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1: INTRODUCTION

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1.0 INTRODUCTION

The biodiversity studies detailed in this report represent one component of the Zambezi Basin Wetlands Conservation and Resource Utilisation Project (ZBWCRUP), funded by CIDA and implemented by IUCN ROSA from 1996 to 2000.

The ZBWCRUP project goal is "to conserve the wetland ecosystems of the Zambezi River Basin while facilitating their sustainable use". The major project objective to which these biodiversity studies relate is "to articulate the true value and importance of the functions, products and attributes of wetland ecosystems at local, national and regional levels".

It has been a general assumption throughout the world, since wetlands achieved prominence in conservation circles, that one of the “true values” of wetlands is their biological diversity. This assumption has been found to be true in many other parts of the world, but has seldom, if ever, been tested in the semi-arid zones characteristic of most of the Zambezi Basin, and indeed of much of southern Africa.

The ZBWCRUP adopts a basinwide perspective on wetlands conservation, but selected four major Zambezi wetlands as the focus for its fieldwork. These were: the Barotseland floodplains in western Zambia; the Chobe-Linyanti wetlands in Botswana and Namibia; the Lower Shire marshes in southern Malawi and Mozambique; and the Zambezi Delta in central Mozambique.

The biodiversity studies were implemented in two phases, and followed a similar approach. The first phase, of twelve months’ duration, focused primarily on the acquisition of existing information from within the basin, but with a particular focus on the four selected ZBWCRUP project areas. A second, two-year main phase utilised detailed reviews of selected taxa from a basinwide perspective, together with field surveys in the Barotse floodplains and Zambezi Delta, to achieve a number of objectives.

These objectives and the associated activities and outputs are detailed in the full Terms of Reference for this main phase and are included in this report as Volume 1: Appendix 1. For the purpose of this introduction, however, it is useful to focus on IUCN’s more generalised requirements: an assessment of the importance of the biodiversity of wetlands to the Zambezi Basin as a whole; a determination of the major biological features of the wetlands; and a determination of the impacts of development and land use change on wetland biodiversity.

It is important to define what we mean by biological diversity, the Zambezi Basin, and wetlands - three terms that can be subjected to differing interpretations. For the purposes of these studies, then, we have held to the following definition of biological diversity:

"**Biodiversity**, an abbreviated form of the words "biological diversity", is defined under the Convention on Biological Diversity as "...the variability among living organisms, including, *inter alia,* terrestrial, marine and other ecosystems and the ecological complexes of which they are part; this includes diversity within species (genetic diversity), between species (organismal or species diversity) and of ecosystems (ecological diversity)."

Heywood, in the book *Global Biodiversity Assessment*, states: "Strictly speaking the word biodiversity refers to the quality, range or extent of differences between the biological entities of a given set. In total it would thus be the diversity of all life and is a characteristic or property of nature, not an entity or resource."

Biodiversity is a measurable attribute, something which can be surveyed and quantitatively described at one of three levels – genetic, specific or ecological. The units of measurement, however, are not tons per hectare but units of diversity such as numbers of species or processes; generally it is measured using species number. Biodiversity is a biological measurement, not a measure of utilisation or utility.

This latter misconception – of biodiversity as a measure of utility – is often perpetuated by politicians, social scientists and even some conservationists within the region, as evidenced by statements such as "rural communities depend on biodiversity ....for poles for huts, for food, for fish..." or for whatever commodity happens to be under discussion. We would suggest that this is a particularly misleading interpretation, as it focuses on precisely those ecosystem components that could more advantageously be farmed as exceedingly undiverse monocultures, and ignores the entire question of ecosystem complexity.

The Zambezi Basin can be clearly defined today as the area in south central Africa within which incident rainfall eventually drains, directly or through a series of tributaries, into the Zambezi River (Figure 1 - see map at the end of this Volume, page 65). However, it has to be recognised that this is not a fixed entity and was substantially different in extent even in geologically-recent times. For most of the reviews, full cognizance was taken of those wetlands technically outside of the present-day basin, such as the Bangweulu Swamps, Okavango Delta and Lake Chilwa. This makes good biological sense as they were all joined not so long ago. However, the main focus of the reviews is on the present-day basin, especially the four IUCN sub-project areas of the Barotse floodplains, Chobe/East Caprivi floodplains, Lower Shire marshes and the Zambezi Delta.

Various definitions of '**wetlands**' have been used in the past. For these studies, a definition adapted from that used by the US Fish and Wildlife Service was initially adopted – "land where an excess of water is the dominant factor determining the nature of soil development and the types of animal and plant communities living at the soil surface. It spans a continuum of environments where terrestrial and aquatic systems intergrade".

This definition is biological, defining a wetland on the basis of the species occurring there. However, such a wide definition would have made most of the reviews unmanageable given the widespread extent, and biological importance, of pans, dambos and similar grasslands within the basin. Hence, for the purposes of the lists and reviews, only lakes, channels, swamps and regularly flooded floodplains were covered. Specifically excluded in most cases were riverbanks, dambos, edaphic grasslands, pans and seeps. The differences and definitions are discussed more fully in Volume II, Chapter 1.

It is, however, when we begin to deal with issues such as the relative importance of wetlands to biodiversity within the Zambezi Basin that difficulties can arise. As a direct result of these studies we now know a good deal more about Zambezi Basin wetland diversity than we do about many other habitats and ecosystems within the basin. Obviously, then, it is impossible to evaluate relative importance without comparable data from these other habitats and ecosystems. As phrased, the question is therefore largely unanswerable within the confines of these studies. Furthermore, as pointed out in Section 2 of this report, it is neither possible to measure all biological diversity in given areas, nor to make definitive statements about species. What can be said with some certainty, however, is that the Basin's wetlands collectively represent a range of habitats with associations of species and ecosystem processes not represented by other basin ecosystems.

Relative questions – whether wetlands are more or less important than other ecosystems, which both compare apples and oranges and imply some sort of triage process – can be dangerous red herrings, created by the need to make inevitably superficial prioritisations due to pressing human need and a lack of resources for more comprehensive biodiversity conservation initiatives. The wetland ecosystems are important both in their own right, and as diverse components of the Zambezi Basin landscape.

Between wetlands themselves, as noted in Sections 6 and 7, some comments can be made concerning viability, endemicity and habitat types, and a number of wetlands and species can be identified as meriting conservation attention and, if necessary, action. These conclusions and recommendations are detailed in Volume I of this report. The detailed information from which these and other conclusions were drawn form Volumes II and III.

Volume II includes detailed reviews of the taxa initially selected as being most feasible and appropriate in terms of the project objectives. These reviews are supplemented by limited fieldwork in the Barotse floodplains and the Zambezi Delta. Volume III deals with changes in land use in the same areas, and is supplemented by a more general overview of human impacts on Zambezi Basin wetlands. From these reviews the inescapable conclusion – and one that is timely in view of the activities of the World Commission on Dams – is that impoundments such as those at Kariba and Cabora Bassa are one of the major single causes of ecosystem change in Zambezi Basin wetlands. Conversion, whether to agriculture or to other forms of land use, also features strongly; and one might conjecture that it would feature even more strongly had the basin's dambos formed more of a project focus. Meanwhile Volume IV consists of the annotated bibliography that represents a major project output, and that formed the basis for much of the initial work in the first project phase.

It can be said with some certainty that the findings of these studies provide a good preliminary technical basis for a general wetlands conservation thrust within the Zambezi Basin, and for focused conservation action directed at specific major wetlands. Unfortunately, conclusion of the biodiversity studies coincided closely with the termination of the present ZBWCRUP phase. In the absence of a confirmed further phase the implementation of conservation action, in addition to that undertaken by ZBWCRUP over the past three years, and incorporating the results of the biodiversity studies, is currently left unaddressed.

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2 : PHYSICAL AND BIOLOGICAL BACKGROUND

2.0 INTRODUCTION

The Zambezi Basin in its present form is not an ancient basin; it is the result of many changes in drainage pattern across the Central African Plateau, many of which are, in geological terms, comparatively recent. This section describes the main features of the present-day basin and briefly indicates how it has been modified over the past few million years. This has major significance in understanding patterns of distribution of biodiversity. The evolutionary background, and the often-confused ideas on what is a species, are also described. These are important in determining what conservation priorities and actions should be.

2.1 THE ZAMBEZI BASIN

The Zambezi Basin lies across South Central Africa and drains into the Indian Ocean north of Beira (Figure 1 - see end of this Volume). It is approximately 1.3 million km^2 in extent and covers a small part of eastern Angola, much of Zambia, the East Caprivi of Namibia, part of northern Botswana, about half of Zimbabwe, most of Malawi and a small portion of southwestern Tanzania (if the catchment of Lake Malawi is included) and the central part of Mozambique. Much of the area it drains is woodland and savanna lying on the raised Central African Plateau, and the underlying rocks are comparatively old. The upper reaches of the river appear to be of great antiquity, but the middle and lower course of the river is probably comparatively young.

The Zambezi River is often divided into three distinct geographical sections – the Upper Zambezi, Middle Zambezi and the Lower Zambezi. In this discussion the main geomorphological features of each section of relevance to biodiversity are highlighted. The Bangweulu Swamps, Okavango Delta and Lakes Malawi and Chilwa are included even though technically they lie outside the present-day basin. These are described more fully in the earlier Phase I report.

2.1.1 **Upper Zambezi**

The Upper Zambezi is the broad extent of the Zambezi River from the source 25 km southeast of Kalene Hill in Mwinilunga District, northwest Zambia, through Angola and Barotseland to the Victoria Falls. It is at this latter point that the river markedly changes its character, ecology and typical flora and fauna. The Upper Zambezi includes the Lower Kwando, the Chobe/Caprivi and Linyanti system, the lower Okavango River and Okavango Swamps, and the Kafue system. Although not always hydrologically linked, the first three systems flow into each other at times, were undoubtedly more closely linked in the past, and are biologically inseparable. This upper part of the Zambezi Basin typically comprises a series of broad floodplains separated by low sand plateaux, all set in a comparatively old, flat landscape. Swamps are scattered and generally small. The area is overlain by Kalahari sands with very little outcropping rock.

2.1.2 **Middle Zambezi**

The Middle Zambezi is here defined as that section of the river between Victoria Falls and the Lupata Gorge above Tambara in Mozambique, some 70 km downstream from Tete. However, others have defined it as only extending as far downstream as the lower end of the Cabora Bassa rapids near the present-day Cabora Bassa dam. It is dominated geographically and ecologically by two large dams – Lake Kariba, which forms part of the Zambia-Zimbabwe boundary, and Lake Cabora

Bassa in Mozambique. Also included in the broad Middle Zambezi Basin are major tributaries such as the Gwayi, Sengwa, Sanyati, Manyame and Mazoe, which rise in the Zimbabwe highveld, and the Luangwa in Zambia.

The character of the Middle Zambezi, especially since impoundment, is of a regulated river running through a combination of narrow gorges and broad fault-derived valleys in a hot, dry landscape of deciduous woodland. Floodplains are very limited in extent since the construction of Kariba, those in the Mana Pools-Sapi area between the Lupata confluence downstream of Kariba gorge and the Mupata Gorge being the best developed. Flooding rarely occurs now, and then only locally.

Along the Zambezi watershed in Zimbabwe are many broad, seasonally-waterlogged grasslands or dambos, similar in character (and perhaps also in plant species composition) to the dambos that so typify much of the Zambian highveld. The latter, however, mostly feed into the Upper Zambezi or the Luangwa. Biologically and ecologically these dambos present a great contrast to the essentially dry and low altitude flora, fauna and ecology of most of the Middle Zambezi valley.

2.1.3 **Lower Zambezi**

This, final, section of the Zambezi starts at Lupata Gorge some 70 km downstream of Tete in Mozambique, and some 40 km downstream of the point at which the penultimate major tributary – the Rio Luenha, or Mazoe River – joins it. Others, however, suggest it starts at the base of the Cabora Bassa rapids. From Lupata Gorge downstream the river is broad, often comprising many anastomosing channels with shifting sandbanks, until it reaches the sea at Chinde. Just below Mutarara, the Shire River, which drains much of southern Malawi and takes the overflow from Lake Malawi, joins from the north.

The Zambezi Delta is difficult to define, but can be said to start at Mopeia, some 120 km from the coast. Here the Rio Cuacula, effectively a channel of the Zambezi, flows away to the east towards Quelimane while the main Zambezi flows south east. Lying between the Cuacula and the Zambezi proper is an extensive area of grassland and wetland with few trees. Likewise, to the south lies the area of Marromeu with palm savanna and short grassland interspersed with creeks. It is a moot point whether these latter wetlands are now principally fed from the Zambezi, or from seepage and runoff from the Cheringoma plateau to the west.

2.2 EVOLUTION OF PRESENT-DAY DRAINAGE

The proto-Upper Zambezi, 2-5 million years ago, consisted of a number of rivers which fed a series of large inland lakes in the Kafue, East Caprivi and southern Okavango areas. These rivers included what are today the Kavango, Kwando, Upper Zambezi, Kafue and Upper Chambeshi. From these large inland lakes, the waters flowed into palaeo-Lake Makgadikgadi in central Botswana, and from there into what is now the Shashe then Limpopo rivers. At an early stage it is probable that the Gwayi, Matetsi and other rivers of northern Matabeleland also flowed westwards into these lakes. What is now the Middle and Lower Zambezi was a separate drainage system incorporating the Luangwa, Sanyati and Gwembe trough, as well as the Shire, which arises in Lake Malawi. It is believed the main course of the Lower Zambezi followed the Shire southwards along the Rift Valley to enter the ocean near Beira after being joined by the Pungwe and Busi.

Various of the headwaters were captured by rivers draining into the Congo Basin, such as the Luapula and Kasai, as seen in the similarity of biodiversity across the upper reaches today. But perhaps the major event, or series of events, was the capture of the waters of the Upper Zambezi by the backward-cutting headwaters of the palaeo-Middle Zambezi somewhere in the region of Katombora/Victoria Falls. These events led to the draining of palaeo-Lake Caprivi in the East Caprivi and the diversion of the vast quantity of water draining southwards from the central African Plateau into the eastwards-flowing "Zambezi". It is this sudden quantity of water that is believed to have led to the 'short cut' of the river into the present-day Zambezi Delta, which is comparatively recent. This series of river captures, about 1 to 2 million years ago, also caused the effective separation of the Kavango/Okavango system from the main Zambezi, and hence the drying up of Lake Makgadikgadi and the severing of the link to the Shashe/Limpopo.

Although in evolutionary terms, these hydrological changes are comparatively recent, the biodiversity of the present-day Zambezi Basin still reflects in large degree the old pattern. There is a marked disjunction in the diversity of many plant and animal groups, especially the more aquatic ones, between the palaeo-Upper Zambezi and the Middle and Lower Zambezi basins. In addition, the biodiversity of the Okavango and Bangweulu swamps, which lie outside the present-day basin, is very similar to that of the present-day Upper Zambezi. Therefore any assessment of biodiversity and required conservation actions must look beyond the confines of the present-day basin, and the evolutionary forces that shaped the flora and fauna then (as today), must be taken into account.

2.3 CONCEPTUAL AND BIOLOGICAL BACKGROUND

2.3.1 **Biodiversity and its assessment**

Biodiversity is the total variety of life on earth, in an ocean or continent or in some smaller geographical domain, whether a landscape or habitat. Biodiversity can be used, conserved or destroyed.

Different properties of biodiversity can be measured; these can be genetic, organismal or ecological. Nevertheless, it is important to reconcile ourselves to the fact that it is practicably impossible to measure all biodiversity within any region of concern, whether a lake, wetland, agroeco-landscape, or protected area. Hence, priorities have to be set. Sound prioritization can only be carried out when based on knowledge of the patterns of biodiversity composition and on an informed understanding of the ecology of the landscapes where species have evolved and persist.

2.3.2 **Species as evolutionary lineages**

In common belief and practice, species are the currency of conservation and have been traditionally defined as reproductively isolated populations. Biologists need only identify and map species using these criteria and all properties of biodiversity will be revealed, it was believed. In reality, the nature of species and their scientific characterization is in no way so straightforward. Species characterization based primarily on the criterion of reproductive isolation is both biassed and too coarse. For example, cryptic species are often missed and evolutionally-significant populations are lumped as composite 'species'. If the resolution that picks out species in an assessment of biodiversity is too coarse, then significant biodiversity will be ignored. Greater objectivity and accuracy is required for a scientific assessment of biodiversity. Ideally, measurement of the composition of biodiversity should mirror its natural constitution: biologists should aim "to carve nature at its historical joints"; in other words, discover and describe the real products of evolution.

The species category continues to be debated in evolutionary biology. Over 20 different species concepts have been proposed and some, such as the Biological Species Concept (BSC) and

Evolutionary Species Concept (ESC) and their variants, have been applied with varying success to describe and classify the living world. What comprises a species is not just an esoteric issue – in conservation it is vital not to let cryptic species "slip through the net" by using an imprecise taxonomy. There is an increasing amount of evidence, much of it coming from cellular and molecular studies, to show that hidden or cryptic species are common.

The impetus to discover and classify the actual species that comprise biodiversity – on objective criteria – originates mostly in systematics, which since the 1960s has increasingly adopted a more objective philosophy and method of classification. This is the methodology of cladistics, which seeks to discover and classify natural groups of species as higher taxa. Cladistics has now become the most widely applied method of classifying species and has revolutionized the discipline of phylogenetic systematics. Its widespread adoption has focused the attention of systematists on describing the evolutionary dimensions of taxa, with greater emphasis on recognizing the temporal dimension of species. The core goal is to discover biological history with respect to the evolution of species and the biota of which they are part. This historically orientated approach increasingly complements and supersedes the mainstream focus in traditional taxonomy on existing populations occurring only in ecological scales of space and time. Construing species in terms of their evolutionary history, and not just their modern properties, has caused radical changes in how species are characterized. This, in turn, impacts on biodiversity conservation.

Perhaps the best known example of impacts of a revision of the species category is in ornithology, where the number of existing species of birds recognized worldwide has recently been doubled. This follows a replacement of an ecologically-based Biological Species Concept with a historically-based Phylogenetic Species Concept that recognizes a more fine-grained diversity in living birds based on the evolutionary divergence of their populations. In consequence, populations that were merely considered subspecies or parts of a single species are now classified as full species. Previously there were approximately 9000 species of birds recognized on the basis of the BSC, but this has since been increased to over 16,000, with obvious impacts on conservation priorities, planning and activities.

Reproductive isolation versus evolutionary divergence are just two of many properties of a species. Herein lies the source of much confusion and disagreement amongst biologists in their attempts to "carve nature at its joints". Recently, De Queiroz has emphasised the General Lineage Concept of the species category. A commonality shared by all species concepts is that each species exists as a population that has persisted through space and time – not just in ecological space but through evolutionary time between its origin and extinction. Fundamentally, a species is an evolutionary lineage that exists as one or more populations that have persisted as a result of the constituent organisms' breeding. Each species concept focuses on certain properties of a species' lineage (for example, the criteria of reproductive isolation, genetic divergence and monophyly), and each emphasizes its respective criterion as superior in species characterization. In reality, a species has many different properties, and their relative importance varies with respect to the age of the species in its life history (between origin and extinction) and how its constituent organisms reproduce – sexually or asexually (for example, plants compared to vertebrates). An example of this from the Zambezi Basin wetlands is the lechwe antelope. Traditionally, lechwe were considered a single, polytypic species, but scrutiny of their present biogeography strongly suggests that there are at least four described species and perhaps another five species (see Volume II, Chapter 3).

2.3.3 **Targets for conservation**

Three schisms of tension are found in conservation biology. One is the concern over single species (invariably larger, charismatic organisms) versus the broader focus on entire biota and ecological entities. This disagreement can be defused by recognizing that no single species can persist independent of key ecological resources and its natural environment. Ex situ conservation is undoubtedly important, especially for education, but it is obviously impossible to maintain all biodiversity in zoos, botanic gardens and laboratory cultures. The logical imperative is for a central focus on selected biotic assemblages in certain areas of the biosphere, which should be the core of a biodiversity conservation strategy.

This leads to the second area of tension in conservation biology: we cannot conserve all biodiversity, but which to select for priority attention? Choices have to be made about priority areas based on representation, richness or uniqueness. Biogeographical patterns can be identified by assessments of where species occur based on measures of species richness and endemism. Thus, the Ethiopian Highlands and Africa's Great Lakes contain many endemic species, and their unique biodiversity is of high conservation concern. Lake Malawi, for example, has evolved an exceptionally high diversity of cichlid fishes and, in addition, its fauna of aquatic molluscs is similarly unique (see Volume II, Chapters 7 and 8). It can also be argued that habitats containing unique higher taxa (such as the bird family Balaenicipitidae represented solely by the Shoebill, *Balaeniceps rex*) deserve higher conservation priority. This decision is based on the assumption that a monospecific clade is cause for higher conservation concern because shoebills represent a particular evolutionary lineage with critical habitat requirements. Conversely, the herons and storks (families Ardeidae and Ciconidae) have many wetland species but are widely distributed through many African wetlands. Thus, the Bangweulu Swamps can be considered to be of high conservation concern based on the presence of the Shoebill as an indicator species. Furthermore, the status of the swamps is reinforced as it is the only area where the endemic black lechwe, *Kobus smithemani*, occurs. The precautionary principle further endorses consideration of the less conspicuous parts of Bangweulu biodiversity, especially invertebrates.

The data available to evaluate conservation criteria are extremely limited in geographical and taxonomic scope. Furthermore, there are few datasets that are free of bias toward certain better surveyed taxa, and much of their data is historical and may be out of date. The reason is that there has been very poor support for comprehensive surveys of biodiversity in all areas of the world, especially Africa. Certain groups (birds, butterflies, plants, fishes and mammals) have been more systematically sampled, but huge gaps (such as, within the Zambezi Basin, eastern Angola) remain. This deficiency will only be remedied by a large investment in biodiversity survey – at local, national and regional levels. Attempts to assess conservation priorities and the coverage of protected area networks must acknowledge the huge uncertainty arising from inadequate knowledge, and structure decisions and conservation planning accordingly. We can only guess at what occurs in northern Mozambique and eastern Angola: extrapolation from the patchy data available for surrounding territories is so fraught with uncertainties to be of questionable scientific value. Lastly, there have been no evaluations of biodiversity conservation priorities in Africa that have incorporated an objective criterion of species delimitation as emphasized above.

The third tension exists between the conservation of protected areas and the maintenance of ecological integrity. The persistence of species and populations over the longer term requires the maintenance of critical ecological processes. For example, the persistence of aquatic organisms within streams and rivers flowing through a protected area is dependent on what happens upstream. No park is an island.

Ultimately, this requires the management of all landscapes to meet certain minimum criteria to maintain ecological integrity across nations and regions. This applies to agricultural lands and urban areas (especially industry) as well as protected areas selected using criteria of unique (endemic) or high (species richness) biodiversity and/or representativeness of biodiversity. One such region is the Zambezi Basin, united in its management requirements by sharing a suite of ecological processes that are largely underpinned by common hydrological patterns.

2.3.4 **Landscapes and ecological processes**

Species are distributed heterogeneously across landscapes. This pattern greatly influences plans and activities in conservation with respect to maintenance of biodiversity and ecological processes. Organisms in a population require specific resources restricted to certain habitat patches. The existence of and access to such patches of habitat are especially important for successful reproduction. Examples include the spawning grounds of many central African fishes which lie in dambos of Zambezi tributary headwaters. A useful model that accommodates the dynamics of populations in terms of habitat quality is that of sources and sinks. The source patches vary widely with respect to different organisms, and differ in scale. Source habitats for aquatic insects are often limited to certain pools and individual plants, while, conversely, certain mammals and birds require large areas where predation risk is relatively low.

2.3.5 **Why biodiversity should be conserved**

The main reason for conservation of biodiversity is the persistence of ecological goods and services. Ultimately, the existence and stability of global, regional and local economies depends on their maintained integrity. The continued existence of significant large wetlands (in our area, especially the Bangweulu, Okavango, Chobe/East Caprivi and Zambezi Delta) is of significant economic importance. The same argument also applies to the maintenance and expansion of other protected areas in southern Africa.

A conservation strategy is urgently required to implement the maintenance of biodiversity and ecological goods and services in the Zambezi Basin, and this must be based on knowledge of the regional patterns in biodiversity composition within the basin. Objective planning requires that all available scientific information on the status and distributions of species is used. This strategy must be based on the paradigm of ecosystem management to maintain the ecological integrity of all parts of the landscape, including urban and periurban areas, agro-ecolandscapes and wetlands.

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3 : SUMMARY OF BIOLOGICAL REVIEWS

3.0 INTRODUCTION

A number of detailed reviews were carried out of existing knowledge on the vegetation, wetland plants, wetland antelope, wetland birds, wetland-related reptiles and amphibians, freshwater fish, freshwater molluscs, Odonata, wetland-related Lepidoptera and aquatic invertebrates of the Zambezi Basin. Focussing primarily on providing lists of species recorded and on a comparison between the four IUCN sub-project sites (Barotse floodplains, Chobe/East Caprivi floodplains, Lower Shire marshes and the Zambezi Delta), the reviews also attempted to identify species of particular conservation interest. Reviews are presented in full in Chapters 1 to 11 in Volume II. Below, summaries of the main content and findings are given for each group.

3.1 VEGETATION

Regional-scale vegetation maps are available for the Zambezi Basin, but these only identify wetland areas and provide very little detail within or between them. Medium-scale maps exist for the Barotseland area and for Chobe/East Caprivi, but no comprehensive surveys appear to have been carried out for the Lower Shire or Zambezi Delta. In addition, what was lacking before was a common legend, or set of defined types, for wetland vegetation across the basin which could be used in any comparison.

After reviewing what vegetation studies have been done of the basin wetlands, a common legend covering 10 wetland vegetation types, ranging from open water through swamp to floodplains, riverbanks, pans and dambos, is described. This legend is then applied to revisions, based on satellite imagery, of the existing surveys of the Barotse floodplains and Chobe/East Caprivi areas.

The total extent of wetland vegetation in the Barotseland study area was around 8650 km^2, comprising approximately 7200 km^2 of floodplains inundated for a longer or shorter period each year, and around 180-220 km^2 of perennial or seasonal swamp.

Two maps were prepared for the Chobe/East Caprivi area – one based in an existing vegetation map and the other on a new interpretation of imagery. The total wetland extent, and the proportions of the various types, differed significantly. The approximate extent of wetland in the area is 2160 to 2840 km^2, with floodplains covering 1670 to 1870 km^2, and perennial/seasonal swamp ranging from over 250 to over 1000 km^2.

A vegetation survey of the Zambezi Delta was carried out using satellite imagery, aerial and ground survey. This resulted in a map covering 14,092 km^2 with 14 described vegetation types. Seasonally or perennially wet grasslands cover around 2400 km^2 with an additional 750 km^2 being swamp dominated by papyrus. Mangrove forests and mud flats cover around 1600 km^2.

An equivalent vegetation survey for the Lower Shire, as well as some other major wetland areas such as the Busango swamps, is not available.

On the basis of the diversity of their vegetation types, the most important wetlands for conservation in the present-day basin are the Barotse floodplains (plus surrounding woodlands and dambos) and the Zambezi Delta. The latter is particularly unique as it covers a range of wetland habitats, species-rich woodland and dry forest, mangroves and dune grassland. This is the only locality in the basin for the latter two types. Although not specifically covered here, the other two wetland areas considered important from a vegetation perspective are the *mushitus* and grasslands associated with the Zambezi headwaters in northwestern Zambia and northeastern Angola, and the Okavango Delta.

3.2 WETLAND PLANTS

The number of vascular plant species in the Zambezi Basin is around 6-7000, and many of these can be found in what might broadly be called wetland habitats. The review restricted itself to a listing and discussion of the 'obligate' wetland species found in or on the edge of open water, swamps, marshes and regularly-inundated floodplains. Although much richer and more interesting botanically, plants of pans and dambos were excluded.

The list of wetland plants covered 736 species. Our knowledge of distributions is still very patchy, thus the pattern of distribution between major wetlands is still not clear. The best known areas are probably the Okavango and Chobe/East Caprivi areas, with the Zambezi Delta being the least known. It would appear that many swamp and marsh species are widely distributed across the basin, but a greater difference between areas is seen with floodplain species. The species of greatest interest in terms of restricted distribution are probably those of dambos (seasonally inundated upland grasslands) and pans, although these were not specifically covered in the review. What is noticeable is that the proportion of listed wetland species that are widely distributed (77%) is much higher than would be expected with species from montane, forest or even woodland habitats, while the proportion (4%) of species with restricted (i.e. sub-basin endemic) distribution is much lower. The great majority of wetland species are herbaceous (93%), not woody, with the grass and sedge families being the most significant (24% and 19% of total species respectively).

There are very few species – only six – that appear to be endemic either to the basin or a proportion of it; this probably reflects the adaptations to an unstable environment and widespread dispersal of many wetland plants. However, the marked lack of knowledge on species distributions across the basin makes this only a very tentative finding. There are disproportionally more woody species that are endemic or of restricted distribution.

Introduced aquatic weeds are of major economic significance in many wetland areas, the main species being Kariba weed (*Salvinia molesta*), water fern (*Azolla filiculoides*), water lettuce (*Pistia stratiotes*) and water hyacinth (*Eichhornia crassipes*).

Only nine wetland species from the Zambezi Basin have been listed as threatened, although five do not fall under the definition of a wetland species used here. Given our lack of knowledge on distributions and status of plant species, this figure must not be considered anything more than tentative. Owing to the widespread distribution of the great majority of wetland species, very few are likely to be under threat of extirpation, except locally.

The Okavango and Zambezi deltas are the most important wetland conservation areas within the broadly-defined Zambezi Basin for swamp vegetation and species, while the Barotse floodplains (and perhaps those of the Kafue) is the most important floodplain system. Very little is known about the Busango Swamps on the Kafue River. Of equal importance from a plant conservation viewpoint are dambos, pans, and the *mushitus* of the Zambezi headwaters. The Upper Zambezi area is far more important in this respect than areas downstream.

3.3 REDUNCINE ANTELOPE

This group of wetland-associated antelope – lechwe, waterbuck, puku, reedbuck – was chosen for detailed review as it demonstrates some of the recent evolutionary patterns found in the Zambezi Basin, principally those associated with the mosaic of grasslands, woodlands and wetlands on the gently-undulating Central African Plateau of the palaeo-Upper Zambezi.

The review focuses on describing the populations and inter-population variation of these antelopes, including recently or possibly extinct populations, and shows how these have come about over the last few million years in response to habitat fragmentation associated with drainage pattern changes at a landscape scale. For example, the diversification of the lechwe antelope into at least four subspecies (or "evolutionary species") can be related to changes in the drainage pattern of various Upper Zambezi rivers. The Muchinga Escarpment, which separates the main plateau area of the palaeo-Upper Zambezi from the rift-associated Luangwa Valley, appears to be a significant biogeographical boundary for ungulates and some other large mammals, with subspecies (or separate species) evolving separately on each side.

Reduncine antelope comprise two recognized taxa of reedbuck, four taxa of waterbuck, four of lechwe and two of puku. The well-known black lechwe is confined to the Bangweulu wetlands area while the Kafue lechwe is confined to the Kafue Flats. Robert's lechwe, formerly found near Lake Mweru at one of the headwaters of the palaeo-Zambezi, is considered extinct.

The evolutionary divergence over the palaeo-Upper Zambezi shown by these antelope gives an indication of possible patterns of biodiversity in other, less well-known, wetland groups. What may, in many instances, have been regarded as one variable species, could in fact be two or more separate evolutionary lines. The consequences of this phenomenon for identification of areas and species of conservation interest are very significant.

3.4 SMALL MAMMALS

The distribution and diversity of small mammals was not reviewed as there was thought to be only limited and patchy information available across the basin. There is also thought to be only one small mammal – the otter-shrew from the Zambezi headwaters – that is entirely dependent on wetland habitats. Many rodents and shrews, however, need open grassy habitats such as those found on floodplains and dambos, while some bats hunt for insects over open water and wetland.

Findings from the small mammal surveys carried out in Barotseland and the Zambezi Delta, which form the bulk of this chapter, are given in Section 4.

3.5 WETLAND BIRDS

There has been a certain amount of confusion in the past over which bird species should be regarded as wetland species – the definition used here is all those species which are dependent on freshwater wetlands for at least part of their life or activities. The distribution of birds across the basin is better known than for almost all other wetland groups. Recently, various bird atlases have also been produced which document much of this knowledge.

A total of 178 species is found across the basin. The Barotse floodplains support 133 species, the Chobe/East Caprivi 129 species, the Lower Shire 132 species and the Zambezi Delta (which is probably under-recorded) 118 species. There are some differences in species composition between the various areas, but in general most species are widespread and not confined to one or two localities. The Barotse floodplains, Chobe/East Caprivi and the Zambezi Delta, along with the Kafue Flats and Okavango Delta, are important areas for conservation; the Lower Shire is of lesser significance.

Palaearctic migrants, which spend the southern summer feeding in the southern hemisphere, form an important proportion of the species found. However, differences between the different wetlands are probably often not significant as long as suitable wetland habitat exists in southern Africa, as birds are readily mobile.

Some of the more interesting species, in terms of limited distribution and endemics, are confined to the grasslands such as dambos of the Central African Plateau. However, as dambos were specifically excluded from the study, many of these birds are not regarded or listed as 'wetland' species. Of 95 species in this category, eight are regional endemics.

Nine Globally Threatened wetland species occur in the basin and there are also three Regionally Threatened species. Excluding migrants and others not solely dependent on the Zambezi Basin wetlands, there are six species of particular concern – the Slaty Egret, Wattled Crane, Shoebill, Rock Pratincole, African Skimmer and Carmine Bee-eater. The Wattled Crane and African Skimmer are particularly vulnerable. Changed flood regimes along the Zambezi are the major conservation threat.

3.6 WETLAND HERPETOFAUNA

The herpetofauna of the Zambezi Basin is comparatively well-studied, although records from many significant areas are limited. Enough is known to provide a good overview of distribution and composition.

There are 197 species (114 reptiles, 83 amphibians) considered to live in water, on stream banks, dambos or floodplains, or to move onto floodplains when dry. Their distributions across the basin and outside are roughly known. It was found that their distribution patterns can be grouped into 23 range clusters or biogeographical units.

The Barotse floodplains have the richest herpetofauna, probably because they form a meeting place of different biogeographical regions such as the arid Kalahari fauna, elements of the palaeo-Upper Zambezi wetlands, and from the Angolan Highlands and Congo Basin, as well as savanna elements from the east. The Chobe/East Caprivi fauna is similar. The Lower Shire herpetofauna appears to be similar to that of the Zambezi Delta. Although outside the present-day basin, the Lake Bangweulu/Chambeshi River/Lake Mweru area in northeast Zambia appears potentially diverse, and more detailed study there may reveal biogeographical links across the rift (Lake Rukwa, Lake Malawi), as has been noted for fish and large mammals.

Five wetland species of particular concern have been identified; two from Barotseland, one endemic frog from the East Caprivi, and one from the Kafue Flats.

3.7 FRESHWATER FISH

Fish, being restricted to aquatic habitats, provide good indications of changes in drainage across the basin. Biogeographical patterns and the division of the Zambezi into Upper, Middle and Lower are clearly exemplified. Fishes are also a comparatively well-collected group.

The distribution of the 196 species found in the basin (excluding Lake Malawi) shows that the Upper Zambezi, particularly the headwaters and Okavango area, is particularly diverse. The Middle Zambezi is poorer in species, while the Lower Zambezi has an intermediate number. There is a marked difference in species composition between the Upper Zambezi and its tributaries and that of the Middle and Lower Zambezi. This probably reflects a differing origin of the fauna as well as a clear difference in available aquatic habitats. By far the most diverse area, however, is Lake Malawi with around 500 species, 99% of which are endemic to it – an extraordinary high level.

Major threats to fish diversity come from reservoir construction on the main Zambezi as well as its tributaries. This has caused, among other things, a marked change in flooding and habitat, as well as creating extensive open water environments such as lakes Kariba and Cabora Bassa. Further threats to diversity include overfishing, particularly apparent in parts of Lake Malawi and the Shire River, and the introduction of exotic fish species such as trout, bass and tilapia (*Oreochromis niloticus*). The introduction of kapenta to Lake Kariba has been an economic success story with no real impact on native biodiversity as the habitat was newly created. Its introduction into the natural, and very biodiverse, pelagic environment of Lake Malawi, however, may prove to be catastrophic.

By far the most important area for fish biodiversity in the basin is Lake Malawi. Otherwise the relatively unmodified rivers of the Upper Zambezi support a rich fauna, but impoundment, high levels of agricultural activity and the introduction of alien species would threaten this. The other important area is the Zambezi Delta where there is a transition from fresh to salt water; many species are only found here within the basin. This area is also important for its fishery potential and as a nursery area for marine species.

With the exception of the species of Lake Malawi, there are very few species of particular conservation interest in the present-day basin as species are not restricted to just particular sections of river. The headwaters of the Cunene and Kavango rivers in Angola show significant levels of endemicity, and there are also two species of endemic killifish in the Kafue and East Caprivi.

3.8 FRESHWATER MOLLUSCS

Although not many studies have been carried out on the molluscs (gastropods and bivalves) of the Zambezi Basin, the medical importance of some as hosts to the debilitating human parasite schistosomiasis, which causes bilharzia, has led to detailed collecting work. Some of the most detailed molluscan studies have been on these species of economic importance (*Biomphalaria* and *Bulinus*). The disease is common in warmer parts of the basin where human populations are high.

To date, 102 freshwater and brackish water species have been recorded from the basin. Of these, only 90 are strictly indigenous freshwater species. The largest group are the snails, or gastropods. Over half (52%) of the basin's species are found in Lake Malawi. There appear to be 23 endemic mollusc species in the Zambezi Basin, 19 of which are only found in Lake Malawi. In terms of total species number the Congo Basin is richer than the Zambezi, probably as the former has seen few changes in hydrology during the Quaternary period.

Excluding Lake Malawi, the most diverse wetland area is probably the Chobe/East Caprivi with 39 species, followed by the Zambezi Delta with 21 species. However, this is more likely an artefact of collecting intensity. Both the Barotse floodplains and Lower Shire are very poorly collected. An area of particular interest, although outside the present-day basin, is the Chambeshi/Bangweulu/Luapula system of northeastern Zambia. Not only is the area rich in molluscs but it appears to provide a link to the Congo Basin fauna.

By far the most important area for molluscan diversity is Lake Malawi, although Lake Tanganyika (outside the Zambezi Basin) appears richer. Here some of the more interesting species are confined to deep waters, a habitat not normally found elsewhere in the basin. Eight species of gastropod from Lake Malawi are listed as threatened in the IUCN Red List, all of which are only found in specific localities around the lake.

3.9 ODONATA

Much of our knowledge on the dragonflies and damselflies of the Zambezi Basin derives from the studies by Pinhey. They are also a comparatively well-known invertebrate group as well as being one generally confined to wetlands and water for their breeding requirements.

The total number of species recorded from the wetlands of the basin is 217. The richest area by far is the headwaters in Mwinilunga, northwestern Zambia, with 148 species (including 12 endemics), followed by the Katambora/Victoria Falls sector of the Zambezi with 88 species and the Okavango Delta with 84 species (seven of which appear to be endemic). Undoubtedly, the forested headwaters region is very diverse for Odonata, as it is for butterflies and other invertebrate groups, but the relatively low numbers noted for such areas as Barotseland and the Zambezi Delta reflect poor collecting.

Odonata, being an obligate aquatic/wetland group, are useful indicators of the health of aquatic ecosystems. However, no work on this aspect has yet been done in the Zambezi Basin.

3.10 WETLAND LEPIDOPTERA

Lepidoptera are another well-known invertebrate group, especially the butterflies, and species distributions across much of the basin provide good comparisons. Much of our knowledge on this group comes from amateur collectors.

As a group, butterfly distribution is determined primarily by distribution of the larval host plant. In some instances it is not yet clear what each species' foodplant is. Out of 588 species recorded as being associated with the Zambezi River area, only 21 can be considered as truly wetland species.

These are confined to wetland areas (including stream sides) and/or are dependent on such obligate wetland plants as *Polygonum* spp. during their larval stage. As with Odonata, by far the highest Lepidopteran diversity is found in the Zambezi headwaters region of northwestern Zambia and northeast Angola. A total of 467 species have been recorded from this comparatively well-collected area, compared to only 58 along the Barotse floodplains, 181 in the Chobe/East Caprivi to Victoria Falls area and 44 in the Zambezi Delta. The low Barotseland and Zambezi Delta figures are a result of poor collecting rather than a particularly depauperate fauna.

Of the wetland species, four are under some threat, principally from destruction of their localized forest/grassland habitat. Quite a few other species listed are on the IUCN Red List, but these are mostly gallery or riparian forest species. The major area of interest is the riverine forest patches of the Zambezi headwaters.

3. 11 AQUATIC INVERTEBRATES

Aquatic invertebrates are an enormously diverse and speciose grouping of organisms covering 35 phyla and an unknown number of species. There have been very few studies on the group as a whole, and most studies that have been done are scattered and specialized. Many are concerned with species that cause human disease, such as bilharzia and malaria. Hence there is no indication yet of total diversity or distribution of that diversity across the Zambezi Basin. Only a small number of studies – in the Caprivi, Lake Kariba and Lake Malawi – have looked at a comprehensive species assemblage from a locality.

Perhaps the groups of greatest interest and ecological significance are the Crustacea and the insects, particularly the flies (Diptera). Some insects have also been successfully introduced as biological control agents for such aquatic weeds as *Salvinia* and *Eichhornia*. Recently much interest has been expressed in the use of a suite of aquatic invertebrates as a means of assessing and monitoring water quality.

The most vulnerable habitat for the group is the temporary pools which support a highly-adapted fauna. Continued pumping of water into such pools or pans, and the introduction of fish, can cause local extinction.

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4 : SUMMARY OF BIODIVERSITY FIELD STUDIES

4.0 INTRODUCTION

A series of reconnaissance biological surveys of parts of the Barotse floodplain and Zambezi Delta were carried out during the course of the project. These surveys were implemented by regional specialists in conjunction with the relevant national institutions (museums and herbaria). The Barotse surveys were principally carried out in the latter part of 1998 and early 1999, and most of the trips were independent of each other. Owing to more difficult logistics for the Zambezi Delta, most of these surveys were combined into one 3-week expedition in July-August 1999. Not all groups were surveyed in both areas.

The approach adopted was to visit two to four representative areas so that (a) a range of typical habitats were sampled, and (b) there would be some degree of comparability between surveys. Survey techniques used were standard methodologies for that particular group.

In most cases a preliminary checklist for the area, identification of any species of particular interest and an assessment of the conservation status for that group was made. Detailed accounts of most of the trips, including species lists, are given as appendices of the relevant chapters in Volume II.

4.1 BAROTSE FLOODPLAINS

Areas selected for survey work in Barotseland were:

(a) the Bulozi floodplain flanking the Zambezi River near Mongu,
(b) the Luena Flats some 50 km north of Mongu,
(c) the wetlands along the Luanginga River northwest of Kalabo,
(d) the area around Ndau School 25 km southwest of Mongu on the west bank of the Zambezi (this was a particular site chosen by IUCN for a detailed study on community-based biodiversity conservation monitoring).

Site (b) proved too difficult to reach in most cases owing to flooding. Timing and personnel involved in field survey of the Barotse floodplain area are shown in Table 4.1. In some cases, initial surveys were not satisfactory, so an additional visit was made.

Table 4.1 Personnel and dates of Barotse field trips.

Group	Persons involved	Dates
Plants	M. Bingham, B. Luwiika	10-25 Feb 1999
Small mammals	F. Cotterill, A. Ndlovu	2-12 Nov 1998
Birds	K. Hustler, V. Katanekwa B. Stjernstedt, P. van Daele P. van Daele	2-12 Nov 1998 23-28 Mar 1999 25-29 Aug 1999
Herps	G. Rasmussen, S. Broadley (reptiles) A. Channing, J. Measey (amphibians) D. Broadley, S. Broadley	26 Oct-4 Nov 1998 26 Oct-4 Nov 1998 20 Mar-1 Apr 1999
Odonata/Lepidoptera	R. Chiwanda, P. Mhlanga, A. Chambers	20 Mar-4 Apr 1999

4.1.1 Plants

Collections were made at four localities – the Bulozi floodplain near Mongu, the wetlands along the Luangingwa River near Kalabo, on the floodplain near Ndau school, and on sand bars along the Zambezi River. In conjunction with previous trips by the consultant to the same areas, a total of 236 species were recorded, not all of them wetland species. A full report on this survey giving localities, species lists and an evaluation of findings is given as Appendix 2.4 of the wetland plant review.

The area is not particularly rich as regard wetland plants and nothing of exceptional interest was noted. Although the wetland flora is not particularly rich or in any way unusual, there were a few species and sites of interest. The newly-described lily, *Gloriosa sessiliflora*, was found associated with slightly raised ground (it cannot be considered a true wetland species), and the fern *Osmunda regalis* was noted in patches of swamp forest. Two patches of swamp forest noted are of particular interest as there are very few trees on the floodplain itself. The main species there is probably *Syzygium owariense*; *Syzygium cordatum* and *Anthocleista leibrechtsiana* are also found on the floodplain margin and on banks of the more stable tributaries.

Other species of interest include the woody suffrutices, but these are principally confined to dambos above the floodplain. The peaty soils around seeps contain a richer flora indicating higher fertility levels, and many such seeps have not been destroyed.

4.1.2 Small mammals

Owing to vehicle problems, only two dambo sites were visited during this survey. The main finding was a surprising paucity of terrestrial small mammals (9 individuals of 4 species over 300 trap-nights). This is thought to be a result of regular fires and human depredation. However, 26 species of bats were collected, mostly by use of mist nets over pools in the dambos. The bats are thought to be roosting in the adjacent woodland, feeding over the grassland areas, and are particularly attracted to the scattered pools for drinking and greater insect activity. Extracts from the report are given as a section in Volume II, Chapter 4.

Western Zambia has been poorly collected for small mammals in the past; hence some significant records were noted during the survey and important collections were made of five species of bat,. for example, the bat *Scotoecus albigula* (previously only recorded from E Zambia) and *Chaerephon chapinii* (previously only known in Zambia from two collections). These records, however, are almost definitely a result of under-recording rather than an indication of any particular uniqueness of the Barotse floodplains.

4.1.3 Birds

Three survey trips were undertaken – one in conjunction with the small mammal survey in November1998, one in March 1999 and one in August 1999. The earlier trip had vehicle problems and could only record at two dambo sites on the west bank, while the second trip visited six sites, including Mongu, Ndau and the Lui Valley. The third trip concentrated on the Luena sector north of Mongu, including pans.

On the November 1998 trip 187 species (not all of them wetland species) were recorded, including some new records for the area. Ten specimens were collected. The March 1999 trip recorded 159 species, 125 of them from the Ndau area. Baseline transects were also established and recorded at Ndau School for future monitoring. The August 1999 trip recorded 198 species from 14 different sites on the east bank, mostly in dambos and pans on the plateau.

An observation of particular interest from the November survey was the sighting of 10-15,000 individuals of the Black-winged Pratincole (*Glareola nordmannii*). This sighting was significant as some sources say the global population is only 20,000 individuals, which now seems very unlikely. Guineafowl and francolins were conspicuous by their absence – a finding that may reflect heavy hunting pressure. One of the bird specimens collected in November was probably a new species or subspecies of *Cisticola tinneans*, apparently endemic to wet dambos of the Upper Zambezi in W. Zambia. The cisticolas are a taxonomically difficult group and further species and subspecies are likely to be described. It appears that the grasslands of the Upper Zambezi, including the Barotse floodplain area, are a major area of diversity and speciation (see Volume II, Chapter 5).

The March 1999 trip reported the presence of several important wetland bird breeding sites on the floodplain. One record of interest from the August 1999 survey was the breeding along the Zambezi of Avocet, a palaearctic migrant. The banks and sandbanks of the Zambezi River itself appear to be a valuable habitat from a conservation perspective.

Overall, the diversity of bird habitats was high, particularly in the Luena sector, and this is reflected in the relatively high number of bird species recorded during each survey. However, in many cases the number of individuals noted per species was rather low. It is thought that the Ndau and Mongu areas do not have as rich an avifauna as other parts of the Barotse floodplain and wetlands on the plateau.

4.1.4 **Herpetofauna**

There were two surveys of the herpetofauna – one in October/November 1998 as the rains were about to break (generally the best time for amphibians), and another in March 1999. Unfortunately, the October trip was a little too early for the rains and was not that successful. The purpose of the second trip was to try and improve on this, but the vegetation at that time was too tall and dense to be able to carry out effective collecting. An overall account of the herpetofauna of the Barotse floodplain area is given as Appendix 6.2 in Volume II.

The October amphibian survey covered four areas – the floodplain near Mongu, the Ndau School area, the edge of the Luena Flats, and the lower Luanginga River near Kalabo. Results and an assessment are given in Appendix 6.1. During this period a pitfall trap transect that could be used for future monitoring was set up at Ndau School. Unfortunately, owing to the short period and dry weather conditions only three specimens were caught in the traps. A total of 20 amphibian species were recorded in October (some were added by the small mammal survey a week later when the rains had broken), including a new species of frog (*Hemisus* sp. nov.) which is now in the process of being formally described. One other species (*Ptychadena perplicata*) was a new record for Zambia, and there were an additional two new records for Barotseland (*Bufo poweri* and *Ptychadena mascareniensis*).

The March herps survey did not yield many amphibians – only 13 species were recorded including further collections of the new *Hemisus* and *Bufo poweri*, the second record of this species from Zambia.

Reptiles were recorded from the same localities as amphibians in November 1998, and further detailed collecting was done at Ndau in March 1999. Nineteen species were collected, three of which (*Panaspis* sp. nov., *Hemidactylus mabouia* and *Ichnotropis squamulosa*) were new records for Barotseland, while one lizard and one snake species were recorded east of the Zambezi for the first time. Full details are incorporated in Appendix 6.2.

The total known herpetofauna of the Barotse floodplains (including historic collecting) now includes 70 species of reptile and 34 species of amphibian, making it probably the most species-rich wetland in the Zambezi Basin. The total number is likely to be somewhat higher.

4.1.5 **Insects**

Both Odonata and Lepidoptera were surveyed in March/April 1999. Four sites were visited – Ndau School, Mongu floodplain, Kalabo area and Sefula. A total of 31 species of Odonata and 31 species of Lepidoptera were recorded, listed as Appendix 9.1 in the Odonata review and Appendix 10.1 in the Lepidoptera review, respectively. Previously the total number of Odonata species recorded from Barotseland was five; thus the survey represents a six-fold increase in recorded diversity.

No particular Odonata or Lepidoptera species of interest were noted and the assemblage is more or less what would have been expected. However, collecting to date has been very superficial, and some particular habitats of interest were not sampled.

4.2 ZAMBEZI DELTA

Areas selected for survey work in the Zambezi Delta were:

(a) seasonally flooded grassland/woodland ecotone in Coutada 11 on the northwestern edge of the Marromeu Buffalo Reserve,
(b) the village of Malingapanse along the Rio Micelo some 20 km below its confluence with the Zambezi,
(c) the fallow fields and riparian fringe along the Zambezi River near Marromeu town.

Timing and personnel involved in field survey of the Zambezi Delta are shown in Table 4.2. Most of the survey work was done during an expedition to the area in July/August 1999. A helicopter was available for four days during this period to take specialists into wetland areas otherwise inaccessible, and for vegetation survey work. Prior to this, in September 1998, a reconnaissance trip had been made with two fixed-wing aircraft, during which some vegetation reconnaissance work was carried out.

Table 4.2. Timing and personnel involved in field trips in the Zambezi Delta.

Group	Persons	Dates
Vegetation	J. Timberlake J. Timberlake, T. Muller	Sept 1998 22 July-12 Aug 1999
Plants	T. Muller, A. Mapaura, E. Macamo	22 July-12 Aug 1999
Small mammals	F. Cotterill, A. Ndhlovu	22 July-9 Aug 1999
Birds	C. Bento	Sept 1998-Sept 1999
Herps	W. Branch, B. Muantinte	22 July-12 Aug 1999
Fish	R. Bills, P. Yose, N. Loureiro	25 July-14 Aug 1999
Odonata	R. Kinvig	June 1999
Lepidoptera	N. Feltham	June 1999

4.2.1 **Vegetation**

An initial trip was done in September 1998 during which a preliminary satellite image interpretation was checked using low-level aerial reconnaissance. This was followed by a second trip in July/August 1999 and further low-level work using a helicopter and ground-based fieldwork. Results are given in Section 1.4, and Figure 1.5 of Chapter 1 and Appendix 1.1 in Volume II. Given limitations on accessibility to much of the wetland area, and to the north bank, the survey must be considered preliminary in terms of the descriptions.

Findings of interest were an extensive area of papyrus swamp along the Rio Cuacua west of Quelimane, and what is probably a physiographic or soil-related difference in the wetland grasslands/savanna of the southern Marromeu sector.

4.2.2 **Plants**

Plant collections were made at various localities, principally in the miombo woodland and floodplain margins of Coutada 11, around Marromeu town and in the irrigation scheme, and around Malingapanse. Opportunistic collections were also made in mangrove forest along the Rio Micelo. A total of 445 species/subspecies were recorded; five of which appear to be new records for Mozambique and an additional five are new records for the area of central Mozambique south of the Zambezi (MS division of Flora Zambesiaca).

The diversity of habitats is large and it is certain that many more species have yet to be recorded from the area – probably well over 700 species. The most diverse habitats are those associated with the woodland and forest; the grassland and mangrove areas appear to be rather poor in terms of species number.

The major species of particular interest from the wetlands was the oil palm, *Elaeis guineensis*, which is only found from a small area on the southeastern margins of the delta. It is not yet clear if this is the wild oil palm – in which case its presence represents a large southern range extension from S Kenya – or naturalized individuals of the cultivated form, which, in southern Africa is only known from the northern shores of Lake Malawi. One probably new and still undescribed orchid (*Habenaria* sp. close to *H. galpinii*) was collected close to the place where it was first discovered almost 30 years ago. Three species appear to be endemic to the Zambezi Delta (*Vahlia capensis* subsp. *macrantha*, *Nesaea linearis* and *N. racemosa*).

4.2.3 **Small mammals**

Two areas were surveyed for small mammals – the grassland/woodland boundary of the Marromeu Reserve in Coutada 11, and the Malingapanse village area along the Rio Micelo. Collections were not considered very good as it was not the best time of year. Specimens of 15 species were collected, with an additional 14 species noted from sightings or spoor. The full report is given as a section in Chapter 4 of Volume II.

In general the collections were disappointing given the number of trapping nights. This was probably because mammal activity had not recommenced after the dry season with the rise in ambient temperatures. All small mammal records appear to be new for this area because of inadequate recording in the past.

Two records of fruit bats were interesting. At Marromeu the colony of *Eidolon helvum* is probably the first permanent colony recorded for southern Africa. A specimen of *Lissonycteris angolensis* *goliath* collected represents a significant range extension from the Eastern Highlands of Zimbabwe and Chimoio.

4.2.4 **Birds**

The birds were surveyed over a period of time from September 1998 to September 1999 in conjunction with ongoing research into changes in the hydrology of the delta and its effect on wetland birds and on the ecology of the Wattled Crane. The main areas recorded were Marromeu and downstream along the Zambezi, Coutada 11 on the margin of the Marromeu Reserve, the Malingapanse area and Chinde Island. A full report is given as Appendix 5.3 in Volume II. In addition to this survey, records were made of birds seen during the July/August 1999 expedition. These records are incorporated into the checklist in the wetland bird review.

A total of 73 species of waterbirds were noted during these surveys. The bird records from the July/August 1999 expedition totalled 181 species, many of which were woodland or grassland species. Prior to this there were very few confirmed observations available for the area.

Although known for some years to be present in the area, the presence of the Wattled Crane has attracted particular interest. Other birds recorded that are of conservation concern are the Bateleur Eagle, African Skimmer and Mangrove Kingfisher, as well as 13 other species considered rare in southern Africa. For some of these the Zambezi Delta is a significant breeding locality.

4.2.5 **Herpetofauna**

Three areas were surveyed for reptiles and amphibians during the July/August 1999 expedition – the woodland/grassland boundary in Coutada 11, the Malingapanse area along the lower Rio Micelo, and the area around Marromeu town and the irrigation scheme. The full report is given as Appendix 6.4 in Volume II.

Collections were not as good as had been hoped as it was still too cool for much herp activity. A total of 19 amphibian and 33 reptile species were recorded. None of these were new species, however one *Hyperolius* frog is of uncertain identity. Another small frog (*Hyperolius parkeri*) was found which has only been collected once before in Mozambique. Eight other amphibian species were noted that had not previously been recorded from the Lower Zambezi area. Three of the reptile species found represent significant range extensions (Blue-tailed tree lizard, Black file snake, Cross-barred tree snake).

4.2.6 **Fish**

A detailed fish survey was carried out in July/August 1999 of the freshwater aquatic habitats of the Lower Zambezi downstream of Marromeu to the sea, and some of the floodplain channels. A full report is given as Appendix 7.1 in Volume II.

The total number of species recorded was 70, which brings the total for this very under-recorded part of the Zambezi River to 94 species. This included 21 new records for the Lower Zambezi, all secondary freshwater species. Although the survey was fairly comprehensive, it was thought that some habitats, such as water over rocky substrates and smaller floodplain channels, were insufficiently sampled. In addition, July is the cool, low flow period so additional species may be expected at a different time of year.

There appear to be no Lower Zambezi endemics and as the habitats are widespread it is unlikely that any fish species is in danger of extinction at present.

4.2.7 **Insects**

Both Odonata and Lepidoptera were surveyed in early June 1999 when insects would be likely to be more active owing to the warmer weather. Owing to limited accessibility at the time only habitats along the river and in the hinterland of Marromeu were sampled.

A total of 25 Odonata species were collected, including four new records for Mozambique. Previously, a total of only 18 species of Odonata had been recorded for the area. The collections must be considered preliminary as they only covered a small area and were not carried out at the optimum time of year for this group.

A total of 47 species of butterflies were recorded. It appears that there were no previous records from the delta area, so all are new records. The species noted were mostly fairly widely distributed ones. Undoubtedly, if the woodland/forest area had been sampled many more species, including some of restricted distribution, would have been found.

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5 : SUMMARY OF LAND USE CHANGE AND HUMAN IMPACTS STUDIES

5.0 INTRODUCTION

In addition to the reviews and synthesis of biological knowledge from the basin wetlands, the project looked at changes in land use patterns from the Barotseland and Zambezi Delta areas, with particular reference to biological concerns, and also at the overall impacts of human activities on biodiversity (Volume III). IUCN-ROSA has a particular interest in the Ndau School area, southwest of Mongu on the Barotse floodplain, so this area was chosen for more detailed study.

5.1 BAROTSE FLOODPLAINS

Human habitation of the Bulozi Plain in Barotseland and surrounding areas is of very long standing, but it is probable that early Man had little effect on the biodiversity of the area. There was probably little agriculture or tree-cutting. Even the introduction of cattle, perhaps a thousand years ago, may not have had any great effect. As elsewhere in the region, it was the large-scale movements of population in the early part of the 19th century that first brought major changes, followed by the advent of guns and a cash economy by Europeans in the latter part. Cattle numbers have greatly increased this century owing to disease control, fencing, and the much larger human population.

As far as biodiversity is concerned, it is probably increased grazing pressure (although the area as a whole cannot yet be considered overstocked) and tree cutting on the surrounding dryland that have had the greatest deleterious effect. Trees cut for construction as well as for export from the area have allowed fire to become a more regular and destructive agent, and this has led to changes in hydrology and soil erosion – both physical particle removal and nutrient leaching.

In recent years attempts to grow rice both in upland dambos and pans, and on the floodplain, have led to environmental damage and possible biodiversity loss.

Fishing pressures are now heavy, but it is not clear if catches are declining owing to over-exploitation. It is very likely, though, that some fish species (and associated species) have been lost to the area or populations greatly reduced in number.

Although probably never a rich area in terms of larger mammals, the diversity and numbers of these have experienced a decline over the last 100-150 years. This has also happened more recently with large edible birds. Perhaps the major impact has been in the (assumed) loss of hippo, as large numbers of these animals not only graze the short floodplain grass (a role now taken on by cattle) but also greatly assist in keeping open water channels and maintaining a diversity of aquatic habitats.

Land use changes on the Barotse floodplains have therefore been marked over the last century, but probably significantly less than in arable areas elsewhere in the region. This is partly a function of the regular flooding of the floodplain, inhibiting any but temporary settlement or cultivation, but it is also due to the relatively low human population and land use pressures until recently. Arable agriculture, livestock grazing, forestry and hunting have had significant impacts on biodiversity and ecological function, but to a lesser extent than in, say, the Chobe/East Caprivi area.

The Ndau study area of around 150 km^2, situated 25 km southwest of Mongu, is typical of the settlements situated on higher ground on the edge of the floodplain. The major forms of land use are cattle raising, fishing and subsistence cropping.

Owing to unavailability at the time of historical airphotos, a comparative assessment of land use change in terms of settlement pattern and location of fields was not done. A series of vegetation transects have now been established to allow for monitoring. Initial baseline results show much disturbance and degradation of woodland on the sandy ridge, a dominance of grazing-adapted grass species on the drier plains, and a diversity of wetland grasses in regularly flooded or inundated areas.

However, it does not appear that there has been any major change in land use practice or patterns over the last 50 years, although it is possible that pressures are somewhat greater now. The area of major conservation and economic concern is the degraded woodland on the sand ridge which provides timber for local use and dry season grazing.

5.2 ZAMBEZI DELTA

The coastal and delta area where the Zambezi exits to the sea has been settled for many hundreds of years, and has also seen probably more interaction through cross-cultural trading and outside influence than any other place in the basin. Owing to changes in methods of transportation and lines of communication, as well as marked civil instability over the last 30 years, the area has now been marginalised. The major influences in terms of land use and their effects on biodiversity were at their height in the pre-Independence era.

The major direct impacts on the biodiversity of the Zambezi Delta are, or have been, subsistence agriculture, commercial sugar and coconut plantation, commercial hunting and, probably, the extensive felling of trees for fuel in the days of river transport. The two major indirect impacts have been the construction of first Kariba dam then, in the early 1970s, Cabora Bassa dam. Prior to these impoundments a series of dykes was built to keep the Zambezi floodwaters out of the sugar plantations. This regulation of river flow and flooding events has almost certainly had a major impact on species abundances and distributions, but the extent of these changes, given a naturally variable and changing environment, is still not clear.

Using a combination of airphotos, satellite imagery, oral and written history and some ground observation, an assessment of the land cover changes in the southern part of the delta was made. These analyses show a significant thickening of the palm savanna vegetation, some invasion of open wetland grassy areas by savanna plant species, and changes in mangrove forest distribution and drainage pattern close to the coast. The woodland/forest boundary with the palm savanna and grassland does not appear to have changed; this is determined by topographical differences, not just soil moisture levels. It is the extent of wetland grassland and permanent swamp that has changed most, and with it the abundance of those animals dependent on it for feeding or breeding, such as the Wattled Crane.

There has been a catastrophic decline in large herbivore populations in the area in recent years, although these are now recovering. The reduction in grazing pressure, particularly from buffalo and hippo, has probably compounded the noted 'drying out' of the delta. Fire is also a major factor over the grasslands, although it is not clear if this is now more frequent than 30-50 years ago.

Suggested actions which could ameliorate these changes are (a) prescribed flood release from Cabora Bassa, (b) opening up by means of culverts or bridges the major distributer channels coming off the main Zambezi River that feed the swamp areas, such as the Solane Depression, and (c) ensuring that the forested Cheringoma Plateau which is an important source of runoff for the southwestern parts of the delta wetlands is not deforested.

The diversity of habitats encompassed within the delta region is enormous, and despite flood regulation and various detrimental land use practices it remains an area of major international importance for biodiversity conservation.

5.3 HUMAN IMPACTS ACROSS THE BASIN

The effects of human activities on wetland and aquatic biodiversity across the Zambezi Basin are still rather speculative when it comes to detailed assessments. The major reason for this is the shamefully inadequate or non-existent baseline data on species composition and abundance; thus an assessment of change deriving from a major development, such as a dam, is not possible. The region does not have many well-dated sites from which to construct a regional scenario of biodiversity change, and impact assessments have too often been conspicuously lacking for major water resources development projects. One significant exception to this was with the Kafue and Itezhi Tezhi dams, which attracted much study and discussion before construction took place, and strong efforts were made to ameliorate any deleterious effects at the design stage.

With increasing pressure on water resources in the basin, the effects on wetland biodiversity are likely to grow. Many more initial studies, focusing on smaller organisms as well as charismatic large mammals and trees, are required.

Effects on biodiversity can be categorized as those resulting from water resources developments (such as dam construction and flood control), those resulting from human settlements and agriculture, including organic and inorganic pollution, and those resulting from climate change. Regarding the latter, recent modelling suggests that with increased temperatures, runoff will decrease significantly, and evaporation will increase to the point where wetland extent in the Zambezi Basin may be markedly diminished.

Although dambos or vleis are often excluded from studies on wetlands, a strong plea is made here for their inclusion. They are noted to contain significant and important biodiversity, as well as to regulate downstream flows. Many of the upland dambos have been significantly modified by agriculture, construction or drainage, but they have a good capacity to regenerate if the fundamental elements are still present.

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6 : EVALUATION OF SITES AND SPECIES OF CONCERN

6.0. INTRODUCTION

The prevailing paradigm of thought in conservation is still that large areas need to be protected in one way or another in order to conserve the species and essential ecological processes within them. This is often not possible today with increasing land use pressures. Also, some species such as large mammals or migrant birds require a range of conservation areas to satisfy their life requirements. An alternative, at least for many less mobile and smaller species, is a network of sites which are fully protected within which they can carry out their full life-cycle. Identification and protection of such sites should ensure continued conservation of a range of species.

Although for conservation to be successful the fundamental ecological processes underlying the habitat, on which all species are dependent, must be maintained, it is difficult for management – or the public and decision makers – to see or monitor this. However, it can be achieved by using a surrogate – a particular species – which ideally is readily identifiable and charismatic.

This section lists the species that have been identified in the course of the review as being of particular value, interest or importance for conservation. It also attempts to identify particular areas or sites that are of special concern across the wetlands of the basin.

6.1. SPECIES OF INTEREST OR CONCERN

Species of interest or concern for conservation fall into one of four categories: species that are endemic to relatively limited areas, hence could become extinct more readily; species that are particularly rare or of scattered, localized distribution; species that are under specific threat, such as from hunting or particular developments; and species which are charismatic and can be "flagship" conservation species, under the umbrella of which many other species can be conserved. It is also important to note that our knowledge of biodiversity across the basin is often not comprehensive, so it is difficult to determine if particular species are under threat or if they actually have restricted distributions. Given the limitations on our knowledge, any listing of species on interest or concern is bound to be biassed towards the better-known groups and only be very preliminary.

For some groups, Red Data lists have been prepared, and wetland species in these publications are obviously of particular concern at a continental or global level.

Plants

Wetland plants are generally of wide continental distribution. Those species that are much more restricted, or endemic, are mostly found in dambos or on drier floodplains, habitats which are mostly excluded in this study. Only six obligate wetland taxa are endemic to the Zambezi Basin, or part of it. These are the orchid *Habenaria pasmithi*; the trees/shrubs *Acacia hebeclada* subsp. *chobiensis*; *Syzgyium guineense* subsp. *barotsensis*; *Ficus pygmaea*; *Rotala longistyla*; and *Pandanus petersii*. A further 19 endemic (or near-endemic) wetland taxa are not restricted to permanently wet situations. These are listed in Volume II, Chapter 2.

The Red Data list for plants has only four plants that fall under the definition of a wetland species. These are: *Acacia hebeclada* subsp. *chobiensis*; *Pandanus petersii, Nepatopoa longipes* and *Vahlia* *capensis* subsp. *macrantha*. The others are more strictly termed riverine, pan or dry floodplain species.

Mammals
The various subspecies (or species) of lechwe antelope are both endemic to the basin (or specific wetlands) and threatened. The Black lechwe in the Bangweulu was, and still is, a good flagship species for wetland conservation in that area, and the Kafue lechwe likewise for the Kafue Flats.

Birds
Excluding migrant species, there are five species of waterbird in the basin that are of particular conservation importance, plus the Shoebill which occurs in wetlands just outside. These are the Slaty Egret, Wattled Crane, Rock Pratincole, African Skimmer and Carmine Bee-eater.

The African Skimmer and Carmine Bee-eater are threatened by loss of flooding which removes their breeding sites, while the Rock Pratincole is threatened by dam construction. The Wattled Crane is threatened by a number of factors, but principally by changes in flood regime which interfere with its breeding.

Both the Wattled Crane and African Skimmer can be considered flagship species in that their requirements for regular major floods for breeding will ensure the continued conservation of a number of typical wetlands habitats and species.

Reptiles and Amphibians
Detailed knowledge on distributions of herpetofauna is still very incomplete, so some species thought to be of local distribution may appear to be more widespread. Five species (two snakes and three frogs) were noted to be of particular interest. The three frogs, *Hemisus barotseensis, Ptychadena mapacha* and *Hyperolius marmoratus pyrrhodictyon,* are endemic to the Barotse floodplain, East Caprivi and Kafue Flats, respectively. One snake, the Barotse Water Snake *Crotaphopeltis barotseensis,* is restricted to papyrus swamps of the palaeo-Upper Zambezi. The other snake, the Eyebrow Viper *Proatheris superciliaris,* is confined to coastal floodplains and around Lake Malawi. None is known to be under specific threat, but draining of wetland areas and pollution would have major impacts on populations.

Fish
There are more fish endemic to Lake Malawi (around 500 species) than species found in the whole remainder of the basin. The taxonomy of these (mostly cichlid) fish has still not been clarified. Nearly all the species found in the lake are of conservation interest, and all are threatened by overfishing, pollution and the possibility of introduction of alien species.

Aside from these there are only two killifish, *Nothobranchius* sp. and *N. kafuensis,* that are endemic to some wetlands in the basin (East Caprivi and the Kafue Flats). The status of most other species, apart from those in man-made dams, is not sufficiently well-known to determine if they are under threat.

Molluscs
There are a number of molluscs endemic to Lake Malawi which are of particular interest. Eight of these are listed in the IUCN Red List on the basis of small, isolated and fragmented populations. Three other endemics are recorded from northern Zambia. As little is known of the status of most mollusc species, it is not known how threatened the remaining species are.

Insects
Sporadic collecting of Odonata across the basin means that levels of endemicity, population numbers and threats are not known. There are 12 endemic species recorded from the Zambezi headwaters, although it is likely they are also found in the Congo Basin, and seven species from the Okavango River and Delta. One other species, *Archaephlebia victoriae*, is only known from the Victoria Falls area.

Distribution of Lepidoptera is better-known. Most of the species of interest noted in the review are associated with the forested Zambezi headwaters. Five of the wetland species are believed to be of restricted distribution; all are from the headwaters area plus one from the Barotse area. *Zeritis fontainei* and *Acraea mirifica* are particularly restricted in their distribution and the Zambezi Basin is thought to hold an important proportion of the global population.

Too little is known on the species and distribution of aquatic invertebrates to identify particular species of interest or concern.

6.2. SITES OF INTEREST

Owing to the scale of the study, only areas of some hundreds of square kilometres of particular interest were identified. The purpose of identifying such areas is to help focus conservation attention on particular wetlands rather than over the whole basin.

At global or continental scale, one wetland area within the basin is of particular significance – Lake Malawi. Its conservation significance is due to the hundreds of endemic fish species which have evolved in this deep natural lake, as well as to the many molluscs. There are threats to this biodiversity in the form of over-fishing, pollution and possible invasion by alien species. The lake is of only minor significance for other wetland species such as plants, birds and herps.

Three other areas of possible continental significance for biodiversity conservation are the Okavango Delta, the Zambezi Delta and hinterland, and the Barotse floodplains and associated plateaux.

The Okavango Delta, a vast inland swamp, is one of the better examples of relatively unmodified swamps in Africa but is technically outside the present-day Zambezi Basin. It is under lesser threat than some other wetlands. The Okavango supports a wide range of habitats and species of most biological groups, but does not show a high level of endemism. Nearly all species present there are also found in other similar wetlands of the palaeo-Upper Zambezi.

The Zambezi Delta and hinterland is of particular significance as it has an extraordinary range of habitats in a comparatively small area ranging from rift valley and dry savanna woodlands to forest, wetland, mangrove and dune vegetation. The number of species in most groups is moderately high, although there are very few endemics or species of restricted distribution.

The Zambezian domain is an extensive area of south central Africa which extends further than the present-day Zambezi Basin. Relatively high levels of endemicity at a continental level are found here. The broadly-defined Barotse floodplains and associated woodlands, pans and grasslands on the surrounding sandy plateaux, are representative of a significant part of this biodiversity. The Barotse area is also comparatively species-rich, not primarily from any particularly high habitat diversity but as the meeting place for arid-adapted Kalahari species, tropical species from the Congo Basin, and savanna species. This holds for such groups as plants, retiles and amphibians. In addition, it lies within the broad centre of diversity for a number of groups which evolved over the past few million years on the stable gently-undulating Central African Plateau – groups such as the Reduncine antelope, grassland birds and geoxylic suffrutex plants. A similar case could be made for other wetland areas of the palaeo-Upper Zambezi, such as the Busango and Bangweulu Swamps. However, the Upper Barotse floodplains, upstream of the Liuwa Plains, are probably one of the best, and least modified, examples. As with the Zambezi Delta, conservation approaches should take a landscape perspective. It is the essential ecological processes that need to be maintained, rather than all the areas within it. If these are maintained, by judicious and environmentally-friendly development, then such areas can continue to be centres of evolutionary diversification.

At a basinwide level, one of the most significant areas from a conservation perspective is the Zambezi headwaters in northeastern Angola and northeastern Zambia (Mwinilunga District). Here, for many groups, especially insects and plants, a multitude of species are found that are not seen elsewhere in the Basin. This area, which occupies only about 1.5% of the Zambezi Basin, contains almost three-quarters of the butterflies associated with the Zambezi and 68% of the Odonata. Plant biodiversity is also exceptionally high. The main reason for this is the presence of forest patches (*mushitus*) along small watercourses which contain species associated with the tropical forests of the Congo Basin. Such species are only found in a very small part of the Zambezi Basin, but are generally much more widespread in the Congo Basin. Such a small area contains a disproportionally high amount of the basin's wetland biodiversity; it is also under high levels of threat from clearing for agriculture and settlement.

6.3. INDICATOR SPECIES

Indicator species are those the presence, absence or relative abundance of which gives an indication of some environmental factor or change. Strictly speaking most species indicate one factor or another – soils, climate, disturbance – but here we have only considered species which indicate some aspect of wetland ecosystem health.

Given the range of environments (climate, soils, etc.) across which the wetlands of the Zambezi Basin occur, the choice of species which indicate, basinwide, particular states of wetland health or particular perturbations, is limited. The identified species, to be useful indicators, must also be easily recognised in the field and clearly indicate a particular state, i.e. only be present (or present as a common constituent) when that state prevails. Thus species which are present in most wetlands, but only become common with, for example, disturbance (such as "weeds") are not included.

Two major problems in identifying useful indicator species basinwide are that (a) many are not found right across the basin, and (b) species' ecology, and hence utility as indicators, changes across the basin with climate or associated species. There are species which are indicators of, for example, clay-rich soils in wetland in Barotseland, but their presence in the Zambezi Delta may indicate something different.

Papyrus (*Cyperus papyrus*) is an important plant in many wetlands areas. Its presence signifies permanent swamp as it cannot survive for other than a very short time in solely damp or dry conditions. It requires some level of standing water year-round. Indeed, it is the best defining species for permanent 'swamp', as opposed to seasonal swamp floodplain, marsh, etc.

Two grasses that are also useful indicators of wetland habitat type are *Phragmites mauritianus* and *Vossia cuspidata*. *Phragmites* invariably indicates perennially moist conditions, but not with standing water year-round, i.e. seasonal swamp; *Vossia* requires perennially wet conditions such as found in or at the edge of swamps.

Birds are mobile, and therefore not the best group to provide indicators. One species that was identified in the reviews is the African Skimmer, which needs regularly flooded rivers to create the non-vegetated sandbanks it requires for breeding.

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7 : SYNTHESIS OF BIOLOGICAL FINDINGS AND OVERALL ASSESSMENT OF IMPORTANCE OF WETLAND BIODIVERSITY

7.0 INTRODUCTION

An evaluation of the importance of each wetland area for biodiversity conservation is a value-ridden exercise. Each wetland area has its own importance in providing "ecological goods and services", and this often depends on the landscape within which it sits. It should also be recognized that the reduction or loss of one species or suite of species usually results in the increase of another. Sometimes the conservation or economic value of the replacement species or community can be as significant as those replaced, although obviously arable weeds do not have a high conservation interest. A less value-ridden approach to biodiversity value is to look at the functions of each wetland ecosystem in order to determine (a) whether the system is functioning "healthily", (b) which are the major species and functions involved, and (c) what level of "goods and services" it is supporting.

The evaluation of the importance of wetland biodiversity is even more difficult when the totality of the wetlands within the basin are being assessed compared to wetlands elsewhere on the continent – or worldwide. Such an broad assessment has not been attempted here, where we restrict ourselves to an assessment of the biodiversity importance of each of the four sub-project sites and its significance from a basinwide perspective. This is followed by an overall assessment of the importance of wetlands within the Zambezi Basin as a whole.

7.1 BAROTSELAND

This sub-project area is not well-defined. If it is taken in its broadest sense – to include the floodplains of the Zambezi, the upland dambos and pans and the wooded plateaux – it covers a wide range of habitats. Species can move between the various habitats in this landscape mosaic to avoid extreme events such as flooding or drought, or for feeding (e.g. bats, birds) or breeding (e.g. birds). Ecological processes can also operate between wetland and dryland, and most invariably do. Landscape-scale conservation, the only long-term way in which communities (as opposed to individual species) can be assured of survival, can be implemented and the risk of local extinction due to stochastic events or locally high predator pressure is much reduced. Also significant is that much of northern and western Zambia and adjacent Angola appears to have been the site of evolutionary adaptation and radiation over the past few million years, for example with the Reduncine antelope, various grassland birds and geoxylic suffrutex plants ("underground trees"). Of particular importance here are the upland dambos on the plateau, interspersed with, and often including, much more limited areas of other wetland habitats such as floodplains and swamps. It is these habitats that appear to have been the focus of much of the evolution, and where the endemic species or species of restricted distribution are found, such as the "underground trees" and various bulbous herbs.

In the present reviews, dambos and pans were specifically excluded and only swamps and floodplains included. Thus a discussion of the importance of dambos has not been done, and their importance from the perspective of biodiversity conservation is not highlighted.

In summary, the Barotse sub-project area, if taken in its broadest possible context to include much of the surrounding plateau and dambos, supports a unique range of biodiversity, particularly in the dambos, and offers a good opportunity for landscape-scale conservation. It has not been excessively impacted by man, and much of the vegetative cover and many of ecological processes and hydrology appear to be still functional. Future problems include (a) extensive regular burning, (b) local over-cultivation on the plateau margins leading to erosion, (c) burning of old peat deposits which acted as "sponges", and (d) the excessive cultivation of nutrient-rich seeps.

7.2 CHOBE/EAST CAPRIVI

This sub-project area has been excessively impacted on by humans, both by those eking a living there now and by the South African military before independence. In addition, extensive and severe damage by elephants is apparent on the Chobe waterfront. Much of the area was a giant palaeo-lake some hundreds of thousands of years ago, and old lacustrine deposits are still apparent. Because of its position at the meeting place of palaeo-Upper Zambezi, palaeo-Kafue, and palaeo-Kwando rivers it has been a comparatively unstable environment with species originating from various other places. Any endemics (very few are recorded for fish and amphibians, although further collecting may remove this status) are probably neo-endemics. The status of the wetlands is fragile, principally owing to its susceptibility to minor tectonic movements which can substantially alter flows in such a flat landscape, and also to its dependence on flows from upstream which depend on seasonal rainfall. The area itself does not have particularly high rainfall and it is not a "sink" as is the Okavango, but a "temporary stopping place" for waters on their way to the ocean.

It would appear that there is little in the way of biodiversity in the Chobe-Linyanti-Zambezi floodplains and swamps – processes as well as species – that is not also present in the Okavango, where it is generally more extensive and better developed. There are also a substantial number of species found in the Okavango but not in the Chobe/East Caprivi.

7.3 LOWER SHIRE

This sub-project area has not been extensively studied during this phase, and is also known to be heavily impacted on by humans. A proposal to carry out a vegetation survey, and hence gain a better understanding of its habitat-diversity and species composition, was unfortunately not funded. The wetland area is comparatively small with a large margin-to-area ratio. It is fed by flows from Lake Malawi and the southern Malawi highlands which are more reliable than those over much of the Chobe-Caprivi. Extensive cultivation at a subsistence and commercial (sugar plantation) level is widespread and the area supports a very high human population. The beneficial effect, from a biodiversity perspective, of a mosaic of habitats is not really present over much of the area as the dryland areas have also been extensively modified and fragmented. It is possible that the Mozambique portion of the Ndinde Marsh still offers some potential for biodiversity conservation, but this needs to be verified by ground survey.

Some interesting biological records have come from the Elephant and Ndinde marshes over the years, and the two areas have been compared to, for example, the Barotse floodplains. However, it is not clear how much of that diversity now remains given marked land use pressures and utilization in recent years. There have been no endemic species reported, as far as can be determined, and most species are fairly widespread.

7.4 ZAMBEZI DELTA

The Zambezi Delta is the largest sub-project area (depending on whether the Barotse sub-project areas is taken to include only the floodplains or also the surrounding plateaux) and covers the greatest range of habitats – ranging from forest and miombo woodland through a range of wetland types to mangrove forest and dune vegetation. Although human impacts have been heavy along the main Zambezi River and along parts of the coast, the effects do not extend inland, with the exception of the extensive sugar plantations around Marromeu and Luabo. In addition, the effects of many of these impacts have been ameliorated in recent years by instability due to the civil war resulting in reduced economic activity and extensive fallows. The exception was the wholesale destruction of large mammals in the Marromeu complex during the latter years of the civil war and first few years of peace.

The delta, fed in part by the Zambezi itself and partly by runoff from the woodland plateaux to the north and west (as well as by incident rainfall on a very level landscape), is a vast mosaic of habitats, many of which are wetlands. The extent and distribution of these various wetland habitats appears to vary, probably a result of reduced flooding from the Zambezi owing to the construction of bunds to protect the sugar plantations and infrastructure and also impoundments upstream (such as Kariba and Cabora Bassa), but also due to biotic factors such as channel blockage from plant growth, reduced hippo numbers and aquatic weeds.

The Zambezi Delta offers perhaps the best potential for landscape-level conservation of any wetland area within the basin. It also appears to have the best developed and most extensive swamp and allied vegetation in the region, other than the Bangweulu and Okavango swamps. The main hydrological and biological processes are still in place, although modified to a significant extent by flood regulation measures and upstream impoundment, and the area contains much in the way of charismatic megafauna such as elephants, buffalo, and various cranes and waterbirds. The extensive dense dry forests and woodlands of the Cheringoma and Campo plateaux are important conservation areas in their own right for birds and mammals as well as plants, despite heavy selective logging in the past.

The delta wetlands do not appear to support any endemic species of plant or animal (although this may be a function of poor collecting and uncertainty), but the area as a whole supports a number of species which are not found elsewhere in the basin. For example, the delta area contains mangroves, salt flats and sand dunes which are not otherwise present in the Zambezi Basin, although widely distributed outside it. The marine influence is also reflected in the presence of estuarine and salt-water fish and in sea birds. The area forms part of the East African costal mosaic, a biogeographical region extending from coastal Somalia to southern Mozambique and northern KwaZulu-Natal that is restricted to a broad coastal belt but does not extend far inland. This zone is significant not just for plants but also for insects, herpetofauna and, to a lesser extent, birds.

In summary, because of its extensive and diverse nature, and comparatively little impacted status, the Zambezi Delta offers perhaps the best opportunity in the basin for long-term sustained landscape-level conservation. Ecological and evolutionary processes can continue to operate and the richness and charisma of the biota provide good possibilities for tourism and related activities. Although few, if any, endemics are recorded from the delta itself, many of the species occurring there (and in the surrounding woodlands) are not found elsewhere in the Zambezi Basin.

7.5 ZAMBEZI BASIN WETLANDS

Apart from the four IUCN sub-project areas, there are a number of other wetland areas within the palaeo-Zambezi Basin as defined in this study. As reported previously (Phase I report, Timberlake 1998), it is considered more meaningful to work within the context of a biologically (and historically)-contiguous basin that was current 0.5-2 million years ago, than to restrict discussion to the comparatively recent present-day basin boundaries. The other major swamps are the Okavango Delta, the Bangweulu and the Busango swamps, while major open water habitats (apart from the Zambezi River itself) are Lakes Kariba, Cabora Bassa, and Malawi, the first two being man-made impoundments less than 50 years old. Important floodplains are those associated with the Upper Zambezi including the IUCN Barotse sub-project site, the Kafue Flats, the Mana/mid-Zambezi floodplains, and those on the Lower Zambezi between Tambara and Sena. Although specifically excluded from this study, the upland dambos and pans are of great importance ecologically and for the biodiversity they contain.

In this assessment of the importance of the various wetlands of the Zambezi Basin to biodiversity conservation, the context is that of the palaeo-Zambezi Basin; continental or regional importance is not specifically addressed.

The Zambezi Basin contains four terrestrial biomes or broad biogeographical regions – the Congolian, the Zambezian, the East African coastal and the montane. The Congolian biome is, as its name suggests, associated with the Congo River Basin and is essentially moist tropical. It only just comes into the present-day Zambezi Basin in Mwinilunga District in northwestern Zambia and adjacent parts of northeastern NE Angola (although details here are lacking), and comprises just 1.5% of the total basin extent. The Zambezian biome is mostly sub-tropical woodland and grassland and covers the great majority of the present-day basin (95%). The East African coastal biome comprising tropical, relatively moist woodlands, forests and grasslands is restricted to a relatively narrow belt along the Indian Ocean coastline and within the basin only occupies 1% of the total area. The Montane biome comprises almost temperate forest woodlands, heathlands and grasslands associated with mountain massifs such as the Nyika, Misuku Hills, Mt. Mulanje, Shire Highlands and Nyanga and occupies 2.5% of the basin.

The wetlands of the Zambezi Basin nearly all lie in the Zambezian biome and are thus of comparatively similar biological composition. This may be thought to lead to a modicum of biodiversity redundancy in that the loss of any one wetland is of little significant to overall conservation. The gallery forests, swamp forests and dambo-like grasslands of the Mwinilunga/northeast Angola areas, although generally not covered in the reviews presented here, are very different in their species composition and substantially richer. For example, out of a total of 588 butterfly species recorded along the length of the Zambezi, 337 are only found in the Mwinilunga area. Such species may be commonly found outside the Zambezi Basin, but within the basin the Zambezi headwaters area is very species-rich and contains a number of species not found elsewhere. Thus the wetland habitats here such as riverine (gallery) forests and swamp forest are of great significance from a biodiversity perspective.

The Zambezi Delta mostly lies within the East African coastal biome, the only area within the Zambezi Basin to do so. Therefore, a number of species, although widespread along the East African coast (for example, mangroves, various palms, some reptiles), are only found here. In addition, there are ocean-related species such as seabirds and saltwater fish.

Although there may be much similarity between the wetland vegetation types of the various wetlands within the Zambezian biome (with the exceptions of dambos and pans as discussed earlier), there are some significant differences in the species composition of some animal groups. These differences are mostly between areas associated with the palaeo-Upper Zambezi river system (i.e. Bangweulu, Kafue, Okavango, Chobe, Zambezi above Victoria Falls) and those associated with the apparently-younger Middle and Lower Zambezi and tributaries (i.e. Luangwa, Manyame, Mazoe, Lower Shire). The differences are particularly apparent in fish and herpetofauna, but to a lesser extent are mirrored in insects, birds, mammals and plants. Of greater significance to mammals, (and also noted for Lepidoptera) is the Muchinga Escarpment that forms the western boundary of the Luangwa Valley and which separates 'eastern' and 'western' species.

Aquatic species, such as fish, do not fall so clearly into these four terrestrial biomes. The recently-formed lakes of Kariba and Cabora Bassa are still 'settling-down' and their species composition is in a state of flux, depending on inflow and lake level. Lake Malawi, on the other hand, is of comparative antiquity (perhaps tens of millions of years, although its level has fluctuated greatly) and has been rather cut-off from similar water bodies. These two factors have combined to create a unique environment and a unique fauna. It is estimated that perhaps 95% of the fish species in Lake Malawi are endemic, often to only a small part of the lakeshore.

Care should be taken, therefore, in clearly separating wetlands of the Upper Zambezi with the less-developed and more recent ones of the Middle and Lower Zambezi. Any discussion on conservation redundancy should not confound these two broad divisions. As discussed previously, the old, relatively stable plateau environments of the palaeo-upper Zambezi with a mosaic of wetland and grassland areas, have been the scene of much evolutionary diversification over the past few million years with the alteration of dry and wet periods during the Pleistocene. This is particularly apparent with some plant groups and is well illustrated here by the Reduncine antelopes. From this perspective, many of the wetlands of the palaeo-Upper Zambezi are of particular significance for biodiversity conservation and redundancy arguments have to be considered carefully, case by case.

Another important consideration in determining the importance of wetlands to biodiversity conservation within the basin is the importance of individual wetlands to migratory species, such as birds. Various bird species use wetlands within the basin for only short periods – as summer feeding grounds, for breeding, or as staging-posts to onward destinations. The loss of an important wetland in this regard, such as the Kafue Flats which seasonally supports vast numbers of waterfowl, may have subtle but catastrophic effects on global populations of species such as palaearctic migrants. If other wetlands are available within the region with adequate and required foodstuffs (invertebrates, fish or plant roots, etc), or with the necessary physical conditions for breeding such as freedom from predators, then migrating birds can adapt. But if such conditions are not available within the region then bird populations may slowly decline.

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8 : CONCLUSIONS AND RECOMMENDATIONS

8.1 CONCLUSIONS

The following preliminary conclusions of a general nature can be drawn from this study:

(a) That the broadly-defined wetland areas of greatest biological interest in terms of terrestrial species composition are associated with the Zambezi headwaters of NW Zambia (and probably NE Angola). This is due to (a) a high species richness, and (b) the presence of Congolian species "spilling over" from the Congo Basin, often the only area within the Zambezi Basin where they can be found. From a regional (although not necessarily continental) perspective, Mwinilunga District and districts in NE Angola are of major biodiversity interest. Most of the diversity present is associated with swamp and riparian gallery forests flanking headwater streams (*mushitus*), and also with open grassy areas similar to dambos. These are not 'true wetlands' as defined in the present report, but are certainly moisture-determined habitats.

(b) That for essentially aquatic organisms, such as freshwater molluscs and freshwater fish, Lake Malawi has exceptionally high levels of endemicity and is of global significance. Such biodiversity, particularly of cichlid fish, is under threat from pollution, excessive run-off resulting from landuse change and fishing. Nowhere else in the basin, wetland or non-wetland, exhibits such levels of endemicity, and the closest is isolated mountain ranges such as Mt. Mulanje in southern Malawi. The endemic biodiversity of Lake Malawi is associated with open water, shallow water and benthic habitats, not with swamps or marshes.

(c) That the old-established environments of the central African plateau, such as the floodplains, dambos and grasslands of Barotseland, Kafue and Bangweulu, have been an important areas for evolutionary diversification and speciation over the past few million years. It is this relative stability at a landscape scale, even if wetland areas changed in size or location, that has allowed such diversification to occur. The species involved, such as some plant groups, Reduncine antelopes and grassland birds, are not "true wetland" species as such, but species associated more with dambos and old floodplains.

(d) That geologically-recent, relatively unstable environments, such as the mid-Zambezi Valley, Lower Zambezi and Zambezi Delta support generally more widespread species, at least on the floodplains and wetlands found there. Species of restricted distribution in such areas are normally those associated with dry forests and woodlands, and are not wetland species.

(e) That from a basin-wide perspective, the wetland areas of major biodiversity interest are: Mwinilunga/Zambezi headwaters, Barotse floodplains, Kafue Flats, Okavango Delta, Lake Malawi and the Zambezi Delta.

(f) That for many biological groups, the majority of wetland species are not confined to specific wetland areas but are widely distributed across wetlands, both inside and outside of the Zambezi Basin. Some of those species considered endemic or restricted to specific wetlands may well prove to be more widely distributed with better collecting.

(g) That various wetlands, such as the Okavango, Kafue, Bangweulu and the Zambezi Delta, even if they do not support endemic species, provide very important breeding or wintering sites for migratory birds. Loss of more than one or two sites could be very deleterious to populations, some of which are palaearctic migrants. Marked reductions in habitat availability may lead to global decline in these species.

(h) That wetlands should be looked at holistically, as part of a broader landscape. They do not exist in isolation from the surrounding areas or from events upstream. Biodiversity, both organismal and ecological, moves between wetland and dryland areas. Animals such as birds and mammals retreat to dry ground during flooding events, and often also for breeding or feeding. Marginal areas act as refuges for some plant species in wetter periods, and conversely, the drier parts of wetland areas can act as a refuge for dryland species during drought periods. Both areas need to be maintained if conservation actions are to be successful.

(i) Following from the above, it is recognized that the various wetland habitats are not fixed but are often highly mobile in both space and time. Management and conservation must not be predicated on maintaining the status quo, but should seek to maintain the processes that determine the presence and value of wetlands.

8.2 RECOMMENDATIONS

From the review and conclusions, the following preliminary recommendations are made:

1. That occasional and significant flood releases are made from the network of dams on the Zambezi and its tributaries, particularly Itezhi Tezhi, Kariba and Cabora Bassa, in order to maintain open habitats, clear clogged channels and flush out accumulated nutrients. This will benefit the presently threatened species that require open habitats or regular flood regimes.

2. That the Zambezi Delta and associated hinterland be regarded and managed as an internationally-significant landscape and biodiversity conservation area. The delta wetlands form an integral and important part of this area.

3. That the floodplains, upland dambos, plateaux and pans of Barotseland, western Zambia be conserved at a landscape scale as an important centre of biodiversity and of evolutionary processes.

4. That a detailed synthesis of the information deriving from the biodiversity component of the wetlands project be prepared using a biogeographical, palaeo-ecological and conservation perspective in order to more carefully identify the major ecological and evolutionary processes over time and to identify and describe the most important areas for conservation.

5. That Lake Malawi is considered as a conservation area of global significance for aquatic organisms such as fish and molluscs.

6. That dambos, specifically excluded in this study, be looked at in future as important biodiversity conservation areas for a wide range of organisms.

7. That the Zambezi headwaters in NW Zambia and NE Angola be regarded and managed as important biodiversity conservation areas on the grounds of both species-richness and for supporting many species otherwise not found in the Zambezi Basin.

8. That the Okavango Delta, although technically outside the present-day Zambezi Basin, is regarded and managed as a wetland of major international significance.

9. That changes in biodiversity resulting from impoundments and other human activities be carefully monitored in the Bangweulu swamps, Kafue Flats and Zambezi Delta, and that any necessary amelioration measures be implemented.

10. That further biodiversity survey be carried out of plants, Odonata, Lepidoptera, freshwater molluscs, fish and amphibians in selected wetland areas in order to obtain good comparative data across the wetlands of the basin so that comparative species richness, composition and importance can be determined.

11. That research be initiated into freshwater invertebrates in a selection of wetland areas from the point of view of using comparative composition as an indicator of water quality and wetland health.

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9 : ACKNOWLEDGEMENTS

The main people involved in this study, whether at a technical level or in project administration, logistics and reporting, are listed in Appendices 2 and 3. Our grateful thanks to them all.

In addition, a number of people assisted with various components of the fieldwork. In particular we wish to thank the IUCN Field Project Officers concerned, Dora Ndlovu-Kamweneshe and Baldeu Chande, and their staffs in Mongu and Marromeu.

Finally, we wish to thank the IUCN Project Manager, Eric Hiscock, for his understanding and forbearance with delays and changes.

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VOLUME I : APPENDIX I
TERMS OF REFERENCE

1. INTRODUCTION

The inception mission for the Zambezi Basin Wetlands Conservation and Resource Utilisation Project identified a number of issues relating to the reduction of biodiversity in the basin's wetlands. Accordingly project work plans call for an assessment of the role of Zambezi Basin wetlands in overall biodiversity preservation. Particular reference is made to four specific field sub-project areas which are:

- the Delta in Mozambique
- the Lower Shire wetlands in Malawi and Mozambique
- the Barotse Flood Plain in western Zambia
- the Chobe-Caprivi area in Botswana and Namibia

Wetlands contain important biodiversity at both species and ecosystem levels. Maintaining the integrity of these wetland ecosystems is generally considered important for various reasons:

- They are often biologically unique, with rare or restricted vegetation types and species;
- They provide a perennial and regulated water supply;
- They provide buffering against floods;
- They help maintain water quality through their filtration and biological processing capacities;
- They provide ecological goods and services of great importance to local economies.
- While wetlands cover only a small percentage of the total Zambezi Basin, they are thought to be of disproportionate importance and to contain a large proportion of its biodiversity, although the information acquired during Phase I indicates that Zambezi Basin wetlands may not be as significant to overall biodiversity conservation as had been thought.

Biodiversity considerations at a landscape or regional scale need to be looked at holistically. This requires an assessment, not only of what is happening in the wetlands themselves, but also of events in adjacent areas, especially upstream. Hence, the four wetland areas are only loosely defined.

IUCN requires an assessment of the importance of the biodiversity of these four wetlands to the Zambezi Basin as a whole, to determine the major biological features of the wetlands, and to determine how biodiversity will be affected by developments and land use changes. IUCN also wishes to obtain an indication of the use and economic importance of these wetlands to local populations. Overall, the project aims to better identify the importance of wetlands within the Zambezi Basin from biodiversity and socio-economic perspectives, in order to conserve them more effectively.

It was decided that a two-phase study was needed to satisfy these requirements. In December 1996 The Zambezi Society, in collaboration with the Biodiversity Foundation for Africa, entered into a contract with IUCN to carry out the first phase of the study. Phase I gathered and evaluated existing information, made preliminary assessments of importance and threats, and generally set the scene for detailed fieldwork and analysis in Phase II. It has also produced documentation and conclusions which can be used directly and immediately by the IUCN Zambezi Basin Wetlands Conservation and Resource Utilisation Project, and others in the region, for planning and as a basis for future studies.

That contract is now complete and Phase II is the subject of this contract.

The Zambezi Society, in collaboration with the Biodiversity Foundation for Africa, is in a position to execute Phase II.

Although the biodiversity of all Zambezi Basin wetlands, as represented by the four field sub-project areas, is of interest to IUCN, due to funding constraints, field activities will be confined to the Barotse Flood Plain and the Zambezi Delta. These areas are still relatively intact and can be treated at a landscape scale. A basinwide perspective will be retained through taxonomic reviews, mapping, other activities as applicable, and knowledge acquired during Phase I.

2. DURATION OF CONTRACT

The contract shall begin on the signing date of this document and terminate not later than 31 December 1999.

3. TASKS TO BE PERFORMED

3.1 **Related objectives**

Tasks to be performed under this contract will be aimed at satisfying the following objectives.

3.1.1 To collect, assess and make available information on the ecology and biodiversity of the Zambezi Basin wetlands, with particular reference to the Barotse Flood Plain and Zambezi Delta sub-project sites

3.1.2 To carry out ecological surveys and inventories of selected biological groups within the Barotse Flood Plain and Zambezi Delta

3.1.3 To identify and describe the major biodiversity features of the selected wetlands, and identify and prioritise biological communities and species of concern

3.1.4 To determine the regional importance of Zambezi Basin wetlands, particularly the two sub-project sites, for the conservation of biodiversity

3.1.5 To assess the threats to biodiversity arising from human activity, changes in land use or development projects

3.1.6 To assist in facilitating a socio-economic assessment of Zambezi Basin wetlands biodiversity, and in particular of the four sub-project sites, through liaison and information-sharing with the contractor for Economic Valuation of Wetlands Goods and Services

3.2 **Activities**

The contractor will carry out the following activities:

3.2.1 Undertake a biodiversity inventory of selected groups at the Barotse Flood Plain and Zambezi Delta sub-project wetland sites. Museum and herbarium technicians and local expertise will be used where available and trained as required. In achieving this inasmuch as it applies to plants, the contractor will make optimal use of IUCN's relationship with the Southern African Botanical Diversity Network with a view to economising on resources to the degree possible.

3.2.2 Compile checklists of better-known groups for the two selected sub-project wetland sites utilising the inventory referred to under Activity 3.2.1 as augmented by existing published and unpublished data and by reference to museum and herbarium specimens where possible. Entries will be annotated as to status, frequency, broad habitat requirements, and other points of interest, and will be produced in a format suitable for comparison between sites.

3.2.3 Produce detailed reviews of knowledge on selected wetland biological groups from a basinwide perspective, incorporating checklists of available data. Groups to be included are: wetland plants, Reduncine antelopes, wetland birds, reptiles, fish, freshwater molluscs, Odonata, Lepidoptera and aquatic invertebrates. Reviews will incorporate assessments of biodiversity and conservation importance of each group, conservation trends and threats, and identification of species of particular concern. A biogeographical analysis of differences in composition across the Basin will also be carried out.

3.2.4 Identify sites and species of particular interest or concern further developing the preliminary identification achieved in Phase I, with more detailed documentation and justification.

3.2.5 Undertake further evaluation of human impacts on the biodiversity of Zambezi Basin wetlands, building on work already undertaken during Phase I with particular emphasis on the two selected sub-project sites.

3.2.6 Produce ecoligical maps of the four sub-project sites using recent satellite imagery and delineating relatively homogeneous units from a landscape ecology perspective. The legend will represent a unified classification covering all Zambezi Basin wetland areas while being compatible with previously-published descriptions.

3.2.7 Produce a vegetation map of the Zambezi Delta area based on satellite imagery and generalised field work. This will be carried out in consideration of other vegetation mapping initiatives in the Delta, such as the mangrove mapping initiative sponsored by the Government of the Netherlands, with a view to economising on the use of study resources and avoidance of duplication.

3.2.8 Compile semi-detailed land use change maps of the Barotse floodplains and Zambezi Delta areas, and immediate catchments. This will be accompanied by a report on the nature and extent of changes and the possible consequences for biodiversity conservation.

3.2.9 Publish an annnotated bibliography and review, based on a substantial revision of the Phase I report with additional data. Modification to the Phase I version will include the incorporation of information and checklists resulting from Phase II activities, rendering it more "user-friendly", and revision to overcome some of its present shortcomings (keywords, detail in annotation, and the inclusion of further references).

3.2.10 Generate a minimum of 100 good quality captioned 35mm colour slides of areas, sites and species of high interest and/or concern from within the Barotse Flood Plain and Zambezi Delta sub-project areas. These slides will be clearly captioned and placed in plastic slide folders.

3.2.11 Contribute to the execution of the contract for Economic Valuation of Wetlands Goods and Services between IUCN and the Namibian Directorate of Environmental Affairs dated 8 January 1998, through liaison and information-sharing.

3.2.12 Write a comprehensive report, with an Executive Summary in both English and Portuguese, describing the above noted activities and resultant outputs.

3.3 Outputs

The contractor will deliver the following outputs:

3.3.1 Annotated bibliography and review, based on a substantial revision of the Phase I report with additional data (relates to Activity 3.2.9)

3.3.2 Biodiversity inventories and checklists for the Barotse Flood Plain and Zambezi Delta wetland sub-project sites (relates to Activities 3.2.1 and 3.2.2)

3.3.3 Bibliographic database incorporating substantial additions to, and modifications of, Phase I products (relates to Activities 3.2.3 and 3.2.9)

3.3.4 Ecological maps of the four sub-project sites and vegetation maps for the Delta sub-project site(relates to Activities 3.2.6 and 3.2.7)

3.3.5 Assessment and mapping of recent land use change in the Barotse Flood Plain and Zambezi Delta project sites (relates to Activity 3.2.8)

3.3.6 Detailed reviews of knowledge on selected wetland biological groups, focusing on the four sub-project sites but with a Basinwide perspective, incorporating checklists of available data. Reviews will incorporate assessments of biodiversity importance, conservation trends and threats, and identification of species of particular concern (relates to Activity 3.2.3)

3.3.7 Identification of indicator taxa (relates to Activities 3.2.1 and 3.2.4)

3.3.8 identification of sites and species of concern (relates to Activity 3.2.4)

3.3.9 Evaluation of the impacts of human activity on wetland biodiversity (relates to Activity 3.2.5)

3.3.10 Evaluation of the importance of each sub-project site and of the Zambezi Basin wetlands as a whole to biodiversity conservation, identification of wetland biodiversity conservation priorities, and recommendations for future actions (relates to Activities 3.2.1 and 3.2.8)

3.3.11 On-the-job training for local scientists and museum/herbarium technicians in methods and procedures required to execute applicable components of the contract (relates to Activity 3.2.1)

3.3.12 Collections of well-labelled herbarium and museum specimens with locality data (relates to Activity 3.2.1)

3.3.13 One hundred 35mm captioned colour slides of important species and sites (relates to Activity 3.2.10)

3.3.14 Information on Zambezi basin biodiversity, inasmuch as it is available, provided to the wetlands economic valuation study contractors for Phase I of the evconomic valuation study and for Phase II of that study, should it materialise (relates to Activity 3.2.11)

3.3.15 Fifty paper copies and one electronic copy of a comprehensive report with an Executive Summary in both English and Portuguese, describing the above noted activities and resultant outputs (relates to Activity 3.2.12) (NB: this output was subsequently amended to reflect the eventual report structure, which required a five-part volume of technical reviews; a volume devoted to the bibliography; and a volume (of which this section forms a part) detailing the findings, conclusions and recommendations derived from the biodiversity studies)

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VOLUME I : APPENDIX 2
LIST OF EXPERTISE INVOLVED IN STUDY

Mr Richard **Beilfuss**, International Crane Foundation, Baraboo, USA
Delta land use change

Mr Carlos **Bento**, Natural History Museum, Maputo, Mozambique
Delta bird survey

Dr Roger **Bills**, J.L.B. Smith Institute of Ichthyology, Grahamstown, South Africa
Delta fish survey, peer review

Mr Mike **Bingham**, Lusaka, Zambia
Plant review, Barotseland plant survey, Barotseland land use

Mrs Wendy **Borello**, Gaborone, Botswana
Bird review

Dr William (Bill) **Branch**, Port Elizabeth Museum, Port Elizabeth, South Africa
Delta herps survey, Delta bird survey

Dr Donald **Broadley,** BFA, Bulawayo, Zimbabwe
Herpetofauna review, Barotseland herps survey, peer review

Mrs Sheila **Broadley**, Natural History Museum, Bulawayo, Zimbabwe
Barotseland herps surveys

Dr Alan **Channing**, University of the Western Cape, Cape Town, South Africa
Barotseland herps survey

Ms Susan **Childes**, BFA, Harare, Zimbabwe
Bibliography, geomorphology, peer review

Mr Evaristo **Chilesha**, Animal Production & Health Department, Mongu, Zambia
Ndau school transects

Mr Rafael **Chiwanga**, Natural History Museum, Bulawayo, Zimbabwe
Barotseland Odonata/Lepidoptera survey

Mr Fenton **Cotterill**, Natural History Museum, Bulawayo/BFA, Bulawayo, Zimbabwe
Reduncine antelope review, small mammal surveys (Barotseland and Delta), peer review

Mr Robert **Drummond,** BFA, Harare, Zimbabwe
Plant review, plant identifications (Delta and Barotseland)

Dr Cornell **Dudley**, Chancellor College, Zomba, Malawi
Freshwater molluscs review, peer review

Mr Paul **Dutton**, Durban, South Africa
Delta land use change

Ms Nicola **Feltham**, University of Natal, Dept of Zoology & Botany, Pietermaritzburg, South Africa
Delta Lepidoptera survey

Mrs Moira **Fitzpatrick**, BFA, Bulawayo, Zimbabwe
Odonata review

Dr Alan **Gardiner**, BFA, Harare, Zimbabwe
Lepidoptera review

Mr Mike **Gardiner**, Bulawayo, Zimbabwe
Lepidoptera identification (Barotseland)

Mrs Dale **Hanmer**, Mutare, Zimbabwe
Bird review

Dr Kit **Hustler**, BFA, Bulawayo, Zimbabwe
Bird review, Barotseland bird survey

Mr Michael Stuart **Irwin**, BirdLife Zimbabwe, Harare, Zimbabwe
Bird review

Mr Punky **Jose**, J.L.B. Smith Institute of Ichtyology, Grahamstown, South Africa
Delta fish survey

Mr Vincent **Katanekwa**, Livingstone Museum, Livingstone, Zambia
Barotseland bird survey

Mr Richard **Kinvig**, University of Natal, Dept of Zoology & Botany, Pietermaritzburg, South Africa
Delta Lepidoptera survey

Mr Pete **Leonard**, Zambian Ornithological Association, Choma, Zambia
Bird review

Ms Narcisa **Loureiro**, Instituto de Investigação de Pescas, Maputo, Mozambique
Delta fish survey

Mr Ben **Luwiika**, Mt Makulu Herbarium, Lusaka, Zambia
Barotseland plant survey

Mr Ernesto **Macamo**, Universidade Eduardo Mondlane, Maputo, Mozambique
Delta plant survey

Prof Chris **Magadza**, University of Zimbabwe, Harare, Zimbabwe
Human impacts review

Mr Boneface **Magwizi**, Natural History Museum, Bulawayo, Zimbabwe
Bird review

Mr Anthony **Mapaura**, National Herbarium, Harare, Zimbabwe
Delta plant survey

Prof. Brian **Marshall**, University of Zimbabwe, Harare, Zimbabwe
Fish review, aquatic invertebrates review, peer review

Mr J. **Measey**, University of Western Cape, Cape Town, South Africa
Barotse herps survey

Mr Philip **Mhlanga**, Natural History Museum, Bulawayo, Zimbabwe
Barotseland Odonata/Lepidoptera survey

Mr John **Minshull**, BFA, Bulawayo, Zimbabwe
Aquatic invertebrates review

Mr Doorn **Moore**, International Crane Foundation, Baraboo, USA
Delta land use change

Mrs Audrey **Msimanga**, Natural History Museum, Bulawayo, Zimbabwe
Bird review

Dr Tom **Müller**, Harare, Zimbabwe
Delta plant/vegetation survey, pper review

Dr Peter **Mundy,** Department of National Parks/BFA, Bulawayo, Zimbabwe
Bird review

Mr Aleck **Ndlhovu,** Natural History Museum, Bulawayo, Zimbabwe
Small mammal surveys (Barotseland and Delta)

Mr Greg **Rasmussen**, Painted Dog Research Project, Dete, Zimbabwe
Barotseland herps survey

Prof Michael **Samways**, University of Natal, Dept of Zoology & Botany, Pietermaritzburg, South Africa
Odonata identification (Barotseland)

Mr Pete **Smith** (deceased), Okavango Research Station, Maun, Botswana
Plant review

Mr Robert **Stjernstedt**, Livingstone, Zambia
Barotseland bird survey

Mr Jonathan **Timberlake**, BFA, Bulawayo, Zimbabwe

Coordination, plant review, vegetation studies, Delta vegetation survey, annotated bibliography, peer review, report writing, editing, compilation

Mr Paul **Van Daele**, Livingstone, Zambia

Barotseland bird survey

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VOLUME I : APPENDIX 3
PERSONS INVOLVED - LOGISTICS AND SUPPORT

Ms Denise **Carter,** The Zambezi Society, Harare, Zimbabwe
Logistics

Mr Alistair **Chambers**, Ruwa, Zimbabwe
Barotse transport & support (Odonata/Lepidoptera)

Ms Vienessa **Goodwin**, Bulawayo, Zimbabwe
Typing

Ms Verity **Mundy**, BFA, Bulawayo, Zimbabwe
Administration

Ms Barbie **Pickering**, The Zambezi Society, Harare, Zimbabwe
Finance

Mr Dick **Pitman**, The Zambezi Society, Harare, Zimbabwe
Project management, reporting

Mr Mike **Scott**, Khangela Safaris, Bulawayo, Zimbabwe
Delta logistics, transport

Mr Bernard **Sibanda**, Khangela Safaris, Bulawayo, Zimbabwe
Delta logistics, transport

Ms Evyline **Sithole**, The Zambezi Society, Harare, Zimbabwe
Finance

Ms Priscilla **Smith**, The Zambezi Society, Harare, Zimbabwe
Logistics

Ms Sally **Wynn**, The Zambezi Society, Harare, Zimbabwe
Photographs, reporting, layout

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VOLUME I : APPENDIX 4
PHOTOGRAPHS OF WETLAND SITES AND SPECIES OF INTEREST

S	slide	P	print	C	CD ROM		
MGB	Mike Bingham	KH	Kit Hustler	JT	Jonathan Timberlake	WRB	Bill Branch
IRB	Roger Bills	FC	Woody Cotterill	AC	Alan Channing	RK	Richard Kinvig
NF	Nicola Feltham	ACh	Alistair Chambers	RB	Roger Bills		

Photo No.	type	Subject Category	Description	Photo-graphe r
BAROTSELAND				
B1	S	Birds	Rufous-bellied Heron, nr. Mongu	KH
B2	S	Birds	European Nightjar, nr. Mongu	KH
B3	S	Human	Bird specimen preparation, Ndanda, nr. Mongu	KH
B4	S	Birds	Coppery-tailed Coucal, nr. Mongu	KH
B5	S	Habitat	Miombo woodland, 10km S of Mongu	WC
B6	S	Habitat	Perennial pools Ndanda Dambo, nr Mongu	WC
B7	S	Human	Pitfall trap array, Ndanda, nr. Mongu	WC
B8	S	Mammals	*Cryptomys damanrensis* Mole Rat, Ndanda Dambo, nr. Mongu	WC
B9	S	Human	Mammal specimen preparation, 7km W Ndanda School, nr. Mongu	WC
B10	S	Mammals	*Scotoecus hindei*, Ndanda Dambo, nr. Mongu	WC
B11	S	Mammals	*Mops niveiventer*, Ndanda Dambo, nr. Mongu	WC
B12	S	Mammals	*Chaerephon nigeriae*, Ndanda Dambo, nr. Mongu	WC
B13	S	Mammals	*P. rusticus* Rusty Bat, Ndanda Dambo, nr. Mongu	WC
B14	S	Mammals	*M*ollusid bat specimen preparation, nr. Mongu	WC
B15	S	Mammals	*Dasymys cincomtus*, Ndanda Dambo, nr. Mongu	WC
B16	S	Mammals	*Glauconycteris variegata*, Ndanda Dambo, nr. Mongu	WC
B17	S	Mammals	*Laephotis botswanae*, Ndanda Dambo, nr. Mongu	WC
B18	S	Habitat	W of Mongu, Barotse floodplain	AC
B19	S	Habitat	wetlands, Nof Mongu, Barotseland	AC
B20	S	Habitat	wetlands, nr. Kalabo, Barotseland	AC
B21	S	Herps	*Pyxicephalus adspersus*, Barotse floodplain	AC
B22	S	Herps	*Leptopelis bocagii*, Barotse floodplain	AC
B23	S	Herps	*Tomopterna tandyi*, Barotse floodplain	AC
B24	S	Herps	*Hemisus marmoratus*, Barotse floodplain	AC
B25	S	Herps	*Bufo maculatus*, Barotse floodplain	AC
B26	S	Herps	*Xenopus petersi*, Barotse floodplain	AC
B27	S	Herps	*Phrymobatrachus natalensis*, Barotse floodplain	AC
B28	S	Herps	*Phrynobatrachus natalensis*, Barotse floodplain	AC
B29	S	Herps	*Ptychadena taenioscells*, Barotse floodplain	AC
B30	S	Herps	*Ptychadena subpunctata*, Barotse floodplain	AC
B31	S	Herps	*Ptychadena mascareniensis*, Barotse floodplain	AC

Photo No.	type	Subject Category	Description	Photo-grapher
B32	S	Herps	*Ptychadena subpunctata*, Ndau	AC
B33	S	Herps	*Breviceps poweri*, Barotse floodplain	AC
B34	S	Herps	*Gerrhosaurus auritus*, Ndau	Ach
B35	S	Herps	*Kassina senegalensis*, Ndau	ACh
B36	S	Herps	*Ichnotropis capensis*, Ndau	ACh
B37	S	Herps	*Pelusios bechuanicus,* Ndau	ACh
B38	S	Herps	*Ptchadena subpunctata*, Barotse floodplain	ACh
B39	S	Herps	*Bufo poweri*, Ndau	ACh
B40	S	Herps	*Hemisis* sp.nov., Ndau	ACh
B41	S	Herps	*Phrynobatrachus natalensis*, Ndau ?	ACh
B42	S	Insects	Dragonfly, Ndau	ACh
B43	S	Insects	Dragonfly, Ndau	ACh
B44	S	Insects	Dragonfly, Ndau	ACh
B45	S	Insects	Dragonfly, Ndau	ACh
B46	P	Plants	*Nymphaea maculata* (water lily), Mongu	MGB
B47	P	Plants	*Crotalaria* ?*recta* (legume), Mongu	MGB
B48	P	Plants	*Gloriosa sessiliflora* (lily), Lealui	MGB
B49	P	Plants	*Eulophia angolensis* (orchid), Mongu	MGB
B50	P	Plants	*Crinum* sp. (Amaryllidaceae), Mongu	MGB
ZAMBEZI DELTA				
M51	S	Plants	*Pistia sstratiotes*, Marromeu	RB
M52	S	Plants	*Eichhornia crassipes*, Marromeu	RB
M53	S	Plants	*Phoenix reclinata* flowering, sample"island" C Marromeu	JT
M54	S	Habitat	Cutting papyrus, Coutada 14, C. Marromeu	JT
M55	S	Habitat	*Elaeis guineensis* palm grove. Coutada 11, Marromeu	JT
M56	S	Plants	*Elaeis guineensis* palm fruit & leaf. Camp, Coutada 11 C. Marromeu	JT
M57	S	Plant	Staghorn fern, *Platycerium*, Dondo-Caia rd nr Dondo, C. Mozambique	JT
M58	S	Habitat	Papyrus & reeds in old channels, C Marromeu	WC
M59	S	Habitat	Papyrus in old channels, C Marromeu	WC
M60	S	Habitat	Papyrus channel, S. Marromeu wetlands	WRB
M61	S	Habitat	Papyrus, reeds and wetlands, C. Marromeu	WRB
M62	S	Habitat	Wooded island in wetland & papyrus, C. Marromeu	WRB
M63	S	Habitat	Tree-lined channel palm savanna. C. Marromeu	JT
M64	S	Habitat	Site G - Palmgrove, S of Marromeu	NF
M65	S	Habitat	Lagoon, papyrus & grass. C. Marromeu wetlands	JT
M66	S	Habitat	Site A - Safrique nr. Marromeu	NF
M67	S	Insects	*Neptis laeta* (Common Sailor), Marromeu	NF
M68	S	Insects	*Hypolimas misippus* (Common Diadem), Marromeu	NF

Photo No.	type	Subject Category	Description	Photo-grapher
M69	S	Insects	*Aterica galene theophane & Precis oenene oenene*, Marromeu	NF
M70	S	Insects	*Euchrysops osiris* (Osiris Smoky Blue), Marromeu	NF
M71	S	Insects	*Eurema brigitta brigetta* (Broadbordered Grass Yellow), Marromeu	NF
M72	S	Insects	*Amauris ochlaa ochlea* (Novice Friar) & *Acraea natalica natalica*, Marromeu	NF
M73	S	Insects	*Danaus chrysippus aegyptius* (African Monarch) & *Hyalitis eponina*, Marromeu	NF
M74	S	Insects	*Trithemis annulata*, Site C - Zambezi, nr. Marromeu	RK
M75	S	Mammals	*Eidolon lebeurii* (bat), Marromeu town	WC
M76	S	Mammals	*Lissonycteris angolensis* (bat), Coutada 11 Marromeu	WC
M77	S	Mammals	*Mops condylura* (bat), Marromeu	WC
M78	S	Mammals	*Petrodomus tetradactylus* (elephant shrew), Coutada 11, Marromeu	WC
M79	S	Mammals	Buffalo & cattle egrets, S Marromeu	WC
M80	S	Mammals	Buffalo & cattle egrets, S Marromeu	WC
M81	S	Herps	*Ptychadena mossambica* Mozambique Grass Frog	WRB
M82	S	Herps	*Hyperolius marmoratus taeniatus* Painted Reed Frog, Coutada 11, Marromeu	WRB
M83	S	Herps	*Phrynobatracus acridoides* East African Puddle Frog, Marromeu	WRB
M84	S	Herps	*Hyperolius argus* (male) Argus Tree Frog, Coutada 11, Marromeu	WRB
M85	S	Herps	*Pykicephalus edulis* Dwarf Bullfrog, Marromeu	WRB
M86	S	Herps	*Afrixalus fornasini* Greater Leaf-folding frog, Marromeu	WRB
M87	S	Herps	*Leptopelis mossambicaus* Mozambique Tree Frog, Marromeu	WRB
M88	S	Herps	*Hemidactylus platycephalus* Flat headed Gecko, Malingipansi	WRB
M89	S	Herps	*Rhinotyphcops mucruso*, Zambezi Blind Snake, Marromeu	WRB
M90	S	Herps	*Philothamnus semivariegatus*, Spotted Bush Snake, Coutada 11, Marromeu	WRB
M91	S	Herps	*Thecotornis mossambicanus*, Mozambique Twig Snake, Malingipansi	WRB
M92	S	Herps	*Dipsadoboa flavida broadleyi*, Gross Barred Tree Snake, Coutada 11, Marromeu	WRB
M93	S	Herps	*Philothamnus hoplogaster*, Common Green Snake, Malingipansi	WRB
M94	S	Herps	*Holaspis guentheri* Eastern Tree Lizard, Coutada 11, Marromeu	WRB
M95	S	Herps	*Mabuya varia* Common Varied Skink, Marromeu	WRB
M96	S	Herps	*Agama mossambica* Mozambique agama, Coutada 11, Marromeu	WRB
M97	S	Herps	*Natriciteres olivacea*, Olive Swamp Snake, Malingipansi	WRB
M98	S	Fish	Mouth of fish trap: Zambezi Delta	RB
M99	S	Fish	Sun-dried fish - tarpon or Ulawa (*Megalops cyprinoides)* lower Zambezi Delta	RB
M100	S	Fish	Sun-dried fish - *Hilsa kelee*, the dominant delta fishery species in July	RB
M101	S	Fish/ Habitat	Mangrove channel connecting the Zambezi main river and the Micelo River	RB
M102	S	Fish/ Habitat	Zambezi River: the main channel at Marromeu	RB
M103	S	Fish	*Labeo altivelis* dominant species and major component of Delta fisheries catch	RB

Photo No.	type	Subject Category	Description	Photo-grapher
M104	S	Fish	*Labeo altivelis* (above) and *Labeo congoro* (below)	RB
M105	S	Fish	*Mormyrops anguilloides* - Middle/Lower Zambezi endemic	RB
M106	S	Fish	*Mormyrus longirostris* - common in main river channel and important to fisheries	RB
M107	S	Fish	*Marcusenius macrolepidotus* - female above, male below	RB
M108	S	Fish	*Nothobranchius rachovii* - mature male exhibiting breeding colours	RB
M109	S	Fish	*Distochodus schenga* - dominant fishery species	RB
M110	S	Fish	*Distochodus schenga* - juvenile colour pattern	RB
M111	S	Fish	*Distochodus mossambicus*	RB
M112	S	Fish	*Oreochromis placidus* - large adult male	RB
M113	S	Fish	*Ctenopoma multispine* - air-breather, able to “walk” out of water using operculae	RB

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