# Conserving the Miombo Ecoregion

## Final Reconnaissance Summary Report

**25 June, 2001**

Prepared for the WWF Southern Africa
Regional Programme Office (SARPO)
Harare, Zimbabwe

by

Bruce Byers, Team Leader
Miombo Ecoregion Reconnaissance Team

# Table of Contents

## Abbreviations & Acronyms

| | |
|---|---|
| AWF | African Wildlife Foundation |
| CBNRM | Community-Based Natural Resource Management |
| CIFOR | Centre for International Forestry Research |
| GEF | Global Environment Facility |
| SARPO | Southern Africa Regional Programme Office |
| USAID | United States Agency for International Development |
| WWF | World Wildlife Fund or World Wide Fund for Nature |

## Acknowledgements

I would like to thank the members of the Miombo Ecoregion Reconnaissance Team (see Appendix 1) for their participation in the Inception Workshop, and for their rapid and thorough efforts to pull together a vast amount of information, both biological and social, about the ecoregion. I am grateful to David Cumming, Fortune Shonhiwa, and Zipangani Vokhiwa of WWF SARPO for inviting me to lead the reconnaissance process in the Miombo Ecoregion; and to Kate Newman of WWF-US and Yaa Ntiamoa-Baidu of WWF International for encouraging and expediting my participation. Virginia Stettinius, Doreen Robinson, Jason Clay, and Jennifer D'Amico of WWF-US helped by providing critical information and assistance. During a trip to Zambia and Tanzania following the Inception Workshop I talked with many people (see Appendix 2), and their knowledge and insights were very valuable. Thanks to Monica Chundama and the WWF staff in Zambia for arranging and facilitating my visit; and to Peter Sumbi and WWF staff in Tanzania for doing the same there. Peter Frost and Vernon Booth joined a sub-group of the Reconnaissance Team and WWF-SARPO staff at the Review Workshop on April 3-4, 2001. Their perspectives helped to make the Review Workshop a very productive meeting. Comments from staff at WWF International on the draft Synthesis Report that followed the first workshop were summarized by P.J. Stephenson, and these were useful in shaping the Reconnaissance Summary report. Helpful comments on a draft of this report came from David Cumming, Harrison Kojwang, Kate Newman, and Jonathan Timberlake. Thanks to everyone who has contributed to the reconnaissance, and thereby helped to launch the exciting and challenging process of ecoregion conservation in the Miombo Ecoregion.

Bruce A. Byers, Ph.D.
Consultant in Conservation and Natural Resources Management
405 Timber Lane
Falls Church, Virginia 22046 USA
Tel: 703-534-4436 Fax: 703-534-1714 Email: bbyers@igc.org
23 June, 2001

# 1. Background and Introduction

## 1.1 Ecoregion Conservation – What & Why?

The WWF- Southern Africa Regional Programme Office (WWF-SARPO) has initiated a new conservation planning process for the "Miombo" Ecoregion, one of WWF's Global 200 focal ecoregions. An "ecoregion" is a relatively large unit of land or water that harbours a characteristic set of species, communities, dynamics, and environmental conditions. The ultimate goal of ecoregion conservation is to conserve the fullest possible range of biodiversity and ecological processes characteristic of an ecoregion (WWF 1998). The goal of this large-scale, long-term strategic planning process in the Miombo Ecoregion is to contribute to the maintenance of biodiversity and functional ecosystems for the benefit of people and nature in the region.

Ecoregion conservation involves thinking about conservation at large spatial and long temporal scales, an approach that offers several advantages for conservation planning and action. Analysis and planning at these large scales provide the best basis for establishing conservation priorities (Dinerstein, et al. 2000). An ecoregion approach will also more effectively address the broader social, economic, and policy factors that are essential to long-term success (WWF 1998; 2000a). Understanding social and biological processes and dynamics at these scales requires an integrated and multi-disciplinary approach. The ecoregion conservation process emphasizes understanding both the proximate and root causes of biodiversity loss, leading to policy and management interventions at appropriate levels -- from international trade policies to site-specific projects. It enables WWF and other conservation actors to take a more comprehensive approach to biodiversity conservation, connecting conservation action at the local, national, and international levels (WWF 1998). Because ecoregions often cross political boundaries, ecoregion conservation requires thinking beyond national boundaries or programmes, though these political units are critical to the planning and implementation process.

## 1.2 The "Miombo" Ecoregion

Woodlands dominated by trees in the legume subfamily Caesalpinioideae cover an estimated 3.6 million square kilometers in central and southern Africa. These "miombo" savanna woodlands are found in parts of eleven countries (Angola, Botswana, Democratic Republic of Congo, Malawi, Mozambique, Namibia, South Africa, Swaziland, Tanzania, Zambia, and Zimbabwe), potentially covering an area about half as large as the continental U.S., China, or Europe.

The Miombo Ecoregion is of outstanding importance to conservation. About half the elephants and half of the rhinos left in Africa are found in this ecoregion. Nature and wildlife tourism is one of the main economic sectors in the region, with considerable potential for growth. Protected areas occupy about 12% of the land area of the ecoregion, about as much land as can reasonably be allocated to them. The catchment basins for the main rivers of southern Africa (e.g., Zambezi, Kavango, Congo), for two of the African Great Lakes (Lake Malawi/Niassa and Lake Tanganyika), and for the Okavango Delta lie in this ecoregion.

The ecological dynamics of the region have certainly been shaped in many ways by humans, but it may not ever be possible to fully untangle how. If "pristine" is defined as the absence of human influence, no part of the ecoregion is such. For example, fire is an important factor in this ecoregion, it is anthropogenic to a significant extent, and may have been so for tens of thousands of years.

These woodlands are by and large inhabited – the miombo ecoregion is a "social forest" (Campbell 1996). Sixty-five million people inhabit the ecoregion. A large fraction of these human inhabitants are poor, rural, semi-subsistence agriculturalists, who depend heavily on natural resources for their livelihoods. A large fraction of both the rural and urban population depends on wood fuel for their energy needs. These conditions have led to the development of a strong emphasis on the sustainable uses of natural resources and of community-based natural resource management (CBNRM) in some countries in this ecoregion, and those are considered by many to be a global model in this regard.

The survival of people in this ecoregion has always depended on natural resources. For the next 50 years this region will continue to be highly dependent on its natural resources, given the current trends in regional development. Despite people's aspirations, many may even become more dependent on natural resources as poverty and population increase. At present, 70-80% of the miombo ecoregion is under small-scale agriculture, and it is primarily rural farmers who will determine the fate of the miombo landscape. If people do not benefit from using the products of miombo woodlands, they will be more likely to clear the woodlands for agriculture.

The Miombo Ecoregion, perhaps more than most others, has been defined and shaped by human use. However, recent changes, including a growing population, increasing consumption, and increasing regional and global trade, are disrupting traditional social adaptations to the constraints and opportunities of the miombo landscape. These changes have the potential to damage the ecological integrity and resilience of the ecoregion, which in turn would threaten human livelihoods and wellbeing throughout the region. It is critical that we understand these threats to the miombo system, and take advantage of opportunities to address them.

### 1.3 Miombo Ecoregion Reconnaissance

The first step in the ecoregion conservation process for the Miombo Ecoregion has been a "reconnaissance" study (WWF 1999a), a multi-disciplinary, rapid assessment designed to:

- outline the current state of biological and social knowledge for the ecoregion;
- identify major factors influencing environmental change and loss of biodiversity;
- identify major information gaps and needs;
- identify key problems and opportunities for conservation; and,
- set the stage for developing a long-term vision and subsequent action plan for conservation in the ecoregion.

In order to achieve these objectives, the Reconnaissance Team wanted a sensible, pragmatic model of how the miombo system functions. The team felt that such a model could provide a conceptual framework or foundation for conservation in the ecoregion by helping to identify the linkages between biophysical and social, political, and economic processes and trends. This, in turn would help to set priorities and guide conservation in the ecoregion.

The Reconnaissance Team, a group of topical specialists and experts (see Appendix 1), met at a Reconnaissance Inception Workshop held February 22-23, 2001, in Harare, Zimbabwe, to develop an outline for the reconnaissance study. Using the available information on the ecoregion, these specialists prepared technical reports on their areas of expertise. These topical reports came to more than 250 pages of text. This body of technical information was then distilled into a draft "synthesis" report, which was circulated to the Reconnaissance Team and relevant staff at WWF-US and WWF-International. The synthesis report was reviewed by a subgroup of the Reconnaissance Team and additional miombo experts at a Review Workshop held in Harare on April 3-4, 2001. At the Review Workshop the efforts of the group focused on developing a model of the functioning of the miombo system that could serve as a conceptual foundation for Miombo Ecoregion conservation.

This Final Reconnaissance Summary Report aims to capture the essence of our information gathering and analysis during the reconnaissance, and to communicate our findings to a wider audience of regional stakeholders and potential partners. We hope this information will help WWF and its partners create a vision and launch a process of comprehensive strategic planning and implementation for conservation in the Miombo Ecoregion.

### 1.4 Collaboration for Conservation

In the Miombo Ecoregion there are many other organizations besides WWF with longstanding natural resource management and conservation programmes. SADC, the Southern African Development Community, has relevant initiatives and activities, as do international NGOs (e.g. the Zambezi Basin Initiative of the Biodiversity Foundation for Africa, Fauna & Flora International, and the Zambezi Society; AWF's Mana-Zambezi Heartland programme) and bilateral and multilateral donors (e.g. the USAID/AWF Four Corners Transboundary Conservation project, GEF's Gaza-Kruger-Gonarezhou Transfrontier Conservation project). Research programmes with relevance in the Miombo Ecoregion are underway through the Centre for International Forestry Research (CIFOR), the Miombo Forum, the Miombo Network (Desanker, et al. 1997), University of Dar es Salaam, University of Zambia, University of Zimbabwe. Conservation priorities for such a large region can't be set by one organization alone – they must be set with other stakeholders (WWF 2000b). To take advantage of many of the opportunities to contribute to conservation, strategic partnerships will be needed. The ecoregion conservation planning process must develop synergies with other ongoing conservation and sustainable development initiatives. WWF can't do everything, and in fact it is not the core business of WWF to do many of the things that must be done to address the root causes of the threats to the region's biodiversity. WWF may, however, be able to play a catalytic role by introducing the ecoregional approach.

Since collaboration, partnership, and stakeholder collaboration are keys to successful ecoregion conservation (WWF 2000b), and since this ecoregion is particularly large and complex, the ecoregion conservation process followed here must be flexible enough to adapt to the "stakeholder landscape" in the ecoregion, as well as to the biological landscape.

# 2. Biological Description and Ecoregion Boundaries

## 2.1 Original Ecoregion Description and Boundary

The definition of the Miombo Ecoregion presently used by WWF SARPO is an amalgamation of units from the WWF-US Conservation Science Unit map "Terrestrial Ecoregions of Africa" (WWF 1999). It is a broader unit than true miombo woodland (which is defined as woodland dominated by trees of the genera *Brachystegia*, *Julbernardia* and *Isoberlinia* with a well-developed grass layer) and covers ecoregions 49, 50, 52, 53 (Angolan, Central Zambezian, Eastern and Southern miombo woodland, or "true miombo"), 54 (Zambezian and mopane woodland), 61 (Zambezian *Baikiaea* woodland) and 32 (Zambezian *Cryptosepalum* dry forest), with inclusions of ecoregions 56 (Western Zambezian grassland), 63 (Zambezian flooded grassland), and 76, 77, 78, 80, 84 (Southern Rift, South Malawi, Eastern Zimbabwe, Drakensberg and Angolan montane forest-grassland mosaics).

The present definition of the ecoregion has serious limitations, however. The original ecoregion map (WWF 1998), based on Frank White's Vegetation Map of Africa (1983), was modified by different people at various times. The overview and uniform, continental approach of White was partly lost in this process. Also, the subdivision of units (notably two miombo woodland types became four), the confusion over mopane, acacia and other woodland types (which were lumped despite very different composition and ecology), and the omission of *Burkea-Terminalia* open woodland (which has a similar ecology to miombo but is too dry to support *Brachystegia* or *Julbernardia*) has led to a lack of consistency and ecological or phytogeographical clarity. The ecological attributes of miombo and other broad-leaved woodlands were lost, and the subdivisions did not clearly bring out the linkages or range of variation.

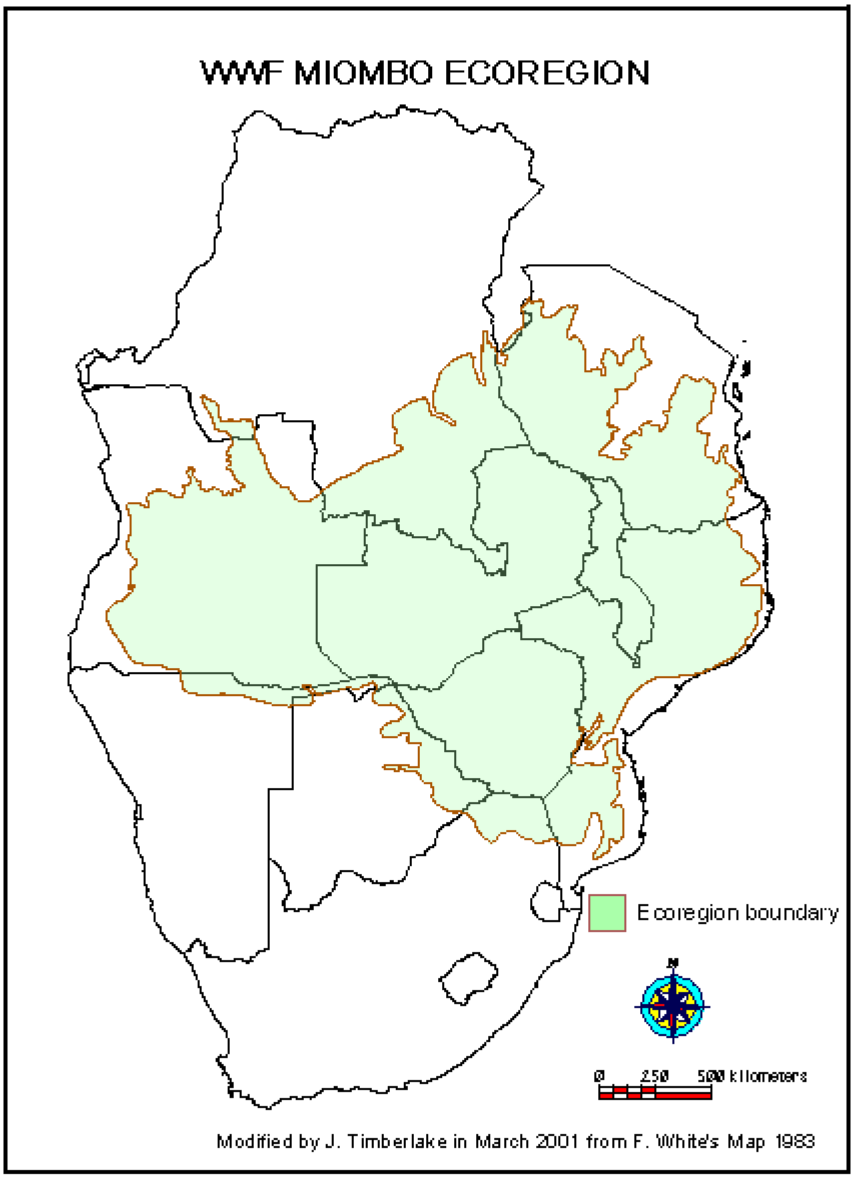
## 2.2 Revised Ecoregion Description and Boundary

WWF guidance on the ecoregion conservation reconnaissance process (WWF, 1999a) suggests that the Reconnaissance Team consider "the appropriateness of the ecoregion as biologically defined. The reconnaissance may gather biological evidence that suggests the need to modify the ecoregion as currently defined and delineated." We have done so, and in order to overcome the limitations and inconsistencies of the present description and boundary we suggest the following:

The revised "Miombo" Ecoregion, which in botanical terms could be also be called southern Caesalpinoid woodlands, can be defined by the dominance (or high frequency) of trees belonging to the legume sub-family Caesalpinioideae, such as *Brachystegia*, *Julbernardia*, *Isoberlinia*, *Baikiaea*, *Cryptosepalum*, *Colophospermum* and *Burkea*. This is a broader unit than miombo woodland *sensu stricto,* which is defined as woodland dominated by trees only of the genera *Brachystegia*, *Julbernardia* and *Isoberlinia*. Caesalpinoid woodlands correspond generally to what has been called broadleaved, "dystrophic" savanna woodland (Huntley 1982). They are deciduous for at least a short period each year during the annual dry season (except *Cryptosepalum*). The woodland canopy is from 6 to 20 m in height, and ranges from 20% cover to almost closed-canopy forest.

White's Vegetation Map of Africa (1983) was used as a basis for defining the revised boundaries of the Miombo Ecoregion, as shown in Figure 1. As defined here, the Miombo Ecoregion closely follows the boundaries of the Zambezian Regional Centre of Endemism (White 1983), except for the transition to the Guinea-Congolia and Zanzibar-Inhambane phytochoria. Improved knowledge of vegetation distribution within the region now allows for some refining of White's original boundaries.

**Figure 1. Miombo Ecoregion Boundaries**



The Miombo Ecoregion as defined here includes more than one vegetation type, but all of the vegetation types that comprise it are dominated by one or more species of the Caesalpinioideae. Other ecoregions may be more or less homogeneous units of vegetation, but the miombo is not. The ecoregion is divided into six vegetation types as shown in Figure 2 and described in Tables 1 and 2. These subdivisions reflect a range of species composition and ecological processes. "Wet" and "dry" miombo are distinguished on the map, and the boundary between these types, shown in Figure 2, is roughly that of White (1983), with some modifications. The distinction between wet and dry miombo should be seen as indicative, not rigid, in reality probably a mosaic of the two types, with a shift towards moist miombo patches as one goes northwards. The ecoregion also contains sizeable inclusions of five other vegetation types.

**Figure 2. Miombo Ecoregion Vegetation Types**

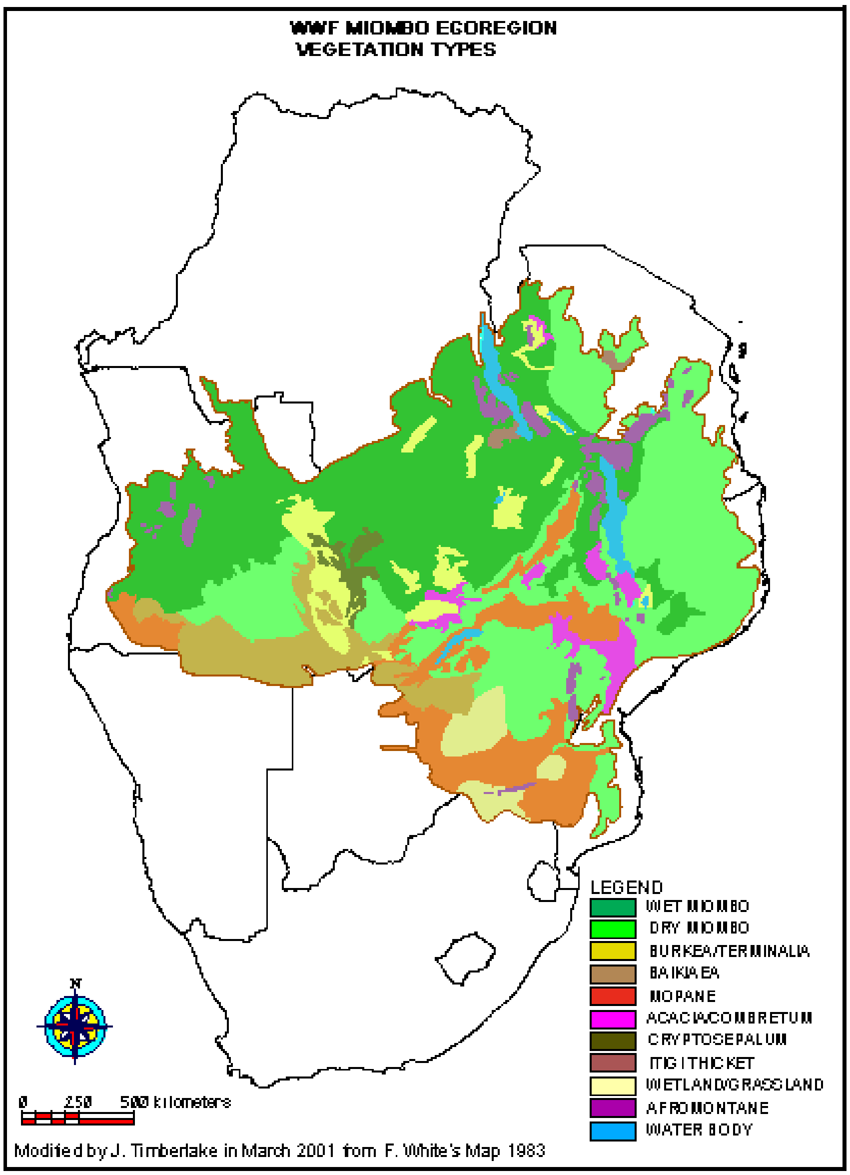


**Table 1. Vegetation Types within the Miombo Ecoregion**

| Type | WWF (1999) unit | White (1983) unit |
|---|---|---|
| 1. Wet miombo woodland | 49 (most), 50 | 25 (most) |
| 2. Dry miombo woodland | 52, 53 | 16a (part), 26 |
| 3. *Burkea - Terminalia* open woodland | 57 (part) | 29d (part) |
| 4. *Baikiaea* woodland | 51, 58 (part) | 221, 47 |
| 5. Mopane woodland/shrubland | 54 (part), 55 (part) | 28 (part) |
| 6. *Acacia - Combretum* woodland | 54 (part) | 29c (part), 35 |

**Table 2. Vegetation Types Area Estimates**

| Vegetation Type | Area (sq. km) |
|---|---|
| Acacia/Combretum | 103,887 |
| Afromontane | 98,685 |
| Baikiaea | 260,171 |
| Burkea/Terminalia | 96,162 |
| Cryptosepalum | 37,908 |
| Dry Miombo | 1,214,533 |
| Wet Miombo | 1,358,175 |
| Mopane | 384,037 |
| Itigi Thicket | 15,405 |
| Wetland Grassland | 179,290 |
| Water Body | 68,951 |
| **Total** | **3,817,204** |

The ecoregion extends from the Angolan escarpment in the west up to (but not including) the coastal woodlands and forests of Mozambique and Tanzania in the east. To the west and southwest it is bounded by Kalahari *Acacia* woodlands in Namibia and Botswana, and to the south by Highveld grassland and mixed *Acacia* woodland in South Africa. It grades into Guinea-Congolia moist evergreen forest of the Congo Basin in the north, while in the north-east it is bounded by dry *Acacia-Commiphora* bushland in Tanzania. Total area is approximately 3.6 million $km^2$.

The Miombo Ecoregion borders the East Africa coastal forest-woodland mosaic at low altitudes close to the Mozambique and Tanzania coast. It is not always easy to separate the two. Coastal woodland and forest is generally much denser in structure, almost evergreen, and has an understorey of mostly forest species (such as from the family Rubiaceae). The grass layer is poorly developed. However, *Brachystegia spiciformis* and other typical miombo species are commonly found in coastal woodlands.

It can be difficult to draw boundaries in what is a continuum of vegetation/ecological change. For example, the coastal or lowland *Brachystegia* woodlands in Mozambique differ significantly from the typical plateau woodlands in some cases, yet sometimes are not sufficiently forest-like to be included in the East African coastal forest ecoregion. A similar situation occurs with the species-rich woodlands and forests of the edge of the Congo Basin.

### 2.3 Justification for the Revision

The revised Miombo Ecoregion does not differ greatly from White's original map units, but overcomes some of the artificial divisions and amalgamation of the WWF (1999) ecoregion map. There is now a better balance between divisions within the broad unit, while similar woodland types, previously excluded, have been incorporated.

The boundaries more accurately depict the extent of what has been called broadleaved, “dystrophic” savanna woodland (Huntley, 1982). The western limits of the woodlands where they grade into wooded grassland or shrubland, often with a less well-developed grass layer and with a different suite of associated arid species, is now more clearly defined. The same goes for areas to the east and north where forest understorey species become predominant.

The purpose of working at an ecoregional scale is to improve the effectiveness of long-term conservation planning and priority-setting (Dinerstein et al., 2000). For this purpose, boundaries have to make practical sense, and in this case including a number of Caesalpinoid-dominated woodland types in the “miombo” ecoregion makes more sense than does a focus only on true miombo woodlands, *sensu stricto*, or than on a focus on any one particular vegetation type within the region. The Miombo Ecoregion as defined here more accurately reflects the range of differing ecological processes found within the southern Caesalpinoid woodland area.

# 3. Conceptual Framework for Conservation in the Miombo Ecoregion

## 3.1 Developing a Model of the Miombo System

The Reconnaissance Team wanted to develop a sensible, pragmatic model of how the miombo system functions. The team felt that such a model could provide a conceptual framework or foundation for conservation in the ecoregion by helping to identify the linkages between biophysical and social, political, and economic processes and trends. This, in turn would help to set priorities and guide conservation in the ecoregion. We wanted a model of how both ecological and social processes operate in southern African Caesalpinoid woodlands that would help to identify:

- causal relationships between biophysical and social variables in both space and time, at a hierarchy of scales;
- strengths, weaknesses, and vulnerabilities of the system, especially concerning its potential resilience in the face of human-induced changes;
- trends, trajectories, and threats to the integrity and resilience of the system;
- proximate and ultimate ("root") causes of threats to the miombo system; and,
- opportunities and priorities for conservation action.

Our goal was to identify the main processes operating in the miombo system across a hierarchy of scales. These processes are both ecological and social; in other words, the miombo ecoregion is ***socio-ecological system***. Like all systems, it displays "emergent properties" -- in other words, some of the large-scale, long-term properties of the system result from processes taking place at smaller spatial scales and shorter time scales. If patterns, processes, and functions are lost at smaller and shorter scales in such a system, the emergent features and patterns may also be lost at larger, longer scales. For example, if the small-scale, short-term hydrological processes involving upland dambos are lost, the large-scale, long-term water storage function of the deep Kalahari Sands at the headwaters of major international rivers (e.g. Zambezi, Congo, Kavango) may be lost also. Or, if the small-scale, short-term ability of woodlands to buffer local and regional climate (through albedo, evapotranspiration, and carbon-storage) is compromised by woodland clearing, regional and even global climate may be affected over the long term.

Biodiversity can be thought of as a system – a system of interactions between genes, species, and the ecosystems they form, influencing and influenced by ecological and evolutionary processes. It is conventionally defined as the variety and variability of the patterns and processes of the biosphere, including genetic variation within species, diversity of species, diversity of ecological communities and ecosystems, and the diversity of ecological and evolutionary processes (Johnson 1995; McNeely, et al. 1990; Reid & Miller 1989). It is not only that ecosystems provide habitats for species; species create, and are, the habitat for other species. And it is species and their interactions that create ecosystems, and their processes and functions. In fact, it is useful to think of species richness as an emergent property of ecosystem processes. In such a system, genes, species, communities, and ecological processes cannot be understood or managed as separate entities or phenomena.

The biophysical and human social systems interact to create the unique characteristics of this ecoregion.  While the biophysical characteristics provide opportunities for, and set limits to, human activities, feedback occurs.  Human activities influence the ecosystem, potentially in ways that compromise its resilience.  Thus compromised, human well-being could be threatened as well, as the ecosystem provides fewer opportunities and more constraints to humans. This, in turn, will cause humans to further stress and damage the ecological functions.

### 3.2  Biophysical Features

The Miombo Ecoregion  is a unique system resulting from the following features, elements, and characteristics:

- geological stability over a long time period
- a dry winter season climate
- flat topography and generally sluggish drainage on plateaus
- old, nutrient-poor soils
- low levels of herbivory
- frequent fire

These six key biophysical determinants are the "driving forces" that pattern the Miombo Ecoregion:

The geologically old, stable crust underlying most of the region is a primary determinant of  its ecology.  This geological situation, interacting with a semiarid climate of strongly seasonal rainfall, have given rise over time to the generally flat topography and sluggish drainage of the region.  River valleys of many of the major rivers of southern Africa wind among plateaus of varying elevations, the remnants of ancient erosional surfaces (pediplains) of several different ages.  This creates landscape heterogeneity at a very large spatial scale across the region.  The geomorphology of the region gives rise, in turn, to complex surface and subsurface hydrological processes that are unique in Africa.  This unique hydrology – a mosaic of dambos and seasonally-flooded grasslands -- is an emergent feature of the geology (old, flat) and climate (semiarid, single long dry season).  The geomorphology and hydrology have led to a region of generally leached, nutrient-poor soils.  Erosion and other processes have created soil nutrient gradients, usually associated with soil moisture gradients, at several scales (e.g., plateaus to valleys, surrounding woodlands to dambos).   These repeated patterns of soil moisture and nutrients are a characteristic feature across the landscapes of  the ecoregion.

This is one of the most stable geological regions on Earth, and one that has moved less than most in relation to the poles.  Despite its relative geological stability, cycles of climatic change have led to the repeated fragmentation and reconnection of habitats in the region over evolutionary time scales of millions of years.  This in turn has stimulated a process of speciation and adaptive radiation – a "species pump" effect -- which has made the region (especially the Paleo-Upper Zambezi area and Barotseland) a centre of endemism and diversity for some taxonomic groups.  One example of such a group is the plant family Caesalpinioideae.  The dominance of this family is a defining characteristic and a unifying feature of the ecoregion, the result of its shared geological stability and climatic history at a large spatial scale and a long temporal scale.

Nutrient-poor soils lead to a low-nutrient ecosystem, or "protein deficient landscape," in which the level of of herbivory is generally low.  This low-nutrient landscape favors bulk-feeding megaherbivores (elephant and buffalo), large-bodied mammals with low intrinsic rates of population increase that are adapted to low population densities.  Such animals are susceptible to overharvesting.  Seasonality of rainfall and low soil fertility leads to animal movements at medium scales.  Nutrient cycling is generally slow because of a lack of moisture during the long dry season and generally low herbivory.

These factors, in turn, make the Caesalpinoid woodlands a "high-carbon" landscape, with an abundance of woody biomass.   This has a number of biological consequences.  For example, fungal biomass and diversity are high (C. Sharp, pers. comm.; Onguene, 2000), and termites are major consumers of vegetation in many areas. Termites are also landscape engineers, concentrating nutrients in their mounds and creating spatial heterogeneity at a small scale.

Climate and human activities lead to frequent, natural fire in Caesalpinoid woodlands.  Fire is a major "consumer" of carbon and redistributor of nutrients, because there are so few herbivores and limited decomposition.  Many plants in these woodlands exhibit adaptations to frequent fire.

These features have shaped the biodiversity of the ecoregion over evolutionary time, and continue to shape it today.  Some further details are summarized in Table 3, below:

**Table 3.  Biophysical Determinants of the Miombo System**

<u>Geology and geomorphology</u>:

- old, weathered "highland" or "plateau" erosion surfaces (of several ages) cover much of the landscape, with lower valleys draining them
- catenary (i.e., soil moisture & nutrient) profiles/patterns are repeated across the landscape at several scales

<u>Climate and hydrology</u>:

- single long dry season limits surface water and soil moisture
- generally arid to semi-arid, with large interannual variation; i.e., drought is natural and common
- increasing precipitation along a SW to NE gradient, but decreasing again farther NE into Tanzania
- variation in rainfall from year to year increases as average rainfall decreases
- higher plateaus receive more rain, valleys less
- watershed/catchments of major river systems (e.g. Zambezi, Congo, Kavango),  Great Lakes (Lake Malawi/Niassa, Lake Tanganyika), and the Okavango Delta lie within this ecoregion
- dambos an important factor in creating micro-scale variation in available water

Soils and soil fertility:

- soils on old erosion surfaces are generally leached and nutrient-poor (oligotrophic), valley soils generally richer (eutrophic)
- generally inverse correlation between soil fertility and rainfall; higher plateaus receive more rain on less fertile soils, valleys receive less rain on more fertile soil
- nutrient cycling "tight," especially in higher rainfall areas and on sandy soils, with most nutrients tied up in biomass
- ectomycorrhizal symbioses are common in true miombo genera, probably as a response to low soil nutrient levels
- termites play a key functional role in decomposition and nutrient cycling; termite mounds create micro-scale variation in soil nutrients, which in turn creates micro-scale diversity in vegetation and fauna

Herbivory:

- low soil fertility and nutrient levels in true miombo woodlands limit productivity and favor a low biomass density of large mammals that is dominated by megaherbivores (elephant and buffalo)
- lack of surface water over large areas during long dry season forces movement/migration of large herbivores, often to river valleys or wetlands
- several resident endemic or near-endemic antelope are medium-sized specialist grazers (give species Lichtenstein's hartebeest, sable antelope)
- smaller antelope, incl. browsers, limited to specialized habitats at medium to small spatial scales (seasonally-flooded grasslands, e.g., Kafue lechwe; termite mounds; dambos)
- "high-carbon" landscape with abundant woody biomass both above and below ground
- termites play a key functional role in energy flow (are a major consumer)
- stands dominated by one or several closely-related species (e.g. mopane) leads to susceptibility to outbreaks of insect herbivores, such as moth caterpillars
- vegetative reproduction through sprouting and coppicing are common, probably as adaptations to frequent fire, drought, and herbivory by elephants

Fire:

- fire is a frequent disturbance, in part because of the long dry-season climate
- fire is anthropogenic to a significant extent, and may have been so for tens of thousands of years
- many miombo species are fire-adapted
- miombo verges on a structural disclimax vegetation type, controlled by fire and herbivory

## 3.3 Social Features

The biophysical features of the miombo ecological system put constraints and limits on societies. They provide the foundation for human activities, at various scales. The biophysical system provides both opportunities and constraints, and humans organize their activities accordingly. Human processes in turn influence the biophysical features of the ecoregion – and have done so for tens of thousands of years. This ecoregion must be viewed as an integrated whole, with humans and their activities included.

Human characteristics or features of the Miombo Ecoregion include:

- humans have inhabited the miombo ecoregion for tens of thousands of years, at least, and human ancestors for hundreds of thousands of years; it is an anthropogenically-shaped woodland
- human use of fire in “miombo” woodlands is probably so old it should be seen as a natural disturbance
- human population densities were historically low, but patchy, because herbivore densities limit hunting productivity and soil fertility limits agricultural productivity
- the colonization of southern Africa by Bantu-speaking agriculturalists is very new, from approximately 600 AD
- tsetse flies and trypanosomiasis limit cattle-keeping in the ecoregion
- the ecological dynamics of the region has certainly been shaped in many ways by humans (e.g., use of fire, honey collection, pre-colonial long-distance caravan trade, the spread of cattle keeping, colonial ivory and slave trade, the great rinderpest epidemic, colonial settlement, the introduction of the plough, tsetse and tsetse control, creation of national parks, logging), but it may not be possible to fully untangle the exact impacts. If “pristine” is defined as lacking human dominance or major influence, no part of the ecoregion is such.

As with the biophysical aspects of the miombo system, the social features of the system – including cultural, political, and economic features – are patterned at a hierarchy of scales.

At the most basic level, the natural resource potential of the ecoregion is a direct consequence of the biophysical characteristics (patterned by the biophysical template) of the system. This natural resource potential is characterized by:

- abundance of woodland products (e.g., wood for building, fuel, fiber, food (fungi, honey, edible insects)) resulting from a high-carbon landscape
- low agricultural potential, protein deficiency, resulting from a low-nutrient landscape
- low food security resulting from climatic variability and low-nutrient landscape
- megaherbivore products (e.g., ivory, rhino horn) resulting from megaherbivore dominance
- mineral wealth (e.g., gold, diamonds, platinum, chrome) resulting from geology

At the local, household scale these characteristics of the natural resources of the ecoregion have led to generally low human population densities, dispersed settlement patterns, and diverse livelihood strategies.  Low-risk, risk-spreading, anti-specialization livelihood strategies are adaptive features of the traditional human ecology of miombo cultures.  These livelihood strategies may also be associated with low maximum returns and potential for capital formation, a characteristic at odds with economic modernization and globalization.

At the same time, however, the natural resource potential of the ecoregion has given rise, at a very large spatial scale, to a political economy long characterized by global trade.  Global trade began in the pre-colonial era with long-distance caravan trade of ivory and gold, and eventually also involved slaves.  It continued and expanded in the colonial era, and continues today for some of natural resources of the region.  It has involved "mining" the wealth of the region, whether that wealth is fundamentally non-renewable, like minerals, or potentially renewable, like ivory and timber.

Capturing benefits from the globally-valuable, tradable natural resources of the region has long involved control of technology and of resource access – control that has often been highly inequitable.  Even as new modes of capturing the wealth of the region are developed, such as through global nature tourism or the cultivation of cash crops (e.g., tobacco, cotton), technology and access remain important issues.

### 3.4  Linkages

Participants at the Reconnaissance Review Workshop agreed that our understanding of the linkages between the biophysical and social processes within the miombo socio-ecological system is weak, and that further analysis will be needed to explore and "flesh out" the linkages between social and ecological processes in our model of the Miombo Ecoregion.

Several ***linking hypotheses*** were proposed:

1.  Biophysical (ecological) characteristics, features, and determinants of the miombo ecoregion are the template for human activities, opportunities, and contraints;
2.  Feedback occurs from human activities to the biophysical/ecological system, affecting its composition and functioning, potentially in ways that compromise the resilience of the system;
3.  Threats to environmental integrity and well-being -- threats both to functional (i.e., ecological processes and services) and structural (taxonomic and biogeographic) elements of biodiversity -- are threats to long-term, sustainable human well-being, and *vice versa*.

***Land use*** clearly is the main linkage between the human social system and the biophysical system.  Extensive land use patterns, characterized by low population densities and dispersed settlements, have been typical in the region.  The traditional, extensive land use patterns have involved:

- dependence on natural resource harvesting;
- shifting, "slash & burn" or chitemene cropping; (adaptation to nutrient-poor soils)

- livestock keeping that is site-specific, limited by water, grazing potential, and tsetse-borne trypanosomiasis; and,
- livestock movement and transhumance in some areas (e.g. western Zambia)

With increasing populations, dependence on natural resource harvesting has increased, fallow cycles in shifting cultivation have become shorter, and pressure to open more land for livestock grazing has increased.

***Energy flows*** also link the social and biophysical systems. In this woodland landscape, most people are dependent on wood for heating and cooking fuel, and there is an increasing, long-distance trade in firewood and charcoal from rural to urban areas.

***Hydrological processes*** provide key links between the human and biophysical systems, at a range of scales. Humans, like other animals, are constrained by the availability of water in this highly-seasonal, semiarid region. Availability of water has influenced human population densities, settlement patterns, and movements, as it does for wildlife. Woodlands play an important role in regulating the unique hydrological processes of the ecoregion at all scales. Deep deposits of Kalahari Sands in the headwater areas of the catchments of major rivers such as the Zambezi play a "capacitator" role, and create long-distance linkages by feeding water to downstream areas long into the dry season. Hydropower from large dams on these rivers (e.g., Kariba, Cabora Bassa) are an important source of urban energy.

Finally, ***regional and global trade*** in and with the region (e.g., agricultural products, tourism, minerals, diamonds, oil), and the associated issues of who benefits from such trade, are important linkage issues between the biophysical and social systems.

### 3.5 Trends & Trajectories

Ecoregion conservation is concerned with conservation and sustainable natural resource use at long-scales. Can the process-oriented model of the miombo socio-ecological system provide insights for setting priorities and guiding conservation? The Reconnaissance Team believes that it can. We began to explore the implications of the model for conservation in the Miombo Ecoregion by asking the following questions:

- Where are the processes described by the model going? Where is the system heading?
- Are there spatial and temporal thresholds in the system beyond which changes will destroy the resilience of the system and alter it in irreversible ways?
- What are the key features (processes) that maintain the integrity and resilience of the system?
- What are the scenarios for the future of the miombo socio-ecological system: an increasing separation of humans and nature, or maintenance and/or redevelopment of an integration of humans and nature?

## 4. Threats & Opportunities

WWF guidance on the ecoregion conservation reconnaissance process (WWF, 1999a; 2000a) asks the Reconnaissance Team WWF to provide "A brief description of threats to, and opportunities for, biodiversity conservation in the ecoregion." The model outlined above can be used as a tool for identifying strengths and weaknesses of the miombo socio-ecological system. In other words, it can help to identify features of the system that are resilient, and able to tolerate considerable stress and change without collapsing, and features that are vulnerable to collapse due to human-caused change and stress. It can thereby help to identify threats, constraints, and opportunities for conservation.

### 4.1 Threats & Their Causes

One clear implication of the socio-ecological model as a conceptual foundation for conservation in the miombo system can be stated as follows***: Threats to environmental integrity and well-being are threats to long-term, sustainable human well-being, and vice versa.***

Participants in the Reconnaissance Review Workshop felt therefore that because people and non-human nature are linked in a system, the human economy of the ecoregion had to be considered at every step of the conservation planning process. They pointed out that biodiversity conservation goals could not be established in isolation from those concerned with human livelihoods and wellbeing. Seventy to eighty percent of the miombo ecoregion is under small-scale agriculture, so rural farmers will play a critical role in determining the fate of the miombo landscape. For the next 50 years people of this region will continue to be highly dependent on natural resources, given the current trends in regional development. Despite their aspirations, many people may even become more dependent on natural resources as poverty and population increase. If people do not benefit from using the products of miombo woodlands, they will be more likely to clear the woodlands for agriculture.

In this ecoregion, the threats to be most concerned about are landscape-scale threats – namely, woodland clearance, and changes in hydrology linked to that woodland clearance. These are threats to both ecological processes and to structural elements of biodiveristy – the species, mainly Caesalpinoid trees, that create these processes. Loss of woodland cover and hydrological functions would have a cascading effect on other patterns and processes in the ecoregion. For example, woodland clearance will have impacts on the "high-carbon" nature of the ecoregion, and thereby on its extraordinarily diverse fungal species and on termites. Changes in hydrology will have direct effects at the species and taxon level – to dambo-associated orchids, or fish, or to endemic wetland antelopes like lechwe and puku, for example. Retaining enough trees to maintain nutrient cycles and prevent soil erosion, and maintain the hydrological and climatic balances of the region may be the key to maintaining the many of the ecological processes of the ecoregion. Woodlands play an important role in regulating the unique hydrological processes of the ecoregion. They also almost certainly play a role in maintaining regional climate through their effect on albedo. In fact, loss of woodland cover and of associated hydrological processes can be seen as the key threats to all of the conservation targets listed in Table 4, below.

It is not surprising, perhaps, that a few critical landscape-scale patterns and processes are the key threats to conservation in an ecoregion. This is probably the case in many, if not most, ecoregions: "In some ecoregions, maintaining critical processes may be more important than conserving local hotspots of species richness. Classic examples are ecoregions that are characterized as flooded grasslands (e.g., the Everglades, Okavango, Pantanal), where maintenance of the hydrological flow regime is more important to conserving the biodiversity of the ecoregion than are all other possible interventions combined." Dinerstein, et al (2000) As in these examples, the Miombo Ecoregion Reconnaissance Team would probably agree that conserving woodland cover, and the unique hydrological regime it supports, is more important to conserving the biodiversity of the ecoregion than any other possible interventions.

**Table 4. Key Threats to the Miombo Ecoregion & Their Causes**[1]

Key Threats to the Integrity of the Miombo Ecoregion and Its Biodiversity

- Loss of woodland cover (ranked as #1 threat by Review Workshop participants)
- Changes in hydrology

Proximate Causes of the Threats

- Rising poverty, unemployment, hunger, debt
- Increase in demand for, use of, natural resources
- Misgovernance, corruption, rent seeking by government officials
- Perverse national economic incentives encouraging land clearance, including agricultural pricing policies
- Refugee movements & settlements

Ultimate ("Root") Causes of the Proximate Causes

- Population growth
- Inequitable land & resource access & tenure
- Economic stagnation
- Weak government institutions
- Civil unrest & war

---

[1] Review Workshop participants did a priority-ranking card exercise in which each person put up one card with their answer to the question "What are the key threats to the continued integrity of the Miombo Ecoregion and its elements?" Six out of the 14 cards listed "loss of woodland cover," or the equivalent. This was clearly the most important threat perceived by this group. We did another round of cards to "flesh out" our picture of key threats, clumped similar cards, and ended up with 12 different topics. These were then organized into "Key Threats," "Proximate Causes" or "Root Causes"; Table 4 is derived from this exercise.

## 4.2 Opportunities

What are the opportunities for improving the current situation, and for ameliorating the threats and maintaining the integrity of the system? The following stand out:

- civil society is emerging and/or developing in many countries in the ecoregion;
- policies favoring more equitable land and resource access and tenure are being developed;
- changes in governance favoring decentralization and CBNRM are emerging;
- urbanization is increasing, potentially reducing natural resource dependence ***if*** sufficient economic activity is developed to sustain it;
- the range of economic activities and enterprise opportunities, including nature tourism, is increasing;
- awareness of the importance and value of the environment, and of links between environmental integrity and sustainable development, is increasing;
- alternative energy technologies (solar, wind) have potential to reduce woodfuel dependence;
- improvements in health, family planning, and education for women are leading to a decrease in population growth rates, as is the HIV/AIDS pandemic;
- agricultural intensification through wider availability of new/other technologies has potential to reduce pressure to clear woodlands for low-input, extensive agriculture.

# 5. How to Approach Miombo Ecoregion Conservation

## 5.1 Implications of the Miombo System Model

What conservation vision flows out of the socio-ecological model of the miombo system developed during the reconnaissance process? How do we convert the conceptual framework that was developed into a conservation vision?

Participants in the Reconnaissance Review Workshop made the following main points:

- What is special, unique, and worth conserving in the Miombo Ecoregion is its unique combination of biophysical and social features, and their interactions and emergent properties;

- Conserving biological diversity at all levels within the Miombo Ecoregion – including genetic diversity within species, diversity of species, and the diversity of ecological functions and processes that make up the ecosystem – requires understanding the factors that shape and change the system, and maintaining these determinants within acceptable limits of change.

- Large-scale landscape patterns and processes, such as extensive woodland cover and unique hydrological processes are the highest priority for conservation in the ecoregion, rather than specific species or sites. .

- Threats to environmental well-being and integrity (both to functional/ecological process elements and to structural/taxonomic and biogeographic elements of biodiversity) are threats to long-term, sustainable human well-being, and vice versa.

The miombo model has a couple of further implications for conservation. Some species or higher taxa are of special concern because they are keystone species, determining broader ecological patterns within the ecoregion. Elephants, for example are of special concern for this reason, as are termites and mycorrhizal fungi. Tsetse flies could perhaps be considered another example of a key, or keystone, species because of their effect on the settlement of woodlands by cattle-grazing agriculturalists.

Also, understanding and addressing socio-economic and political factors in general, and especially the dynamics of the current political and economic situation in the region is crucial. The region may be at a "cusp of instability" which could easily result in economic stagnation, poor progress in democratization and governance improvement, continued two-tiered economic systems, and lack of widespread development, leading to enormous pressures on natural resources and pre-empting effective conservation action for decades.

## 5.2 Conservation Targets & Priorities

The main points above lead to the following general outline of conservation targets, or elements of a conservation vision, for the Miombo Ecoregion. Conservation in the Miombo Ecoregion should seek to maintain and sustain:

- biophysical features & processes that maintain ecological resilience and integrity
  - level of woodland cover
  - hydrological system that releases water slowly over time
  - nutrient cycling
  - mosaic of habitats (at several scales)
  - keystone species (maintain both ecological processes/functions and structure)
  - mobility of organisms between habitats areas
- ecological processes that produce essential goods and services that sustain human livelihoods
- diversity and endemism of species and higher taxa
- unique habitats, communities, and landscapes
- human livelihoods and social systems, norms, and knowledge that allow the biophysical system to be sustained
- other features of global importance

Some further details about each of these are summarized in Table 5, below:

**Table 5. Conservation Targets in the Miombo Ecoregion**

<u>Biophysical Features & Processes that Maintain Ecological Resilience and Integrity</u>

(Or, "What ecological processes need to be maintained to conserve the system?" " What are the key phenomena that are ecologically determining within the ecoregion?"

- Complex surface/subsurface hydrological processes (dambos, seasonally-flooded grasslands, swamps, deep Kalahari Sands) lead to slow release of water from watersheds/catchments, delayed/regulated water flow in major rivers
- Mosaic of habitats at several scales, repeated at large, landscape and ecoregion scale
- High carbon landscape; carbon sequestration maintains integrity and resilience; abundance of woody vegetation & underground woody biomass; surplus of carbon influences microbial processes (e.g. mycorrhizal symbioses), pollination, & plant defenses; high capacity for vegetative reproduction
- Regulatory role of woodlands in hydrological functioning, erosion prevention & nutrient cycling; mycorrhyzzal symbioses & nutrient cycling
- Dominance of megaherbivores; episodic but overall low herbivory

- Mobility of organisms between habitats/areas; many miombo species (including indigenous humans, through their cultures) are adapted to low densities across wide geographic ranges
- Interrelationship of hydrology, wildlife movement, and human settlement
- Fire

Ecological Processes That Produce Essential Goods & Services That Sustain Human Livelihoods

- Slow release of moisture (dambos, swamps, flooded grasslands) including "capacitator" role of deep Kalahari Sands in headwaters of major rivers
- Woody plant regrowth and production (fuel, fiber, fertilizer, food); carbon sinks in woodlands and soils
- Albedo effects of extensive woodland canopy cover that maintain regional climate
- Grazing for economic herbivores

Diversity & Endemism of Species & Higher Taxa

- Plants (refer to consultant's report for targets for plant conservation)
- Centre of Caesalpinoid diversity
- Unique "underground" trees (adaptation to fire?)
- Fungal diversity (most diverse fungal flora in the world) due to high-carbon landscape
- Vertebrates (refer to main report for information on targets for vertebrate conservation)
- Invertebrates (refer to consultant's report for information on targets for invertebrate conservation)
- Termite diversity (due to high-carbon landscape)

Unique Habitats, Communities, & Landscapes

- Inland floodplains (Bulozi, Kilombero, Kafue)
- Itigi and similar thickets & dry forests
- Serpentine grasslands (Great Dyke of Zimbabwe)
- Chipya (Zambia)
- Cryptosepalum dry forests
- Mushitu woodland mosaic
- Plains grassland (e.g. NW Zambia, Somabula)
- Montane grasslands interface with miombo
- Mopane woodlands
- Anthropogenic landscapes (e.g. chitemene, sacred groves) The unique "chitemene" landscape of northern Zambia, for example, is "a target worthy of conservation." In the UK, there is a conservation emphasis on fens and chalk downs for example, and those are anthropogenic landscapes (with a lot of unique biodiversity).
- Inselbergs of N. Mozambique (e.g. Namuli)
- Transition zones between woodlands and seasonally-flooded grasslands & dambos

Human Livelihoods & Social Systems, Norms, & Knowledge that Allow the Biophysical System to be Sustained

Miombo-adapted social systems, cultural diversity, land-use patterns, norms, and indigenous knowledge that allow the biophysical system to be sustained include features such as:

- Livelihood strategies adapted to low densities across a wide geographic range in low nutrient, low protein systems
- Livelihood resilience strategies in response to drought
- Land use systems based on indigenous knowledge
- Traditional crop biodiversity & cultivation techniques (e.g. finger millets)
- Ash-fertilization agriculture as adaptation to low soil fertility
- Widespread use of edible lepidopteran larvae as a response to protein deficiency
- Transhumance (e.g. Bulozi, Machili floodplains)
- Trypano-tolerant livestock
- Unique indigenous knowledge of edible fungi

Other Features of Global Importance

- Carbon sequestration
- Unique hydrological system, including capacitor role of deep Kalahari Sands in headwaters of major international rivers (e.g. Zambezi, Congo, Kavango)

**5.3 Protected Areas & Conservation in the Miombo Ecoregion**

The WCMC (2001) database lists 247 protected areas that appear to be within the ecoregion. Most areas are in IUCN categories II, IV or VI and most individual protected areas are greater than 1000 $km^2$ in extent (Table 6). Cumming (1999) estimated that state-owned protected areas in southern Africa (i.e. areas in IUCN categories I-VI and forest areas) comprised 11-12% of the total land area. The percentage of the country held in protected areas varied from 4% for Mozambique to 13% for Zimbabwe. Cumming (1999) mapped the distribution of many protected areas within the ecoregion, including protected areas in IUCN categories I-IV and forest and CBNRM areas. The map shows that there is a major concentration of protected areas stretching from western Zambia southwards to the Caprivi Strip, eastwards to the Matetsi/Hwange complex and then north-westwards, first along the Zambezi Valley and then along the Luangwa Valley. There is also a concentration of wildlife land in south-central Zambia. The concentrations reflect the high biomass and diversity of large mammals to be found in wetland areas and on the more-fertile soils in the valleys of the major river systems. The Selous complex in southern Tanzania is the largest area of wildlife land on the nutrient-poor soils of the *Brachystegia* woodland that is the most typical vegetation type within the ecoregion.

Vegetation uniformity over large areas, and habitat mosaics over extensive landscapes, combined with the existence of many large protected areas within the ecoregion, leads to quite good overall representation of the main woodland types within the protected area network. Some of the unique habitats, communities, and landscapes listed above may require special efforts for conservation.

**Table 6. Protected-Area Types and Areas in the Miombo Ecoregion (WCMC,2001)**

| IUCN Category [a] | Total area ($km^2$) | Total area (km2) of PAs >1000 $km^2$ [b] |
|---|---|---|
| I | 10 | 0 |
| II | 208310 | 200466 |
| III | 102 | 0 |
| IV | 114866 | 110982 |
| V | 3558 | 2830 |
| VI | 337706 | 322840 |
| All | 672840 | 645406 |

[a] Excluding those PAs for which the WCMC database does not provide the area
[b] This does not include those PAs <1000 $km^2$ which are adjacent to another PA of <1000 $km^2$ and thus have a combined area of >1000 $km^2$

Neither the WCMC nor WWF databases provide information on the current standard of protection and management and so some of the protected areas listed in the databases may exist only in theory, particularly in those countries (Angola and DRC) where wars are being fought.

Although current protected areas may address some of the threats to the conservation targets listed above – especially the more taxonomic and biogeographic targets – they may not address some other threats, especially threats to the underlying ecological processes that maintain the integrity and resilience of the miombo system. The large national parks of the region tend to be at lower elevations and in river valleys, for example, not in catchment headwaters. For another example, conserving the network of dambos needed to maintain the essential hydrological processes of the region can not be accomplished through protected areas, so other mechanisms for their conservation are needed. Dambos, wetlands, river valleys and riparian areas are key habitats within the ecoregion, but the conservation of these habitats depends upon maintaining a level of woodland cover above some unknown threshold value in order to preserve natural hydrological functioning.

Participants in the Reconnaissance Review Workshop recommended a "gap" analysis of the coverage of existing protected areas and ***both*** the ecological processes elements of biodiversity identified in our model, as well as the traditional biogeographic/taxonomic elements of biodiversity that are the usual subject of gap analysis in conservation biology. Further analysis is needed to better understand the relationship between the functional, ecological process elements of biodiversity and the taxonomic/structural elements within the Miombo Ecoregion

Protected areas already cover about as much land as can reasonably be allocated to them in the Miombo Ecoregion. The immediate focus needs to be to find ways of extending the area being maintained under natural vegetation, and mitigating biodiversity loss in prime areas outside of protected areas. The key is to adopt a full range of conservation approaches is adopted (i.e., protected areas, CBNRM, sustainable use, conservation on private lands, public-private partnerships) and to recognise that there is strength in a diversity of approaches to conservation.

Protected areas of all types and uses are a cornerstone of biodiversity of conservation. In the long-term, protected areas must exist in a matrix of managed lands. For protected areas to survive and function, biodiversity conservation must be an important consideration across the larger landscape, and its importance must be recognized in economic and development planning (e.g., for land use, infrastructure) planning processes. Governments, whether at the local or national level, have the responsibility to implement and enforce such policies. In the model of ecoregion conservation we envision, protected areas should not be seen as stand-alone bastions of conservation – as unerodable islands of granite washed by rough seas of human use – but rather as denser patches of more natural land in a larger conservation landscape. For this to work, all stakeholders, from rural populations to urban decision makers, must be convinced of the value and importance of biodiversity.

### 5.4 Information Gaps versus Information Needs

The Miombo Ecoregion is relatively well-studied compared to some other ecoregions. This Reconnaissance identified some important information gaps within the region, however, and further information-gathering activities – in some cases involving long-term research – will be needed to close the gaps.

It is very important to keep in mind, however, that knowledge ***gaps*** -- of which there are many, both on the biological and social sides -- are not necessarily the same as information ***needs***. Information needs should be determined by stakeholders and decision-makers and based on ***their*** priorities. Just because we don't know the biogeographic distribution of the species of certain taxonomic groups within the ecoregion doesn't mean conservation planners and managers need that information -- unless there is some reason to believe that a particular taxon is especially important for priority-setting by stakeholders, or decision-making by managers. On the other hand, having such biogeographic information may be important for certain groups, especially if these are "keystone" species or groups that are suspected to have important functional roles in the ecosystem and contribute to maintaining its structure, integrity, and resilience – such as mycorrhizal fungi or termites – or "indicator" species or groups such as Palearctic migrant birds or dambo-associated orchids.

The conceptual framework for miombo conservation described here has a number of implications for further information-gathering and research. For example, because maintaining woodland cover is the highest conservation priority, having adequate information about land cover and land use is currently of much higher priority and value than gathering taxonomic and biogeographic information about species distributions.

***Key information needs include:***

- regional land cover & land use analysis
- gaining a better understanding of the relationship between woodland cover & hydrological functioning
- information about taxa with hypothesized functional importance in maintaining the integrity and resilience of the miombo system, such as mycorrhizal fungi & termites
- tapping indigenous knowledge about important taxa such as fungi

## 6.  Toward a Conservation Vision for the Miombo Ecoregion

The Reconnaissance Team offers the following tentative vision statement as a summary of the thinking of the Reconnaissance Team.  We hope it provides a basis for launching the next stages of the ecoregion conservation process, which will involve developing a conservation vision and implementation plan for the Miombo Ecoregion.

**Tentative Vision Statement for the Miombo Ecoregion:**

In 50 years we would like to see a region in which natural diversity -- including species, a mosaic of habitats, and the processes that sustain them -- is maintained in a functioning system at an extensive, landscape scale, and supports a stable and productive socioeconomic system, and a diversity of land uses, providing livelihoods and equitable opportunities for the sustainable development of the people of the region.

## References

Campbell, B., ed. (1996). The Miombo in Transition: Woodlands and Welfare in Africa. Centre for International forestry Research (CIFOR). Bogor, Indonesia.

Cumming, D.H.M. (1999). Study on the Development of Transboundary Natural Resource Management Areas in Southern Africa – Environmental Context: Natural Resources, Land Use, and Conservation. Biodiversity Support Program. Washington, D.C.

Desanker, P.V., Frost, P.G.H., Justice, C.O. & Scholes, R.J. (eds) (1997). The Miombo Network: Framework for a Terrestrial Transect Study of Land-Use and Land-Cover Change in the Miombo Ecosystems of Central Africa. IGBP Report 41. The International Geosphere-Biosphere Programme (IGBP), Stockholm, Sweden, 109 pp.

Dinerstein, E., G. Powell, D. Olson, E. Wikramanayake, R. Abell, C. Loucks, E. Underwood, T. Allnutt, W. Wettengel, T. Ricketts, H. Strand, S. O'Connor, and N. Burgess. (2000). A Workbook for Conducting Biological Assessments and Developing Biodiversity Visions for Ecoregion-based Conservation: Part I, Terrestrial Ecoregions. World Wildlife Fund: Washington, D.C.

Frost P.G.H. (1996). The ecology of miombo woodlands. In: Campbell, B. (ed.) The Miombo in Transition: Woodlands and Welfare in Africa. pp. 11-57. Centre for International Forestry Research, Bogor, Indonesia, 266 pp

Huntley, B.J. (1982). Southern African savannas. In: Ecology of tropical savannas (eds B.J. Huntley & B.H. Walker). pp.101-119. Springer-Verlag, Berlin.

Johnson, N.C. (1995) Biodiversity in the Balance: Approaches to Setting Geographic Conservation Priorities. Biodiversity Support Program: Washington, D.C.

White, F. (1983). The Vegetation of Africa. Natural Resources Research No. 20. UNESCO, Paris.

McNeely, J.A., K.R. Miller, W.V. Reid, R.A. Mttermeier, and T.B. Werner. (1990). Conserving the World's Biological Diversity. IUCN: Gland, Switzerland.

Onguene, N.A. (2000). Diversity and dynamics of mycorrhizal associations in tropical rain forests with different disturbance regimes in South Cameroon. The Tropenbos-Cameroon programme, Kribi, Cameroon.

Reid, W.V. and K.R. Miller. (1989). Keeping Options Alive: The Scientific Basis for Conserving Biodiversity. World Resources Institute: Washington, D.C.

WCMC. (2001). Protected Areas Programme, Prototype Nationally Designated Protected Areas Database, List of Protected Areas. <http://www.unep-wcmc.org/protected_areas> Site visited 2 March 2001.

WWF. (1998). Proceedings: Ecoregion-Based Conservation Workshop. WWF-US: Washington, D.C. (January 1998).

WWF. (1999a). Guidelines for the Reconnaissance Phase of Ecoregion-Based Conservation. WWF-US: Washington, D.C. (January 1999).

WWF. (1999b). Map of Terrestrial Ecoregions of Africa, revised. Conservation Science Program, WWF-US: Washington, D.C..

WWF. (2000a). Ecoregion Conservation: Broader Visions, Bigger Impact. WWF-US: Washington, D.C., and WWF-International: Gland, Switzerland.

WWF. (2000b). Stakeholder Collaboration: Building Bridges for Conservation. WWF-US: Washington, D.C.

**Appendix 1: Reconnaissance Team Members & Inception Workshop Participants**

| NAME | AFFILIATION/ INSTITUTION | ADDRESS | TELEPHONE | FAX | E-MAIL |
|---|---|---|---|---|---|
| Zipangani Vokhiwa | WWF-SARPO | P.O. Box CY1409<br>Causeway, Harare<br>Zimbabwe | 263-4-252533/4<br>263-4-703902 | 263-4-252533/4<br>263-4-703902 | Zvokhiwa@wwf.org.zw |
| John Hatton | IMPACTO | Av. Martires da Machava, 968<br>Maputo, Mozambique | 258-1-499636/7 | 258-1-493019 | jh@impacto.co.mz |
| Peter Sumbi | WWF Tanzania | P.O. Box 63117<br>Dar es Salaam<br>Tanzania | 255-22-2700077 | 255-222775535 | Psumbi@raha.com |
| Kevin Dunham | Independent Biologist | P.O. CH385<br>Chisipite, Harare<br>Zimbabwe | 263-4-883475 | | faykevin@ecoweb.co.zw |
| Bruce Byers | Consultant in Conservation & NRM | 405 Timber Lane<br>Falls Church, VA<br>22046 USA | 703-534-4436 | 703-534-1714 | bbyers@igc.org |
| Daniel C.W. Nkhuwa | University of Zambia School of Mines | P.O. Box 32379<br>Lusaka<br>Zambia | 260-1-294086 | 260-1-294086 | Dnkhuwa@mines.unza.zm<br>DCWNkhuwa@yahoo.com |
| Russell Taylor | WWF-SARPO | P.O. Box CY1409<br>Causeway, Harare<br>Zimbabwe | 263-4-252533/4<br>263-4-703902 | 263-4-252533/4<br>263-4-703902 | Rtaylor@wwf.org.zw |
| David Cumming | WWF-SARPO | P.O. Box CY1409<br>Causeway, Harare<br>Zimbabwe | 263-4-252533/4<br>263-4-703902 | 263-4-252533/4<br>263-4-703902 | Dcumming@wwf.org.zw<br>Cumming@icon.co.zw |
| Tony Cunningham | Independent Ecologist | 84 Watkin St<br>White Gum Valley<br>6162, Fremantle,<br>Australia | 61-8-93366783 | 61-8-93366783 | Peopleplants@bigpond.com |
| Steve Johnson | Independent NRM Specialist | 10 Lavenham Drive<br>Bluff Hill<br>Harare,Zimbabwe | 263-91-455 455<br>263-4-331679 | 263-4-331679 | Kjohnson@africaonline.co.zw |

| | | | | | |
|---|---|---|---|---|---|
| Roy Bhima | Dept. of National Parks &Wildlife, Malawi | P.O. Box 30131<br>Lilongwe 3<br>Malawi | 265-774059 | 265-774059 | Gtz-dnpw@malawi.net |
| Cornell Dudley | Dept of Biology Chancellor College | P.O. Box 280<br>Zomba, Malawi | | | cdudley@malawi.net |
| Emmanuel Guveya | Dept. of Agricultural Economics, U. of Zimbabwe | P.O. Box MP167<br>Mount Pleasant<br>Harare, Zimbabwe | 263-4-303211<br>Ext 1516 | | Manu@compcentre.uz.ac.zw |
| Ramos Mabugu | Dept. of Economics<br>U. of Zimbabwe | P.O. Box MP167<br>Mount Pleasant<br>Harare, Zimbabwe | 263-4-303211<br>Ext 1843 | 263-4-33407 | Rmabugu@sociol.uz.ac.zw |
| Jonathan Timberlake | Biodiversity Foundation for Africa | P.O. Box FM730<br>Famona<br>Bulawayo | 263-9-286529 | 263-9-285761 | Timber@telconet.co.zw |
| Dominick Kwesha | Forestry Commission, Zimbabwe | P.O. Box HG595<br>Highlands<br>Harare | 263-4-496878/9 | 263-4-497070 | Dkwesha@frchigh.co.zw |
| Tom Milliken | Traffic East/Southern Africa | P.O. Box CY1409<br>Causeway<br>Harare<br>Zimbabwe | 263-4-252533/4<br>263-4-703902 | 263-252533/4<br>263-4-703902 | Milliken@wwf.org.zw |
| Dominic Mazvimavi | Department of Geography<br>U. of Zimbabwe | P.O. Box MP167<br>Mount Pleasant<br>Harare | 263-4-303211<br>Ext. 1265 | 263-4-332059 | Dmazvi@arts.uz.ac.zw |
| Kudakwashe Muhwandagara | WWF-SARPO | P.O. Box CY1409<br>Causeway<br>Harare, Zimbabwe | 263-4-252533/4<br>263-4-703902 | 263-4-252533/4<br>263-4-703902 | Kmuhwa@wwf.org.zw |
| Fay Robertson | Botanist | P.O. Box CH385<br>Chisipite<br>Harare, Zimbabwe | 263-4-883475 | | Faykevin@ecoweb.co.zw |

## Appendix 2: Other Persons Contacted During Reconnaissance Inception Phase: Regional Travel by Bruce Byers to Lusaka, Zambia, and Dar es Salaam, Tanzania

### 26-28 February meetings in Lusaka, Zambia, arranged by Monica Chundama and the WWF Coordination Office

Mike Bingham, Vegetation & Wildlife Ecologist
Emmanuel Chidumayo, Professor of Biological Sciences, University of Zambia
Monica Chundama, WWF Programme Coordinator
Richard Jeffrey, Biologist
Helen Gunther, Chief, Agriculture & Private Sector Office, USAID Zambia
George Kampamba, Head of Research, Zambia Wildlife Authority
John Mulombwa, National Coordinator, Provincial Forestry Action Program, Forestry Department
George Muwowo, Team Leader, Teacher Education, WWF
Henry Mwima, Zambezi Heartland Coordinator, African Wildlife Foundation
Nyambe Nalumino, Project Manager, Kafue Partner for Wetlands Project, WWF
Gabriella Richardson-Temm, Zambia Country Programme Coordinator, IUCN
Obote Shakacite, Chief Extension Officer, Forestry Department
Mwape Sichilongo, Executive Director, Wildlife & Environmental Conservation Society of Zambia
Justina Wake, Director, Tourism Planning, Management & Coordination, Ministry of Tourism
Georgina Zulu, Senior Planning Officer, Department of Planning & Information, Ministry of Environment & Natural Resources

### 1 March meetings in Dar es Salaam, Tanzania, arranged by Peter Sumbi, WWF Tanzania Programme Office

Idris Kikula, Professor, Institute for Resource Assessment, University of Dar es Salaam
J.W.A. Musokwa, Project Implementation Specialist, Tanzania Forest Conservation & Management Project, Ministry of Natural Resources & Tourism
Hermann Mwageni, Conservation Director, WWF Tanzania Programme Office
Paul Seigel, Country Representative, WWF Tanzania Programme Office
Pius Yanda, Coordinator, Tanzania Natural Resources Information Centre, Institute of Resource Assessment, University of Dar es Salaam

## Appendix 3:  List of Reconnaissance Consultant's Reports

**Consultant's reports may be obtained electronically or in hard copy by contacting WWF SARPO§ or WWF-US***

| Topic | Author(s) |
|---|---|
| 1. Ecoregion Boundaries, Vegetation, Plants, Centres of Endemism & Diversity, Impacts of Land Use on Biodiversity | Jonathan Timberlake |
| 2. Climate, Geology,Geomorphology, Hydrology, & Soils | Dominick Mazvimavi, DanielNkhuwa, Linley Lister, & Jonathan Timberlake |
| 3. Vertebrates, Conservation | Kevin Dunham & Roy Bhima |
| 4. Invertebrates | Cornell Dudley |
| 5. Ecological Processes | Fay Robertson, Kevin Dunham, & Roy Bhima |
| 6. Land Use Description | Dominick Kwesha |
| 7. Land Use & Resource Use | Emmanuel Guveya |
| 8. Resource Use: Patterns & Processes | Anthony Cunningham, Tom Milliken |
| 9. Socio-Economic Review | Steve Johnson |
| 10. Economic Valuation | Ramos Mabugu |
| 11. Policy, Legislation, & Institutions | Steve Johnson |
| 12. Stakeholder Analysis | Steve Johnson |
| Boundaries & Vegetation Types Maps (JPEG Image files) | Dominick Kwesha & Jonathan Timberlake |
| Geology & Geomorphology Maps (JPEG Image files) | Linley Lister & Dominick Mazvimavi |

§  Ms. Fortune Shonhiwa by email at <fshonhiwa@wwf.org.zw>
*  Ms. Kate Newman by email at <Newman@wwfus.org>