslands and savannah) which supports the livelihoods of 1 million people. The delta is also well known as a wintering and staging area for million of migratory birds. Other important sub-regional biodiversity values include the west African manatee, a globally endangered species (Beintema and others 2001). The Guinea forest contains half the mammal species on the African continent, including the rare pygmy hippopotamus, the zebra duiker and the drill, the most threatened primate (UNEP and NESDA 2004)

Table 6: The biodiversity features of Western Africa

		Biodiversity opportunity						Threat	Response
		Mammals		Birds		Plants		% of land	% of land
Country	Area km²	Endemic	Total	Endemic	Total	Endemic	Total	transformed	protected
Benin	11 2620	0	188	0	307	0	2 500	9	6
Burkina Faso	274 000	0	147	0	335		1 100	48	12
Cape Verde	4 030	0	5	4	38	86	774		
Gambia	11 300	0	117	0	280	not known	974	42	0
Ghana	238 540	1	222	0	529	43	3 725	17	5
Guinea	245 860	1	190	0	409	88	3 000	14	0
Guinea-Bissau	36 120	0	108	0	234	12	1 000	7	
Côte d'Ivoire	322 460	0	230	2	535	62	3 660	25	6
Liberia	111 370	0	193	1	372	103	2 200	30	1
Mali	1 240 190	0	137	0	397	11	1 741	15	4
Mauritania	1 025 520	1	61	0	273	not known	1 100	3	0
Niger	1 267 000	0	131	0	299	not known	1 460	2	8
Nigeria	923 770	4	274	2	681	205	4 715	34	4
Senegal	196 720	0	192	0	384	26	2 086	47	11
Sierra Leone	71 740	0	147	1	466	74	2 090	38	2
Togo	56 790	0	196	0	391	not known	3 085	7	8
All countries	6 138 030	7		10		710		16	4

Source: Methodology and sources as for Table 1

Challenges faced in realizing opportunities for development

Land degradation and desertification are major causes of biodiversity loss. Three factors contribute:

- A relatively dense and growing population with strong dependence on natural resources:
- Relatively easy access to resources; and
- Recurrent droughts.

These processes affect grasslands, steppes, savannahs and woodlands:

- They fragment forests and alter their structure and composition, especially when they are followed by recurrent forest and bush fires;
- They reduce surface water points and their associated plants;
- They strongly deplete animal populations and notably reduce a number of rare and vulnerable species through habitat degradation, sport hunting and especially through exploitation for bushmeat, which is exacerbated by drought-related food deficits.

Dust storms, forest fires, locust outbreaks and population displacement are all linked to the phenomenon of desertification, and have strongly negative consequences for people, in particular through the loss of livelihood and economic opportunities.

Land degradation is a persistent reduction in the capacity to support life and supply ecosystem services. It affects biological diversity directly and indirectly. It may affect the survival of species and alter processes that support their life, or it may trigger socioeconomic phenomena that impact on living species and their ecosystems. Land degradation phenomena directly affecting biodiversity include water and wind erosion. Along major river basins siltation processes accumulate debris and materials that engulf natural vegetation, such as the *Acacia nilotica* riparian forests. Trees may survive for years, but the diverse understorey may not. Soil erosion contributes to moving the seed capital of the ground, uprooting grassy as well as woody species, and in accumulation areas it smothers valuable species. This occurs in the sand dune areas of countries such as Mauritania, Mali, Niger, Nigeria and Senegal.

Indirect factors associated with land degradation that impact on biodiversity include the coping strategies people adopt to deal with environmental change. The movement of people south towards sub-humid to humid tropical areas has resulted in depletion

of natural resources: loss of primary forests and woodlands, repeated logging of the secondary vegetation, and depletion of a number of species. The influx of refugees from war-stricken areas also triggers severe land degradation in host regions and the overuse of wildlife resources. More diffuse degradation of land resources also occurs in the arid and sub-humid parts. These include the extraction of tree resources outside forests for charcoal making (about 150 million tonnes/year from the savannahs and woodland areas), and the use of high-value woods. Most affected are the Meliacaea family (*Khaya* species), *Pterocarpus erinaceus*, and *Dalbergia melanoxylon*.

The degradation and fragmentation of natural landscapes is caused by agricultural expansion. Agricultural expansion affects the survival and regeneration of animal populations, destroys the structure of wildlife habitat, and strongly contributes to reduction of wildlife populations. The number of species threatened continues to grow; these include lion, elephant, most of the greater antelopes, and water-dependent species such as manatees and crocodiles, which could form the basis of a tourism industry.

Strategies to enhance the opportunities for development

A number of conservation efforts, some involving communities, have been undertaken. An example of a successful conservation initiative involving local communities is shown in Box 6.

The West African Gaboon viper (*Bitis gabonica rhinoceros*) is a venomous and highly camouflaged snake which can fetch up to US$600 in the international exotic pet trade.

Source: J. Gerholdt/Still Pictures

Table 7 shows international protected areas in Western Africa. An example of successful cooperative is the endeavour of Benin, Burkina Faso and Niger, supported by external partners such as France, to protect the extensive transboundary complex of the Pendjari and Arly national parks. Concerted efforts have succeeded in maintaining the overall system and

Box 6: The Diawling National Park (DNP), Mauritania

In the delta of Senegal River, in Mauritania, two dams were constructed in the 1980s: the Manantali dam upstream (in 1989) for flood regulation, hydroelectricity, irrigation and navigation purposes and the Diama one downstream (in 1985), an anti-salt dam.

However, by 1997, only 100 000 ha had been equipped for irrigated agriculture, and only 44 000 ha were farmed in the end because of loss of soil fertility and increased salinity (OMVS and others 1998 cited in Hamerlynck and Duvail 2003). Hydropower production started in 2002. By 2003, no investments had been secured for the navigability scheme. Thus, the negative impacts of the Diama Dam were dire: loss of floodplains traditional functions (fishing, grazing, rain-fed cultivation, handicraft, etc). The dam also prevented exchanges between river freshwater and seawater, with the reduction of the estuary ecosystem's great productivity.

IUCN – The World Conservation Union and the Directorate-General for International Cooperation (DGIS) (Netherlands) proposed then to help restore this delta by reintroducing inundation through the sluice gates of the dam. Negotiation between the various users within the park was undertaken to come out with a consensus water management plan. A consensus scenario for opening and closing the different sluice gates was adopted. This scenario takes into account all the resources (the spawning of fish, the *Sporobolus spp.* growth, the groundwater replenishment, etc) and their behaviour related to water level.

With the return of the floods came the return of people from the cities. Floodplains traditional functions and goods (cattle grazing, artisanal mat weaving using *Sporobolus robustus* and *Acacia nilotica* seedpods (for leather tanning), fisheries, and waterbirds) returned. Thus livelihood activities, by both men and women from this Senegal River valley, were restarted, contributing to the improvement of human well-being.

Source: Hamerlynck and Duvail 2003, IUCN 2003

Table 7: International protected areas in Western Africa

	Biosphere reserve		World heritage sites		RAMSAR sites	
Country	**Number**	**Area ('000 ha)**	**Number**	**Area ('000 ha)**	**Number**	**Area ('000 ha)**
Benin	1	623	0	0	2	139
Burkina Faso	1	186	0	0	3	299
Côte d'Ivoire	2	1 480	3	1 504	1	19
Gambia	0	0	0	0	1	20
Ghana	1	8	0	0	6	178
Guinea	2	133	1	13	6	225
Guinea Bissau	1	110	0	0	1	39
Liberia	0	0	0	0	0	0
Mali	1	2 349	1	400	3	162
Mauritania	0	-	1	1 200	2	1 231
Niger	2	25 128	2	7 957	4	715
Nigeria	1	<1	0	0	1	58
Senegal	3	1 094	2	929	4	100
Sierra Leone	0	-	0	0	1	295
Togo	0	0	0	0	2	194
Total	15	31 111	10	12 003	37	3 674

data for Cape Verde not available

Source: Data from Wetlands International undated, UNESCO 2006a, UNESCO 2006b

resources in the protected areas in the three participating countries. Biodiversity is relatively well conserved in this area: avifauna is represented by around 378 species; fish species, amphibians and reptiles are prominently present; and the greater mammals of the savannahs and woodland areas are extensively featured (10 000 buffalo, 4 500 elephants, 7 500 roan antelopes, 2 000 bubals, 1 100 warthogs and 1 000 kobs). Lions, cheetahs, panthers and hyenas are also well represented. The habitat is also well conserved, and the overall trend of biological diversity is deemed very positive and on the rise.

WESTERN INDIAN OCEAN ISLANDS

Overview of resources

The WIO islands are characterized by significant plant endemism as well as other biodiversity, which is related to their island status. These islands are among the most globally important priorities for conservation, mainly due to the outstanding levels of endemism.

Madagascar has been separated from the African mainland and from India for millions of years (Goodman and others 2003). As a consequence, most of the plant and animal species present there have evolved in long isolation. Madagascar's most striking feature is its exceptionally high endemism in nearly all groups, particularly at the generic and family levels. Many groups also show very high levels of species diversity on Madagascar (Lowry II and others 1997). Plant species richness is currently estimated to be at least 12 000 species, and possibly as many as 14 000, of which more than 90 per cent are endemic. Among vertebrates, the extant mammal fauna comprises 101 native terrestrial species, none of which is found anywhere else on Earth (Goodman and others 2003).

By contrast, the other Indian Ocean islands are composed of relatively recent volcanic islands (the Mascarenes and the Comoros) or fragments of older continental material (the main group of the Seychelles). They are biologically closely linked to Madagascar, and reveal important endemic biodiversity. They add important endemic biodiversity for the total land area of 590 000 km^2 (including the Iles Esparses, a series of small French-held islands surrounding Madagascar: Les Glorieuses, Juan de Nova, Tromlin and Bassas da India).

The Mascarenes have about 1 300 vascular plant species, of which 585 are endemics, the Comoros have about 1 000 species (150 endemic), and there are about 310 species in the Seychelles of which 75 are endemic (Mittermeier and others 2004). Madagascar

Table 8: Biodiversity features of the Western Indian Ocean islands

		Biodiversity opportunity						Threat	Response
		Mammals		Birds		Plants		% of land	% of land
Country	Area km²	Endemic	Total	Endemic	Total	Endemic	Total	transformed	protected
Comoros	2 230	2	12	14	50	136	721	not known	not known
Madagascar	587 040	93	141	105	202	6 500	9 505	11	2
Mauritius	2 040	1	4	8	27	325	750	not known	30
Seychelles	450	2	6	11	38	182	250	not known	12
All countries	591 760	98		138		7 143			

Source: Methodology and sources as for Table 1

and its neighbouring island groups have a total of eight endemic plant families (with seven families endemic to Madagascar and one to the Seychelles), four endemic bird families, and five endemic primate families (Mittermeier and others 2004).

Opportunities for development

The rich biodiversity most of the WIO countries forms a significant natural resource base that provides valuable raw materials for local and commercial use. It is important for tourism, food, construction and shelter (IOC 2004a). In addition, many plant species are used medicinally and several species are being researched for commercial agricultural or pharmaceutical use (IOC 2004b). Management of these species, which offer social and economic opportunities for development, plus the management of other threatened species, are features of environmental policy and programmes in the WIO islands (IOC 2004a).

The 4 million km² of the WIO Exclusive Economic Zone (EEZ) has offered in the past, the opportunity for economic development through deep-sea fishing, but the stocks are now probably exploited to their upper limit. Biological and ecological research and the evaluation of tuna stocks have emerged in the past decade as major fields for conservation studies. These cover oceanographic and environmental aspects that impact on tuna catches, including conventional and electronic tagging for monitoring migration, numbers and size of species, for scientific and commercial purposes. (IOC 2004a, Government of Mauritius 2005). A regional project on aromatic and medicinal plants has provided an inventory of more than 600 species within the member countries, used in traditional practice, as a basis for further scientific and commercial study and development (IOC 2004b).

Challenges faced in realizing opportunities for development

Coastal and marine habitat loss threatens the survival of animal and plant species, and thus undermines livelihood and development options. As small island developing states (SIDS) the WIO islands experience many of the same problems, often linked to tourism, coastal livelihoods and overfishing, waste management, and a high level of vulnerability to natural disasters and human-induced environmental change. Important drivers of and pressures contributing to environmental change include (UNEP 2005a): unsustainable natural resource exploitation, habitat conversion and destruction, the introduction of IAS, pollution and soil degradation, coastal erosion, seawater intrusion, bush fires, overfishing in lagoons, long line and fine net fishing, coastal urban tourist development, building on wetlands, water pollution, land reclamation with its degradation of lagoons and coral reefs (Republic of Seychelles 2004), sand mining in lagoons, islets and coastal areas (Government of Mauritius 2005), hunting (Louette and others 2004), inadequate management of waste and intensive farming.

Loss of forest cover inland, in particular in upland zones, and the adverse impact of IAS, threaten the survival of endemic species. Freshwater ecosystems have been seriously impacted by IAS such as *Eichornia crassipes* (*water hyacinth*) (Langrand and Goodman 1995). Alien domestic animals, such as cattle, sheep and goats, have caused important changes in native plant communities and have helped drive many endemic terrestrial herbivores to the brink of extinction (Dewar 1997). Human activities are thought to be primarily responsible for the current pattern of vegetation change: grassland wildfires set by herders either to stimulate regrowth during the dry season or to eliminate unpalatable herbaceous species (Kull 2000), and forest clearing for agriculture, timber and charcoal production.

Mirza zaza, a new lemur species, discovered in Madagascar in 2005.

Source: D. Haring/Duke University Primate Center

In the Comoros, up to 7 per cent of the land has become deforested, and patterns of rainfall and drainage have also changed (Louette and others 2004).

The main threats to natural habitats in Madagascar and the Comoros are forest loss through slash-and-burn agriculture and fire, with logging and mining on the rise in Madagascar. In Mauritius and the Seychelles, conversion of land for housing and other uses presents the biggest threat.

These factors adversely affect biodiversity and terrestrial and marine ecosystems, including sea-grasses, mangroves and the coral reefs. The prospects for the conservation of rare animal species such as the wandering albatross, turtles, coelacanth, the Mascarene black petrel, the pink pigeon and others, critically depend upon the transformation and scaling-up of intervention from small scientific projects to major mainstream programmes.

Strategies to enhance opportunities for development

Interventions at a national and sub-regional level are important.

There is a need for developing policy-relevant environmental performance indicators for biodiversity. In addition, the identification of sustainable development goals and objectives, with clear objective verifiable indicators, the identification of lead agencies for implementation and results-based budgeting are important planning tools (Republic of Seychelles 2000, Government of Mauritius 2005). Greater technical assessment of the most appropriate means of extending pilot and project work into mainstream programmes is also needed. The work of the sub-regional bodies, such as the IOC, indicates how this technical aspect of work can be taken forward, in concert with that being established in other regions with large numbers of islands states, such as the Pacific and the Caribbean.

Regional support is also essential in human resource programmes, especially for professional, technical and managerial development (UN 2005).

At the national level, establishing protected areas is seen as a key strategy for protecting biodiversity.

Considerable progress has been made in Madagascar, where there has been renewed political commitment to conservation. In 2003, at the World Parks Congress in Durban, South Africa, Madagascar declared its intention to triple the total land area managed for conservation purposes. More recently, during the International Scientific Conference on "Biodiversity, Science and Governance", held in Paris in January 2005, the intention was reiterated and the objective of biodiversity protection was confirmed to be an essential element in decreasing poverty and increasing opportunities. Collaboration at multiple levels supports this. Government, in collaboration with scientists and conservationists, is identifying priority areas for conservation. Additionally, a multidisciplinary group of NGOs is collaborating with the government in identifying potential priority sites for conservation, the legal aspects of implementing management plans, and

the adoption of IUCN protected area categories (Robertson and Hull 2001). By 2002, Madagascar's protected areas network included 46 sites covering between 2 per cent and 2.7 per cent of the country's total surface (Randrianandianina and others 2004). Current approaches for area selection are based on biological collections and on a range of eco-geographic parameters. Thus both large and small areas with unique biodiversity have been identified for protection. During the process of identifying priority conservation areas, scientists identified important data gaps, particularly regarding marine, freshwater and mangrove environments, and also non-vascular plants (National Research Council – Committee on the Formation of the National Biological Survey 1993). Rules have been adopted for a conservation management system that gives the local community an important role. The newly-designated conservation sites will operate based on some improved management principles: more dynamic and flexible management will be encouraged than the current system which over-relies on non-use measures.

The Seychelles have about 208 km^2 of national parks, in varying degrees of implementation. Taken together, all parks, irrespective of the degree of protection, represent about 42 per cent of the land area. There are a further 228 km^2 of marine national parks. In Mauritius, there are ten protected areas within the IUCN categories I – II, with a total area of 70 km^2. In addition there are 90 km^2 of marine protected areas. In the Seychelles and Mauritius, which are economically better off than Madagascar, the factors threatening biodiversity differ substantially from those in Madagascar. Conservation strategies in Mauritius place less emphasis on rural development and poverty alleviation, and more on the political process leading to the establishment of protected areas and improved land-use planning.

In the Comoros, the situation has more in common with Madagascar. There are three protected areas covering 400 km^2, which represents 24.3 per cent of the total land area. Although levels of diversity and endemism are more modest in the Comoros, biodiversity conservation is nevertheless a high priority. In this context, the approach developed in Madagascar, in which carefully compiled and analysed data are being used to inform the process of identifying new conservation sites, could serve as a valuable model.

The principal challenge for the next decade is to convert these projects into mainstream programmes and sustain and improve on the results already achieved. This will depend on long-term political, financial and management support, together with the development of professional and technical services on a local, national and sub-regional basis. Special emphasis is needed in these programmes to link the protection of the environment to the relief of poverty, community and professional education, and the sustained use of natural resources for the benefit of social and economic development at community level. This process of transformation is also vital for continued development of programmes more directly linked to commercial development which depend upon the survival of species used in agriculture, forestry and fisheries, for food, medicine, industry and in the promotion of eco- and educational tourism (UNEP 2005a).

CONCLUSION

Biodiversity is in need of wise management, not simply to satisfy international pressures and obligations, but because it is the basis of most rural livelihoods and is the foundation of major new economic sectors that offer the prospect of better, more sustainable lives.

As NEPAD has recognized, development cannot be achieved through dependence on outside resources, but must rely on the best use of local resources. Biodiversity is one of these, and represents a formidable natural asset. For example, the international trade in flowers bred from a large number of plant species originating in Africa is worth billions of dollars

This beautiful lily, *Zantedeschia aethiopica*, is indigenous to Southern and Eastern Africa and is exported worldwide.

Source: V. Rabesahala

annually, almost all of which accrues outside Africa. For the opportunities offered by biodiversity to be realized, new strategies, which go beyond a focus on a few species and parks, will need to be adopted.

New links need to be made between protecting biodiversity and human needs. There is a need for more function-oriented conservation of ecosystem services essential for human livelihood, including the people-dominated landscapes outside parks (Adams 2001). The coincidence of centres of biodiversity, human cultural heritage and intensive land use partly defines the necessary strategy for conservation and sustainable use policy. If viable populations are to be preserved, particularly in the light of an uncertain future climate, biodiversity conservation cannot be restricted to protected areas, but has to be incorporated as part of sustainable land use even in densely settled areas (Scholes and Biggs 2005). Likewise, conservation of human culture within centres of biodiversity requires approaches different from the concept of protected areas exclusively dedicated to species conservation (Adams 2001, Adams and Hulme 2001, Jepson and Canney 2001). Except under special circumstances, for example, where nature tourism is the best economic land use (Carret and Loyer 2003), species and park-centred strategies of biodiversity conservation are unlikely to achieve poverty reduction goals. Although biodiversity conservation objectives often overlap with other priorities for sustainable use (for example, the conservation of water catchment areas), the overall outcome of such integrated strategies will need to go beyond solely biodiversity-centred conservation targets. This principle is reflected in the "ecosystem approach" adopted by the CBD in 2000 (UNEP 2004b) and underlies the interlinkages approach discussed in Chapter 8: *Interlinkages: The Environment and Policy Web*. Clear and convergent objectives, verifiable targets, collaboration and coordination between conventions and between countries, focused and sustained capacity-building, and harmonized reporting requirements are needed to advance the regional development objectives.

References

Adams, W.M. (2001). *Green Development: Environment and Sustainability in the Third World (2nd Edition)*. Routledge, London

Adams, W.M. and Hulme, D. (2001). If community conservation is the answer in Africa, what is the question? *Oryx*. 35(3), 193-200

Agrawal, A. and Gibson, C.C. (1999). Enchantment and disenchantment: the role of community in natural resource conservation. *World Development*. 27(4), 629-49. http://www.mekonginfo.org/mrc_en/doclib.nsf/0/F52F8186F85933F9472568E80044F906/$FILE/FULLTEXT.html

ARC-All (undated). Livestock Breeds: Bonsmara Cattle. Agricultural Research Council – Animal Improvement Institute. http://www.arc.agric.za/institutes/aii/main/divisions/foreign/bonsmara.htm

Baillie, J., and Groombridge, B. (1996). *1996 IUCN Red List of Threatened Animals*. IUCN – The World Conservation Union, Gland

Balmford, A. and Gaston, K.J. (1999). Why biodiversity surveys are good value. *Nature*. 398, 204-5

Balmford, A., Moore, J.L., Brooks, T., Burgess, N., Hansen, L.A., Williams, P. and Rahbek, C. (2001). Conservation conflicts across Africa. *Science*. 291, 2616-9

Barnard, P. (ed. 1998). *Biological diversity in Namibia: a country study*. Namibian National Biodiversity Task Force / Ministry of Environment and Tourism, Windhoek

Barnes, J.I. (1995). Economic analysis of community-based wildlife utilization initiatives in Botswana. *Development Southern Africa*. 12, 783-803

Barnes, J.I, MacGregor, J. and Weaver, L.C. (2001). Economic analysis of community wildlife use initiatives in Namibia. DEA Research Discussion Paper No. 42. http://www.met.gov.na/publications/research/RDP42.pdf

Barthlott, W., Mutke, J., Rafiqpoor, M.D., Kier, G. and Kreft, H. (2005). Global centres of vascular plant diversity. *Nova Acta Leopoldina*. 92(342), 61-83

Batanouny, K.H. (1999). The wild medicinal plants of North Africa: history and present status. *Acta Horticulturae (ISHS)*. 500, 183-8.

Beentje, H.J. (1996). Centres of plant diversity in Africa. In *The biodiversity of African plants: proceedings XIVth AETFAT congress, 22-27 August 1994, Wageningen, The Netherlands* (eds. Van Der Maesen, L.J.G., Van Der Burgt, X.M., Van Medenbach de Rooy, J.M.) , pp 101-9. Kluwer Academic Publishers, Dordrecht

Beentje, H., Adams, B., Davis, S.D. and Hamilton, A.C. (1994). Regional Overview: Africa. In: *Centres of Plant Diversity: A Guide and Strategy for their Conservation, V. 1: Europe, Africa, South West Asia and the Middle East* (eds. Davis, S.D., Heywood, V.H., Hamilton, A.C.), pp 101-48. IUCN – The World Conservation Union, Cambridge

Beintema, A.J., Fofana, B. and Diallo, M. (2001). *Gestion des forêts inondées dans le Delta Intérieur du Niger, Mali; Management of flood forests in the inner Niger Delta, Mali*. Alterra-rapport 341, Alterra, Green World Research, Wageningen. http://www2.alterra.wur.nl/Webdocs/PDFFiles/Alterrarapporten/AlterraRapport341.pdf

Biggs, R., Bohensky, Fabricius, C., Lynam, T., E., Misselhorn, C. Musvoto, M. Mutale, B. Reyers, R. J. Scholes, S. Shikongo, and A.S. van Jaarsveld (2004). *Nature supporting people: The Southern African Millennium Ecosystem Assessment*. CSIR, Pretoria, South Africa

Bikié, H., Collomb, J-G., Djomo, L., Minnemeyer, S., Ngoufo, R. and Nguiffo, S. (2000). *An Overview of Logging in Cameroon*. A Global Forest Watch Cameroon Report. World Resources Institute, Washington, D.C. http://www.globalforestwatch.org/common/cameroon/english/report.pdf

Biodiversity Support Program (1999). Study on the Development of Transboundary Natural Resource Management Areas in Southern Africa: Highlights and Findings. http://www.worldwildlife.org/bsp/publications/africa/transboundary/TBNRM.pdf

BirdLife International (2004). *State of the world's birds 2004: indicators for our changing world*. BirdLife International, Cambridge

BirdLife International (undated). Action for Birds and People in Africa. The conservation programme of Birdlife International Africa Partnership 2004-2008. BirdLife International, Cambridge. http://www.birdlife.org/regional/africa/pdfs/africa_programme_2004-08.pdf

Blake, S. (2002). *The Ecology of Forest Elephant Distribution and its Implications for Conservation*. Ph.d. Thesis. University of Edinburgh, Edinburgh

Blom, A. (2004). An estimate of the costs of an effective system of protected areas in the Niger Delta – Congo Basin Forest Region. *Biodiversity and Conservation*. 13(14), 2661-78

Brooks, T. Balmford, A., Burgess, N., Fjeldsa, J., Hansen, L.A., Moore, J., Rahbek, C., and Williams, P. (2001). Toward a blueprint for conservation in Africa. *BioScience*. 51(8), 613-24

Burgess, N., D'Amico Hales, J., Underwood, E., and Dinerstein, E. (2004). *Terrestrial Ecoregions of Africa and Madagascar: A Conservation Assessment*. Island Press, Washington

Burgess, N.D., Kuper, W., Mutke, J., Brown, J., Westaway, S., Turpie, S., Meshack, C., Taplin, J., McClean, C. and Lovett, J.C. (2005). Major gaps in the distribution of protected areas for threatened and narrow range Afrotropical plants. *Biodiversity and Conservation*. 14, 1877-94. http://www.botanik.uni-bonn.de/system/mitarbeiter_homepages/kueper/Burgess_et_al_2005_Gap_analysis.pdf

Carret, J.C. and Loyer, D. (2003). Comment financer durablement le réseau d'aires protégées terrestres à Madagascar? Proceedings of the Vth World Parks Congress. Durban, South Africa, 8-17 September. http://www.smbmada.net/documents/Durban_2003.pdf

Carswell,M., Pomeroy, D., Reynolds, J and Tushabe, H (2005). *Bird Atlas of Uganda*. British Ornithologists' Union, Oxford

CBFP (2005). *The Forests of the Congo Basin: A Preliminary Assessment*. The Congo Basin Forest Partnership. http://carpe.umd.edu/products/PDF_Files/FOCB_APrelimAssess.pdf

CBFP (undated). Partenariat pour les forets du Bassins du Congo. Congo Basin Forest Partnership. http://www.cbfp.org/en/index.htm

Champan, L.J. (2001). Fishes of African Rainforests: Diverse Adaptations to Environmental Challenges. In *African Rainforest Ecology and Conservation* (eds. Morland, H.S., Vedder, A., Weber, W., and White, L.), pp 263-90. Yale University Press, New Haven

Christ, C., Hillel, O., Matus, S. and Sweeting, J. (2003). Tourism and Biodiversity: Mapping Tourism's Global Footprint. Conservation International, Washington, D.C. http://www.unep.org/PDF/Tourism_and_biodiversity_report.pdf

CI (2006) Biodiversity Hotspots. Conservation International Washington D.C.. http://www.biodiversityhotspots.org

Collomb, J-G., Mikissa, J-B., Minnemeyer, S., Mundunga, S., Nzao Nzao, H., Madouma, J., Mapaga, J., Mikolo, C., Rabenkogo, N., Akagah, S., Bayani-Ngoye, E., and Mofouma, A. (2000). A First Look at Logging in Gabon. A Global Forest Watch Gabon Report. World Resources Institute, Washington D.C. http://www.globalforestwatch.org/common/gabon/english/report.pdf

COMIFAC (2005). Le Plan de Convergence, Tradition et Modernité: Une plate-forme commune d'actions pour le Bassin du Congo. Central African Forests Commission. http://www.comifac.org/activites/plandeconvergence.htm

Costanza, R., D'Arge, R., De Groot, R., Farber, S., Grasso, M., Hannon, B., Limburg, K., Naeem, S., O'Neill, R.V., Paruelo, J., Raskin, R.G., Sutton., P. And Van Den Belt, M. (1997). The value of the world's ecosystem services and natural capital. *Science*. 387, 253-60

Cowling, R.M., Rundel, P.W., Lamont, B.B., Arroyo, M.K., Arianoutsou, M. (1996). Plant diversity in mediterranean-climate regions. *Trends in Ecology and Evolution*. 11(9), 362-6

Davis, S.D., Heywood, V.H., and Hamilton, A.C. (eds. 1994). Centres of plant diversity. A guide and strategy for their conservation. Vol. 1: Europe, Africa and the Middle East. IUCN Publications Unit, Cambridge

de Klerk, H.M., Crowe, T.M., Fjeldsa, J. and Burgess, N.D. (2002). Biogeographical patterns of endemic terrestrial Afrotropical birds. *Diversity and Distributions*. 8(3), 147-62

de Klerk, H.M., Fjeldsa, J., Blyth, S. and Burgess, N.D. (2004). Gaps in the protected area network for threatened Afrotropical birds. *Biological Conservation*. 117, 529-537

Dewar, R.E. (1997). Were people responsible for the extinction of Madagascar's subfossils, and how will we ever know? In *Natural Change and Human Impact in Madagascar* (eds. Goodman, S.M. and Patterson, D.), pp 364-77. Smithsonian Books, Washington, D.C.

EWNHS (1996). Important Bird Areas of Ethiopia: A first inventory. Ethiopian Wildlife and Natural History Society and BirdLife International, Addis Ababa

FAO (2003). *Forestry Outlook Study for Africa – African Forests: A View to 2020*. Food and Agriculture Organization of the United Nations, Rome. ftp://ftp.fao.org/docrep/fao/005/Y4526B/y4526b00.pdf

FAO (1997). *The State of the World's Plant Genetic Resources for Food and Agriculture*. Food and Agriculture Organization of the United Nations, Rome. http://www.fao.org/ag/AGP/AGPS/Pgrfa/pdf/swrfull.pdf

FAOSTAT (2005). *FAOSTAT – FAO Statistical Databases*. Food and Agriculture Organization of the United Nations. http://faostat.fao.org/

Farnsworth, N.R., Akerele, O., Bingel, A.S., Soejarto, D.D. and Guo, Z. (1985). Medicinal plants in therapy. *Bulletin of the World Health Organization*. 63(6), 965-81. http://whqlibdoc.who.int/bulletin/1985/Vol63-No6/bulletin_1985_63(6)_965-981.pdf

Fjeldsa, J, Burgess, N.D., Blyth, S., and de Klerk, H.M. (2004). Where are the major gaps in the reserve networks for Africa's mammals? *Oryx*. 38(1), 17-25

Fjeldsa, J. and Lovett, J.C. (1997). Geographical patterns of old and young species in African forest biota: the significance of specific montane areas as evolutionary centres. *Biodiversity and Conservation*. 6(3), 325-46

Foden, W., Midgley, G.F., Bond, W.J. and Bishop, J. (2003). Population declines of Aloe dichotoma (Kokerboom) – revealing early impacts of climate change. Proceedings of the National Symposium on Global Change and Regional Sustainability in South Africa, Kistenbosch, Cape Town, 27-29 October

Frodin, D.G. (2001). *Guide to Standard Floras of the World (2nd Edition)*. Cambridge University Press, Cambridge

GAA (2004). Global Amphibian Assessment Database. Global Amphibian Assessment. IUCN – the World Conservation Union. http://www.globalamphibians.org/

Gabon National Parks (undated). Gabon National Parks: Presenting the wonder of Gabon's wildlife. http://www.gabonnationalparks.com/gnp-nationalparks

Gaston, K.J., and Rodrigues, A.S.L. (2003). Reserve selection in regions with poor biological data. Conservation Biology. 17, 188-95

GebreMichael T., Hundessa, T. and Hillma, J.C. (1992). The effects of war on world heritage sites and protected areas in Ethiopia. In *World Heritage Twenty Years Later. Papers presented during the workshops held during the IV World Congress on national parks and protected areas, Caracas, Venezuela, February 1992* (ed. Thorsell, J.C.), pp 143-50. IUCN – The World Conservation Union, Gland

Gibson, C.C. (1999). *Politicians and Poachers – The Political Economy of Wildlife Policy in Africa*. Cambridge University Press, Cambridge

Goldblatt, P. and Manning, J. (2000). Cape plants – A conspectus of the cape flora of South Africa. *Strelitzia*. 9, 7-13

Golding, J. (ed. 2002). Southern African Plant Red Data Lists. *Southern African Botanical Diversity Network Report No. 14*. Southern African Botanical Diversity Network, Pretoria

Goodman, S.M. (2004). Measures of Plant and Land Vertebrate Biodiversity in Madagascar. In *Terrestrial Ecoregions of Africa and Madagascar: A Conservation Assessment* (eds. Burgess, N., D'Amico Hales, J., Underwood, E., and Dinerstein, E.), pp 71-2. Island Press, Washington

Goodman, S.M. and Benstead, J.P. (eds. 2003). The Natural History of Madagascar. University of Chicago Press, Chicago

Goodman, S.M., Ganzhorn, J.U. and Rakotondravony, D. (2003). Introduction to the Mammals. In *The Natural History of Madagascar* (eds. Goodman S.M. and Benstead, J.P.), pp 1159-86. The University of Chicago Press, Chicago

Görgens, A.H.M. and van Wilgen, B.W. (2004). Invasive alien plants and water resources in South Africa: current understanding, predictive ability and research challenges. *South African Journal of Science*. 100, 27-33

Government of Mauritius (2005). Mauritius – Staking out the Future. Ministry of Environment and national Development Unit, Port Louis. http://www.nssd.net/pdf/peer_review/Mauritius.pdf

Groombridge, B. and Jenkins, M. (2002). *World Atlas of Biodiversity: Earth's Living Resources in the 21st Century*. University of California Press, Berkeley

Groombridge, B., and Jenkins, M.D. (eds. 1994). *Biodiversity Data Sourcebook*. WCMC Biodiversity Series No.1. World Conservation Press, Cambridge

Hamerlynck, O. and Duvail, S. (2003). *The Rehabilitation of the Delta of the Senegal River in Mauritania*. IUCN – The World Conservation Union, Gland and Cambridge. http://www.iucn.org/themes/wetlands/pdf/diawling/Diawling_GB.pdf

Hamilton, A.C. and Taylor, D. (1991). History of climate and forests in tropical Africa during the last 8 million years. *Climatic Change*. 19, 65-78

Harcourt, A.H. (2000). Coincidence and mismatch of biodiversity hotspots: a global survey for the order, primates. *Biological Conservation*. 93(2), 163-75

Hawkes, J.G. and Worede, M. (eds. 1991). *Plant Genetic Resources of Ethiopia*. Cambridge University Press, Cambridge

Hegazy, A. K., Fahmy, A. G. and Mohamed, H. M. (2001). Shayeb El-Banat mountain group on the Red Sea coast: a proposed biosphere reserve. *Symposium on Natural Resource Conservation in Egypt and Africa*, Cairo, Egypt, 19-21 March

Hegazy, A. K., Diekman, M. and Ayad, W. G. (1999). Impact of plant invasions on ecosystems and native Gene Pools. In *Environment 2000 and Beyond* (ed. Hegazy, A.K.), pp. 275-310. Horus, Cairo

Hilman, J.C. (1991). The current situation in Ethiopia's wildlife conservation areas. Ethiopian Wildlife Conservation Organisation, Addis Ababa

Hoekstra, J.M., Boucher, T.M., Ricketts, T.H. and Roberts, C. (2005). Confronting a biome crisis: global disparities of habitat loss and protection. *Ecology Letters*. 8, 23-9

Hulme, D. and Murphree, M. (eds. 2001). *African Wildlife and Livelihoods: The Promise and Performance of Community Conservation*. Heinneman, Portsmouth

IEA (2002). Chapter 13: *Energy and Poverty. In World Energy Outlook* 2002. International Energy Agency, Paris. http://www.iea.org/textbase/nppdf/free/2002/energy_poverty.pdf

IOC (2004a). AIMS Synthesis Report, progress on the Barbados Programme of Action. Indian Ocean Commission for the AIMS Group, Port Louis. http://www.sidsnet.org/docshare/other/20041109141045_AIMS_synthesis_report_final.doc

IOC (2004b). Report on Implementation of Barbados Programme of Action, Annex 2. Indian Ocean Commission, Port Louis

IUCN (2003). Annual Report. IUCN – The World Conservation Union, Gland.

IUCN (undated – a). Global Mammal Assessment. IUCN – The World Conservation Union. http://www.iucn.org/themes/ssc/biodiversity_assessments/gma/indexgma.htm

IUCN (undated – b). North Africa Programme. IUCN – The World Conservation Union. http://www.iucn.org/places/wcana/nafrica.htm

IUCN-WCPA (undated). WCPA East and South Africa Region. IUCN – The World Conservation Union World Commission on Protected Areas. http://www.iucn.org/themes/wcpa/region/esafrica/esafrica.html

Jacobs, M.J. and Schloeder, C.A. (2001). Impacts of Conflict on Biodiversity and Protected Areas in Ethiopia. Biodiversity Support Program, Washington, D.C. http://www.worldwildlife.org/bsp/publications/africa/147/titlepage.htm

James, A., Gaston K.J. and Balmford, A. (2001). Can we afford to conserve biodiversity? *BioScience*. 51(1), 43-52

Jepson, P. and Canney, S. (2001). Biodiversity hotspots: hot for what? *Global Ecology & Biogeography*. 10(3), 225-7

Jetz, W. and Rahbek, C. (2001). Geometric constraints explain much of the species richness pattern in African birds. *Proceedings of the National Academy of Sciences of the United States of America*. 98 (10), 5661-6

Kaltenborn, B.P., Nyahongo, J.W. and Mayengo, M. (2003). People and wildlife Interactions around Serengeti National Park: Biodiveristy and the Human-wildlife Interface in Serengeti, Tanzania. NINA Project Report No. 22. Norwegian Institute for Nature Research, Lillehammer. http://www.nina.no/archive/nina/Publikasjoner/project%20report/PR22.pdf

Klopper, R.R., Smith, G.F. and van Rooy, J. (2002). The Biodiversity of Africa. In *Rebirth of Science in Africa: A Shared Vision for Life and Environmental Sciences* (eds. Biaijanath, H. and Singh, Y.), pp 60-86. Umdaus Press, Hatfield

Krug, W., Suich, H., and Haimbodi, N. (2002). Park pricing and economic efficiency in Namibia. DEA Research Discussion Paper, No. 45. Directorate of Environmental Affairs / Ministry of Environment and Tourism, Windhoek. http://www.met.gov.na/publications/research/rdp_0045.pdf

Kull, C.A. (2000). Isle of fire: The political ecology of grassland and woodland burning in highland Madagascar. Ph.D. thesis. University of California, Berkley

Küper, W., Sommer, J.H., Lovett, J.C., Mutke, J., Linder, H.P., Beentje, H.J., Van Rompaey, R.S.A.R., Chatelain, C., Sosef, M. and Barthlott, W. (2004). Africa's Hotspots of Biodiversity Redefined. *Annals of the Missouri Botanical Garden*. 91(4), 525-35. http://www.botanik.uni-bonn.de/system/mitarbeiter_homepages/kueper/Kueper_et_al_2004_Africas_hotspots_redefined.pdf

Kuwairi, A.S. (2004). The Great Man-Made River Project. Proceedings of the 7th Pan African Water Conference, 29-30 November, Sandton, South Africa

Laird, S.A. (ed.) (2002). *Biodiversity and Traditional Knowledge: Equitable Partnerships in Practice*. Earthscan, London

Lambert, J.D.H, Ryden P.A., Esikuri E.E. (2005). Capitalizing on the Bio-Economic Value of Multi-Purpose Medicinal Plants for the Rehabilitation of Drylands in Sub-Saharan Africa. The World Bank, Washington, D.C. http://lnweb18.worldbank.org/ESSD/envext.nsf/45ByDocName/CapitalizingontheBio-EconomicValueofMulti-PurposeMedicinalPlantsfortheRehabilitationofDrylandsinSub-SaharanAfrica/$FILE/CapitalizingMedPlants.pdf

Langrand, O. and Goodman, S.M. (1995). Monitoring Madagascar's Ecosystem : A Look at the Past, Present and the Future of its Wetlands. In *Ecosystem Monitoring and Protected Areas* (eds. Herman, T.B., Bon-Drup-Nielsen, S., Willison, J.H.M. and Munro, N.W.P.), pp. 204-14. Sciences and Management of Protected Areas Association, Wolfville

Louette, M., Meirte, D. and Jocque, R. (2004). La faune terrestre de l'archipel des Comores. Sciences Zoologiques, No. 293. Musée Royal de l'Afrique Centrale, Tervuren

Lovelock, J.E. (1979). *Gaia: A New Look at Life on Earth*. Oxford University Press, Oxford

Lowry, II P.P., Schatz, G.E. and Phillipson, P.B. (1997). The Classification of Natural and Antropogenic Vegetation in Madagascar. In *Natural Change and Human Impact in Madagascar* (eds. Goodman, S.M. and Patterson, B.D.), pp 93-123. Smithsonian Books, Washington, D.C.

MA (2006). *Ecosystems and Human Well-being: Current State and Trends*. Volume 1. Millennium Ecosystem Assessment. Island Press, Washington. http://www.millenniumassessment.org//en/products.global.condition.aspx

MA (2005). *Ecosystems and Human Well-Being: Scenarios, Findings of the Scenarios Working Group*. Millennium Ecosystem Assessment Series. Island Press, Washington, D.C.

MA (2003). *Ecosystems and Human Well-Being: A Framework for Assessment*. Millennium Ecosystem Assessment Series. Island Press, Washington, D.C.

Mayaux, P., Bartholomé, E., Fritz, S. and Belward, A. (2004). A new land-cover map of Africa for the year 2000. *Journal of Biogeography*. 31(6), 861-77

McNeely, J.A., Harrison, J., and Dingwall, P. (eds. 1994). Protecting Nature; Regional Reviews of Protected Areas. IUCN – The World Conservation Union, Gland

Mittermeier, R.A., Gil, P.R., Hoffman, M., Pilgrim, J., Brooks, T., Mittermeier, C.G., Lamoreux and da Fonseca, G.A.B. (2004). *Hotspots Revisited: Earth's Biologically Richest and Most Endangered Terrestrial Ecoregions*. CEMEX Books on Nature Series. CEMEX, Mexico City

Mohamed-Katerere, J.C. (2001). *Review of the Legal and Policy Framework for Transboundary Natural Resource Management in Southern Africa*. Paper No 3, IUCN-ROSA Series on Transboundary Natural Resource Management. IUCN – The World Conservation Union, Harare. http://www.gm-unccd.org/FIELD/NGO/IUCN/IUCNtransb.pdf

Moore, J.L., Balmford, A., Brooks, T., Burgess, N.D., Hansen, L.A., Rahbek, C. and Williams, P.H. (2003). Performance of sub-saharan vertebrates as indicator groups for identifying priority areas for conservation. *Conservation Biology*. 17(1), 207-218

Moore, J.L., Manne, L., Brooks, T., Burgess, N.D., Davies, R., Rahbek, C., Williams, P., Balmford, A. (2002). The distribution of cultural and biological diversity in Africa. *Proceedings of the Royal Society: Biological Sciences*. 269, 1645-53

Mutke, J. and Barthlott, W. (2005). Patterns of vascular plant diversity at continental to global scales. Biologiske Skrifter. 55, 521-537.

Mutke, J., Kier, G., Braun, G., Schultz, C. and Barthlott, W. (2001). Patterns of African vascular plant diversity – a GIS based analysis. *Systematics and Geography of Plants*. 71, 1125-36

Myers, N., Mittermeier, R.A., Mittermeier, C.G., da Fonseca, G.A.B, Kent, J. (2000). Biodiversity hotspots for conservation priorities. *Nature*. 403 (6772), 853-8

National Research Council – Committee on the Formation of the National Biological Survey (1993). A Biological Survey for the Nation. National Academy Press, Washington, D.C.. http://books.nap.edu/html/bio/index.html

Newman, D.J. and Laird, S.A. (1999). The influence of natural products on 1997 pharmaceutical sales figures. In *The Commercial Use of Biodiversity: Access to Genetic Resources and Benefit-Sharing* (eds. ten Kate, K. and Laird, S.A.), pp 333–5. Earthscan, London

O'Brien, T.G. and Kinnaird, M.F. (2003). Caffeine and conservation. *Science*. 300 (5619), 587

Olson, D.M., Dinerstein, E., Wikramanayake, E.D., Burgess, N.D., Powell, G.V.N., Underwood, E.C., D'Amico, J.A., Itoua, I., Strand, H.E., Morrison, J.C., Loucks, C.J., Allnutt, T.F., Ricketts, T.H., Kura, Y., Lamoreux, J.F., Wettengel, W.W., Hedao, P. and Kassem, K.R. (2001). Terrestrial ecoregions of the world: a new map of life on earth. *BioScience*. 51, 933-8. http://www.worldwildlife.org/science/pubs/bioscience.pdf

OMVS, SOGREAH and Coyne & Bellier (1998). Etude complémentaire des endiguements du fleuve Sénégal, Première phase: Rapport d'inventaire – diagnostic. Organisation pour la mise en valeur du fleuve Sénégal, Dakar

OSU (1996). Bonsmara. Oklahoma State University. http://www.ansi.okstate.edu/breeds/cattle/bonsmara/

Poorter, L., Bongers, F., Kouamé, F.N. and Hawthorne, W.D. (eds. 2004). *Biodiversity of West African Forests: an Ecological Atlas of Woody Plant Species*. CABI Publishing, Oxon

Posey, D. and Dutfield, G. (1996). *Beyond Intellectual Property. Toward traditional resource rights for indigenous people and local communities*. International Development Research Centre, Ottawa.

Quensière, J. (ed. 1994). La pêche dans le Delta Central du Niger. IER/ORSTOM/Karthala, Paris

Rahbek, C. (1995). The elevational gradient of species richness: a uniform pattern? *Ecography*. 18, 200-5

Randrianandianina, B.N., Andriamahaly, L.R., Harisoa, F.M. and Nicoll, M.E. (2004). The Role of the Protected Areas in the Management of the Island's Biodiversity. In *The Natural History of Madagascar* (eds. Goodman S.M. and Benstead, J.P.), pp 1423-32. The University of Chicago Press, Chicago

Rates, S.M. (2001). Plants as source of drugs. *Toxicon*. 39 (5), 603-13

RBG (2005). Plant Diversity Hotspot Discovered in Tropical Africa. Press Release. Royal Botanical Gardens, Kew. http://www.rbgkew.org.uk/press/plant_diversity_hotspot.html

Republic of Seychelles (2004). National Assessment of the Barbados Plan of Action +10 Review. http://www.sidsnet.org/docshare/other/20040113105721_Seychelles_NAR_2003.pdf

Republic of Seychelles (2000). Environment Management Plan 2000-2010: Managing for Sustainability. Ministry of Environment and Natural Resources, Mahé. http://www.env.gov.sc/EMPS_2000-2010.pdf

Roberts, C. M., McClean, C. J., Veron, J. E. N., Hawkins, J. P., Allen, G. R., McAllister, D. E., Mittermeier, C. G., Schueler, F. W., Spalding, M., Wells, F., Vynne, C., Werner, T. B. (2002). Marine biodiversity hotspots and conservation priorities for tropical reefs. *Science*. 295, 1280-4

Robertson, D.P. and Hull, R.B. (2001). Beyond biology: toward a more public ecology for conservation. *Conservation Biology*. 15, 970-9

Robinson, J.G. and Bennett, E.L. (2004). Having your wildlife and eating it too: an analysis of hunting sustainability across tropical ecosystems. *Animal Conservation*. 7, 397-408

Robinson, J.G. and Bennett, E.L. (2002). Will alleviating poverty solve the bushmeat crisis? Oryx. 36, 332

Robinson, J.G. and Bennett, E.L. (eds. 2000). *Hunting for Sustainability in Tropical Forests*. Columbia University Press, New York

Rodrigues, A.S.L., Akçakaya, H.R., Andelman, S.J., Bakarr, M.I., Boitani, L., Brooks, T.M., Chanson, J.S., Fishpool, L.D.C., da Fonseca, G.A.B., Gaston, K.J., Hoffmann, M., Marquet, P.A., Pilgrim, J.D., Pressey, R.L., Schipper, J., Sechrest, W., Stuart, S.N., Underhill, L.G., Waller, R.W., Watts, M.E.J. and Yan, X. (2004). Global gap analysis: priority regions for expanding the global protected-area network. *BioScience*. 54(12), 1092-100

Rutherford, M.C., Midgley, G.F., Bond, W.J., Powrie, L.W., Roberts, R. and Allsopp, J. (1999). Plant Biodiversity. In *Climate Change Impacts in Southern Africa* (ed. Kiker, G.). Department of Environment Affairs and Tourism, Pretoria

SADC, IUCN and SARDC (2005). Southern African Environment Outlook 2005. Southern African Development Community, IUCN – the World Conservation Union and Southern African Research and Documentation Centre, Gaborone/Harare

Sala, O.E., Chapin, F.S., Armesto, J.J., Berlow, E., Bloomfield, J., Dirzo, R., Huber-Sanwald, E., Huenneke, L.F., Jackson, R.B., Kinzig, A., Leemans, R., Lodge, D.M., Mooney, H.A., Oesterheld, M., Poff, N.L., Sykes, M.T., Walker, B.H., Walker, M. and Wall, D.H. (2000). Global biodiversity scenarios for the year 2100. *Science*. 287, 1770-4

Sayer, J.A., Harcourt, C.S. and Collins, N.M. (eds. 1992). *The Conservation Atlas of Tropical Forests: Africa*. MacMillan, London

Scholes, R.J. and Biggs, R. (eds. 2004). Ecosystem Services in Southern Africa: a regional assessment. Council for Scientific and Industrial Research, Pretoria

Scholes, R.J. and Biggs, R. (2005). A biodiversity intactness index. Nature. 434, 45-9. Available for download from: www.millenniumassessment.org/proxy/document.750.aspx

Siebert, S.J. and Smith, G.F. (2004). Lessons learnt from the SABONET Project whilst building capacity to document the botanical diversity of southern Africa. *Taxon*. 53(1), 119-26

Songorwa, A.N., Bührs, T. and Hughey, K.. (2000). Community-based wildlife management in Africa: a critical assessment of the literature. *Natural Resources Journal*. 40(3), 603-43

Steenkamp, Y. and Smith, G.F. (2003). Needs of users of botanical information in South Africa: outcomes of a national workshop for the stakeholders and end-users of botanical information and herbaria. *Taxon*. 52(2), 303-6

Steffen, W.L., Sanderson, A., Tyson, P.D., Jäger, J., Matson, P.A., Moore, B., Oldfield, F., Richardson, K., Schellnhuber, H.J., Turner, B.L. and Wasson, R.J. (2004). *Global Change and the Earth System: A Planet Under Pressure*. The International Geosphere-Biosphere Programme Series. Springer, Berlin

Sutherland, W.J. (2003). Parallel extinction risk and global distribution of languages and species. *Nature*. 423(6937), 276-9

Swanson, T.M. (1992). The role of wildlife utilisation and other policies for biodiversity conservation. In *Economics for the Wilds: Wildlife, Diversity and Development* (eds. Swanson, T.M. and Barbier, E.B.), pp 65-102. Island Press, Washington, D.C.

Thomas, D.S.G. and Middleton, N.J. (1994). *Desertification: Exploding the Myth*. John Wiley & Sons, Chichester

UN (2005). Draft Mauritius Strategy for the Further Implementation of the Programme of Action for the Sustainable Development of Small Island Developing States. Proceedings of the International Meeting to Review the Implementation of the programme of Action for the Sustainable Development of Small Island Sates, Port Louis, Mauritius, 10-14 January. United Nations. A/CONF.207/CRP.7. 13 January 2005. http://www.un.org/smallislands2005/pdf/sids_strategy.pdf

UNEP (2005a). *Atlantic and Indian Oceans Environment Outlook, Special Edition for the Mauritius International Meeting for the 10-year Review of the Barbados Programme of Action*. United Nations Environment Outlook, Nairobi

UNEP (2005b). GEO Africa Data Portal. United Nations Environment Programme. www.unep.org/geo/data/africa

UNEP (2004a). *Africa Environment Outlook, Case Studies: Human Vulnerability to Environmental Change*. United Nations Environment Programme, Nairobi. http://www.unep.org/dewa/publications/2004/Africa_Environment_Outlook.pdf

UNEP (2004b). Consideration of the results of the meeting on "2010 – The global biodiversity challenge". United Nations Environment Programme. UNEP/CBD/COP/7/INF/22. Proceedings of the Seventh Ordinary Meeting of the Conference of the Parties to the Convention on Biological Diversity, Kuala Lumpur, Malaysia, 9-20 February. http://www.biodiv.org/doc/meetings/cop/cop-07/information/cop-07-inf-22-en.pdf

UNEP (2002). *Global Environment Outlook 3.* United Nations Environment Programme, Nairobi. http://www.unep.org/geo/geo3/

UNEP (1992). Convention on Biological Diversity. United Nations Environment Programme. http://www.biodiv.org/convention/articles.asp

UNEP and NESDA (2004). *Rapport sur l'Etat de l'Environnement en Afrique de l'Ouest*. United Nations Environment Programme and Network for Environment and Sustainable Development in Africa, Nairobi

UNESCO (2006a). Biosphere Reserves. Africa. United Nations Educational, Scientific and Cultural Organization. http://www.unesco.org/mab/BRs/AFRBrs.shtml

UNESCO (2006b). World Heritage List. United Nations Educational, Scientific and Cultural Organization. http://whc.unesco.org/en/list/

Walsh, P.D., Abernethy, K.A., Bermejo, M., Beyers, R., De Wachter, P., Akou, M.E., Huijbregts, B., Mambounga, D.I., Toham, A.K., Kilbourn, A.M., Lahm, S.A., Latour, S., Maisels, F., Mbina, C., Mihindou, Y., Obiang, S.N., Effa, E.N., Starkey, M.P., Telfer, P., Thibault, M., Tutin, C.E., White, L.J. and Wilkie, D.S. (2004). Catastrophic ape decline in western equatorial Africa. *Nature*. 422(6932), 611-4

Western, D. (1997). *In the Dust of Kilimanjaro*. Shearwater Books/Island Press, Washington, D.C.

Western, D. and Gichohi, H. (1993). Segregation effects and the impoverishment of savannah parks: the case for ecosystem viability analysis. *African Journal of Ecology* 31, 269-81

Wetlands International (undated). Ramsar Sites Database. http://www.wetlands.org/RSDB/default.htm

White, F. (1983). Vegetation of Africa – a descriptive memoir to accompany the Unesco/AETFAT/UNSO vegetation map of Africa. Natural Resources Research Report No. 20. United Nations Educational, Scientific and Cultural Organization, Paris

White, L.J.T. (2001). The African Rainforest: Climate and Vegetation. In *African Rain Forest Ecology and Conservation* (eds. Weber, W., White, L.J.T., Vedder, A. and Naughton-Treves, L.), pp 3-29. Yale University Press, New Haven

WHO (2003). Traditional Medicine. World Health Organization Fact Sheet No. 134. World Health Organization. http://www.who.int/mediacentre/factsheets/fs134/en/index.html

Wilkie, D., Shaw, E., Rotberg, F., Morelli, G. and Auzel, P. (2000). Roads, development, and conservation in the Congo Basin. *Conservation Biology*. 14, 1614-22

Williams, P.H., Moore, J.L., Kamden Toham, A., Brooks, T.M., Strand, H., D'Amico, J., Wisz, M., Burgess, N.D., Balmford, A. and Rahbek, C. (2003). Integrating biodiversity priorities with conflicting socio-economic values in the Guinean-Congolian forest region. *Biodiversity and Conservation*. 12(6), 1297-1320

Wood, S., Sebastian, K. and Scherr, S.J. (2000). *Pilot Analysis of Global Ecosystems: Agroecosystems*. World Resources Institute, Washington, D.C.. http://www.ifpri.org/pubs/books/page/agroeco.pdf

WRI in collaboration with UNEP, UNDP and the World Bank (2005). *World Resources 2005: The Wealth of the Poor – Managing Ecosystems to Fight Poverty*. World Resources Institute in collaboration with the United Nations Environment Programme, the United Nations Development Programme and the World Bank. World Resources Series. World Resources Institute, Washington, D.C. http://pdf.wri.org/wrr05_full_hires.pdf

WRI (2005). *EarthTrends: The Environmental Information Portal*. World Resources Institute, Washington, D.C. http://earthtrends.wri.org

WWF (undated). Conservation Science: Ecoregions. World Wildlife Fund. www.worldwildlife.org/science/ecoregions.cfm

Yalden, D.W., Largen, M.J. and Kock, D. (1986). Catalogue of the mammals of Ethiopia. 6. Perrissodactyla, Proboscidea, Hyracoidea, Lagomorpha, Tubulidentata, Sirenia and Cetacea. *Monit. Zool. ital. N.S. Suppl*. 21(4), 31-103

Yamin, F. (2003). Intellectual property rights, biotechnology and food security. IDS Working Paper 203. Institute of Development Studies, Brighton. http://www.ids.ac.uk/ids/bookshop/wp/wp203.pdf

Yeager, R. and Miller, N.N. (1986). *Wildlife, Wild Death: Land-use and Survival in Eastern Africa*. State University of New York Press, Albany