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BIODIVERSITY OF THE ZAMBEZI BASIN WETLANDS:

REVIEW AND PRELIMINARY ASSESSMENT OF AVAILABLE INFORMATION

PHASE 1

FINAL REPORT

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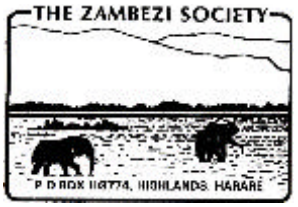
Publishers' note

This evaluation was undertaken as a partnership between the Zambezi Society and the Biodiversity Foundation for Africa



The Zambezi Society is a non governmental, membership agency devoted to the conservation of biodiversity and wilderness in the Zambezi basin. Its partnership role includes donor liaison; financial, logistics and project management; and information dissemination.

The major objective of the Biodiversity Foundation for Africa is to undertake biological research into tropical African biodiversity, and to make the resulting information more accessible. It provides biological, ecological and taxonomic expertise and technical management for the partnership.

The ZAMSOC/BFA partnership applies its combined skills to biodiversity research and conservation within the Zambezi basin.

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EXECUTIVE SUMMARY

The Regional Office for Southern Africa of IUCN (IUCN-ROSA), in conjunction with the Canadian International Development Agency (CIDA), initiated the Zambezi Basin Wetlands Conservation and Resource Utilisation Project (ZBWCRUP) in 1996. This project is aimed at ensuring wise use of natural resources of the wetlands of the Zambezi Basin, focussing in particular on four project sites (the Barotse floodplains in western Zambia, the floodplains and swamps of the Chobe/Caprivi region of Namibia and Botswana, the wetlands of the Lower Shire in southern Malawi and Mozambique, and the Zambezi Delta in Mozambique). One of the project activities is to assess the importance of biodiversity from a conservation perspective, both for the four wetland areas and for the wetlands of the Zambezi Basin as a whole. The Zambezi Society and the Biodiversity Foundation for Africa were invited to carry out this component as Phase 1 of larger project. This volume, the resulting report, consists of a compilation, evaluation and assessment of existing published technical information on the biodiversity of these wetlands.

An annotated bibliography containing 979 references on organismal and ecological biodiversity was compiled, and an edited version of 942 references (excluding those not strictly concerning biodiversity) is presented in an electronic database format. A series of 59 keywords, covering geographical area, biological group and subject area, has been used to facilitate search and retrieval.

Coverage in the literature is very uneven, both for geographical area and biological group. The best documented areas are the Kafue Flats, the Chobe/Caprivi area and Lake Kariba. Barotseland and the Zambezi Delta are particularly poorly documented given their size. The best covered groups are plants, large mammals, birds and fish. Information on small mammals and most invertebrate groups is very limited. Knowledge on taxonomy of the various groups is generally good, with the exception of many invertebrate groups where even a rough indication of numbers of species present is not available. Checklists have been prepared for some groups and for some wetland areas, but there are gaps which preclude, at this stage, a detailed comparison of biodiversity between wetlands and across the basin. Literature on the ecological role, function and productivity of wetland organisms is very scant for the area.

Although there are a number of species restricted to the wetlands of the Zambezi Basin in a number of

different groups, detailed listings are not yet available except for large mammals, birds, reptiles, amphibians and fish. The lechwe antelope (with three subspecies endemic to the floodplains of the proto-Upper Zambezi) and the Wattled Crane (seasonally with 90% of the world population in the wetlands of the Zambezi Basin) are possibly the best "flagship species" for conservation of the wetlands, encompassing most of the major concerns and issues.

The clear division of the Zambezi Basin into three physical and biogeographical sections ! Upper, Middle and Lower ! is described. Biological composition differs greatly between the Upper and Middle/Lower sections, and is thought to be a result of comparatively recent river capture of the proto-Upper Zambezi (which originally included the Bangweulu swamps, Kafue, Kavango and Okavango) by the more recent Middle Zambezi. The instability and biological youth of many of the Zambezi wetlands, particularly the swamps, is discussed. This is shown to be a major factor in their relatively homogeneous composition across the basin. The floodplains of the proto-Upper Zambezi are seen as having been more stable over recent evolutionary time. They appear to be more species-rich and hold a greater number of species of limited distribution than the swamps.

Although perhaps less heavily modified than many river basins in Africa, the Zambezi has been greatly changed in its middle section by large impoundments at Kariba and Cabora Bassa, as well as on the Kafue at Itezhi-Tezhi and on the upper reaches of tributaries in Zimbabwe. Biodiversity composition has been greatly modified in both obvious and indirect ways through the creation of new habitats, facilitation of distribution of species, and through reduced flooding. The effects of flood control in the Zambezi Delta have given rise to conservation concerns, but documentation is hampered by lack of baseline information. However, on the Upper Zambezi any changes in hydrology, extent of wetlands and biodiversity are principally a result of climatic cycles rather than the effects of human activities.

Expertise in organismal biodiversity, both regional and international, was compiled into a database with 135 persons cited. This database, by no means exhaustive, is also presented in an electronic format with keywords to enable rapid searching. The major groups covered are plants and birds, and most of the expertise cited is based in Zimbabwe or South Africa. Expertise in many invertebrate and microscopic groups is dangerously limited. The important role of amateur naturalists is pointed out, particularly for

birds, large mammals and butterflies.

Twenty four recommendations are given. Some are general and apply equally to the whole basin, whilst some cover research topics. It is suggested that a basin-wide perspective is required for conservation, and to achieve this a series of vegetation maps with a common legend are required, more attention needs to be paid to old floodplains and dambos, and detailed reviews of selected biological groups should be carried out. Sites of particular conservation interest need to be identified, as do those wetland species in need of active conservation measures. A series of monitoring sites should ideally be set up across the basin which can be used to detect change due to human impact. The final general recommendation is to make biodiversity information more accessible through appropriate publications and media releases. On the research side, investigation is required into wetland ecological processes and resilience, the effects of river impoundment on the wetlands of the Zambezi Basin, and the potential for use of aquatic organisms as indicator species.

Specific recommendations, some of which could be addressed by ZWCRUP, are a revision and publication of the annotated bibliography incorporating a more concise review, and a series of activities related to the four sub-project sites. These include biodiversity inventory of selected groups, production of compatible vegetation maps, identification of sites of conservation interest, and an assessment of the effects of land use change on biodiversity. The site-specific activities are spelled out in detail.

SUMÁRIO EXECUTIVO

A Sede Regional da IUCN para a África Austral (IUCN-ROSA) em conjunto com a Canadian International Development Agency (CIDA), iniciou o Zambezi Basin Wetlands Conservation and Resource Utilisation Project (ZBWCRUP) em 1996. Esste projecto tem como objectivo assegurar o uso consciente dos recursos naturais das terras húmidas da Bacia do Zambeze, dando especial ênfase a quatro áreas de projectos (as planícies inundadas de Barotse no oeste da Zâmbia, as planícies inundadas e pântanos da região de Chobe/Caprivi da Namíbia e Botswana, as terras húmidas do Baixo Shire no sul do Malawi e Moçambique e o Delta do Zambeze em Moçambique).

Uma das actividades do projecto é de avaliar a importância da biodiversidade sob uma perspectiva de conservação, para as quatro áreas de terras húmidas e para as terras húmidas da Bacia do Zambeze como um todo

A Zambezi Society e a Biodiversity Foundation for Africa foram designadas para levar a cabo esta componente, como Fase 1 de um projecto ainda maior. Este volume, o relatório dos resultados, consiste de uma compilação, interpretação e avaliação de informação técnica existente publicada sobre a biodiversidade destas terras húmidas.

Uma bibliografia detalhada contendo 979 referências sobre biodiversidade de organismos e ecológica foi compilada e existe agora uma versão editada de 942 referências (excluindo as não estritamente relacionadas com biodiversidade) apresentada em forma de base de dados electrónica. Uma série de 59 palavras-chave, abrangendo área geográfica, grupo biológico e área temática, foi usada para facilitar a busca e recuperação. Informação literária sobre a área geográfica e grupo biológico é bastante irregular. As áreas melhor documentadas são as Planícies de Kafue, a área de Chobe/Caprivi e o Lago Kariba. Barotseland e o Delta do Zambeze estão pobremente documentados devido ao seu tamanho. Os grupos melhor abrangidos são plantas, grandes mamíferos, pãssaros e peixes. Informação sobre pequenos mamíferos e sobre a maioria dos grupos de invertebrados é muito limitada. O conhecimento da taxonomia dos vários grupos é geralmente boa, exceptuando muitos dos grupos de invertebrados, onde nem uma vaga indicação do número de espécies presentes está disponível. Foram preparadas listas de verificação para alguns grupos e para algumas áreas de terras húmidas e ao longo da bacia. Literatura sobre o papel,

a função e a productividae ecológica dos organismos da terra húmida é bastante escassa para a área em questão.

Apesar de haver um nùmero de espécies restrictas às terras húmidas da Bacia do Zambeze, numa série de grupos diferentes, listas detalhadas ainda não estão disponíveis, excepto para grandes mamíferos, pássaros, répteis, amfíbios e peixess. O antílope lechwe (com três sub-espécies endémicas das planícies inundadas da zona proto-Alta do Zambeze) e a garça de barbela (sazonalmente com 90% da população mundial nas terras húmidas da Bacia do Zambeze) são possivelmente as melhores “espécies de progaganda” para promover a conservação das terras húmidas, pois abarcam a maioria das preocupações e assuntos principais.

O documento descreve a clara divisã da Bacia do Zambeze em três secções físicas e biogeográficas Alta, Média e Baixa. A composição biológica difere bastante entre as secções Alta e Média/Baixa e pensa-se ser resultado da comparativamente recente extensão do rio da zona proto-Alta do Zambeze (que originalmente incluia os pântanos de Bangueulu, Kafue, Kavango e Okavango) pelo mais recente Médio Zambeze. Discute-se também no relatório a instabilidade e jovialidade biológica de muitas das terras húmidas do Zambeze, particularmente dos pântanos. Este mostrou ser um factor importante na sua relativa composição homogénea ao longo da bacia. As planícies inundadas do proto-Alto Zambeze são vistas como sendo mais estáveis ao longo do tempo evolucionário recente. Parecem ser mais ricas em espécies e possuir maior número de espécies de distribuição limitada em relação aos pântanos.

Embora, talvez, menos altamente modificada que muitas bacias de rios em África, o Zambeze tem sido muito alterado na sua secção média devido a grandes represas em Kariba e Cabora Bassa, assim como em Kafue, no Itezhi-Tezhi e nas áreas altas dos afluentes no Zimbabwe. A composição da biodiversidade tem sido altamente modificada de maneira óbvia e indirecta, através da criação de novos habitats, facilitação de espécies assim como da redução das inundações. Os efeitos do controle de inundações no Delta do Zambeze originaram preocupações de conservação, mas a documentação deste facto é dificultada por falta de informação de base. No entanto, no Alto Zambeze quaisquer alterações na hidrologia, extensão das terras hùmidas e biodiversidade são, principalmente, resultado de ciclos climáticos e não de efeitos de actividade humana.

Uma lista de especialistas, regionais e internacionais, em biodeiversidade de organismos, foi compilada numa base de dados com 135 pessoas citadas. Esta base de dados, de maneira nenhuma exaustiva, está tambem apresentada em forma electrónica com palavras-chave que facilitam uma busca rápida. Os maiores grupos incluidos são plantas e pássaros e a maioria dos especialistas citados estão baseados no Zimbabwe ou África do Sul. O número de especialistas em muitos grupos de invertebrados e microscópicos é seriamente limitado. O importante papel dos naturalistas amadores está enfatizado, particularmente no que se refere a pássaros, grandes mamíferos e borboletas.

Vinte e quatro recommendações são apresentadas. Algumas são gerias e aplicam-se igualmente à bacia como um todo, enquanto que outras cobrem tópicos de investigação. Sugere-se que uma perspectiva sobre toda a bacia é para alcançar isto são precisos uma série de mapas de vegetação, com uma legenda comum. Mais atenção deve ser dada às planícies inundadas velhas e dambos e revisões detalhadas de grupos biológicos seleccionados devem ser levadas a cabo. Zonas particulares para conservação precisam de ser identificadas, assim como as espécies de terras húmidas necessitando de medidas de conservação activas. Uma série de locais de controle devem ser idealmente dispostos ao longo da bacia e podem ser usados para detectar alterações devidas ao impacto humano. A recomendação final geral é de tornar a informação sobre biodiversidade mais acessível, através de publicações apropriadas e artigos noticiosos. Em relação à investigação, menciona-se que esta é necessária sobre processos ecológicos e poder de recuperação das terras húmidas, efeitos do represamento do rio sob as terras húmidas da Bacia do Zambeze e o potencial do uso de organismos aquáticos como espécies indicadoras.

Recomendações específicas, algumas das quais podem ser endereçadas pelo ZWCRUP, são uma revisão e publicação da bibliografia detalhada incorporando uma revisão mais concisa e uma série de actividades relacionadas com as quatro áreas dos sub-projectos. Estas incluem inventário da biodiversidade de grupos seleccionados, produção de mapas de vegetação compatíveis, identificação de locais para conservação e uma avaliação dos efeitos do uso da terra sob a biodiversidade. As actividades específicas para cada zona estão apresentadas em detalhe.

1. INTRODUCTION 1

1.1 BACKGROUND

The Zambezi River and its tributaries constitute one of southern Africa's most important natural resources (IUCN Inception Mission Report 1996), both now and probably increasingly in the future. Given the rapid rate of development and population growth in the Southern Africa Development Community (SADC) region, and the existing shortage of water for urban, industrial and agricultural use, many are looking to the Zambezi River to provide water and hydro-power.

The wetlands of the Zambezi Basin are extensive, particularly in the upper reaches, and are a major resource for many rural people providing, amongst other things, fish and construction materials. However, both the quantity of resources available, and the biodiversity that comprise these wetlands, are little known in formal terms.

There has been increasing interest by IUCN, The World Conservation Union, in wetlands and wetland-related issues worldwide. Within Africa, IUCN has been involved in a number of wetland conservation projects, whilst in southern Africa there have been a number of workshops held since 1991 under the auspices of the IUCN Regional Office for Southern Africa (IUCN-ROSA). Such southern African initiatives resulted in the development, in conjunction with the Canadian International Development Agency (CIDA), of the Zambezi Basin Wetlands Conservation and Resource Utilisation Project (ZBWCRUP), which started in 1996. This project, managed from IUCN-ROSA Harare and funded by CIDA, covers four project areas – the Barotse floodplains of western Zambia, the wetlands of the Chobe-Caprivi area in Namibia/Botswana, the wetlands of the Lower Shire valley in Malawi/Mozambique, and the wetlands of the Zambezi Delta in Mozambique – each with its own Field Project Officer. The 1966 IUCN Inception Mission Report identified various activities which it felt should be carried out. One such activity is the compilation of information on biodiversity for the wetlands of the basin and an assessment of its importance, an activity which is being carried out by The Zambezi Society (a conservation NGO) and the Biodiversity Foundation for Africa (a scientific NGO) – both members of IUCN.

Given the poorly-documented knowledge base on biodiversity within the Zambezi Basin, and the magnitude of the task, it was decided to split this component of ZBWCRUP into two phases (see Proposal for Biodiversity Assessment of Zambezi Basin Wetlands: Third Draft, prepared by the Zambezi Society/BFA in December 1996). A preliminary Phase 1 was to document the existing knowledge base and set the scene for a more-detailed Phase 2 involving focussed field survey (see Terms of Reference, Appendix I, and Section 10). This report is the result.

1.2 WETLANDS AND DEFINITIONS

The first question that has to be addressed when starting a compilation of information on the biodiversity of the Zambezi Basin wetlands is how are these various terms defined? Despite general agreement they are difficult to articulate clearly. For this study the following definitions were adopted:

Biodiversity – a contraction of the words ‹biological diversity', refers to the variety of species, genes and ecosystems comprising the living world (see Section 1.3). It often includes the diversity of ecosystem

processes. The term refers to variety, incorporating the variation and differences among a set of biological entities. It does not refer to utilization of these entities.

Zambezi Basin – this 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 (see Section 2.1.1). However, it has to be recognised that this is not a fixed entity and was substantially different in extent even in geologically-recent times (see Section 2.2). A strict present-day geographical definition does not always make sense biologically.

Wetlands – various definitions have been used in the past. That developed for the Ramsar Convention is not particularly useful in our context. It defines wetlands on the basis of water permanently or seasonally present, which creates difficulties in dry environments where water may only occasionally be found – for example, in dambos. Instead the definition given by Breen (1991), adapted from that used by the US Fish and Wildlife Service, has been adopted here – "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 more biological, defining a wetland on the basis of the species occurring there.

In the bibliography and review, the distinction between wetland and aquatic environments has not always been adhered to rigidly such that some aspects of the ecology of, for example, Lake Kariba, have been incorporated.

Terminology concerning the different wetland types can be very confusing. What is swamp in Namibia, for example, is marsh in Malawi. And where does floodplain end and swamp begin? A good diagrammatic set of definitions has been given by P.A. Smith (1991) for the Okavango (Figure 1.1), and is adhered to here.

1.3 BIODIVERSITY — THE CONCEPTUAL BASE

This section (by F. Cotterill) gives the conceptual basis for an assessment of biodiversity and emphasises the importance of ecosystem and landscape approaches to the subject rather than a solely species-based approach.

1.3.1 **Definitions and scope**

An examination of the complicated relationships between biodiversity and the ecology of a landscape, in this case the larger wetlands of the Zambezi, needs to be built on unambiguous definitions. This need especially applies to the concepts used to define and describe biodiversity, laid out below:

a) Noss (1990) made an important contribution toward formalising the term biodiversity in stating that biodiversity has three key properties ! its structure, its composition, and its function. Furthermore, organisation of the structure, composition and function, and thus their interrelationships, are hierarchical. Thus, these properties are inter-related in scale-dependent ways. The properties of biodiversity vary from genetic, through populations and habitats, to the landscape level.

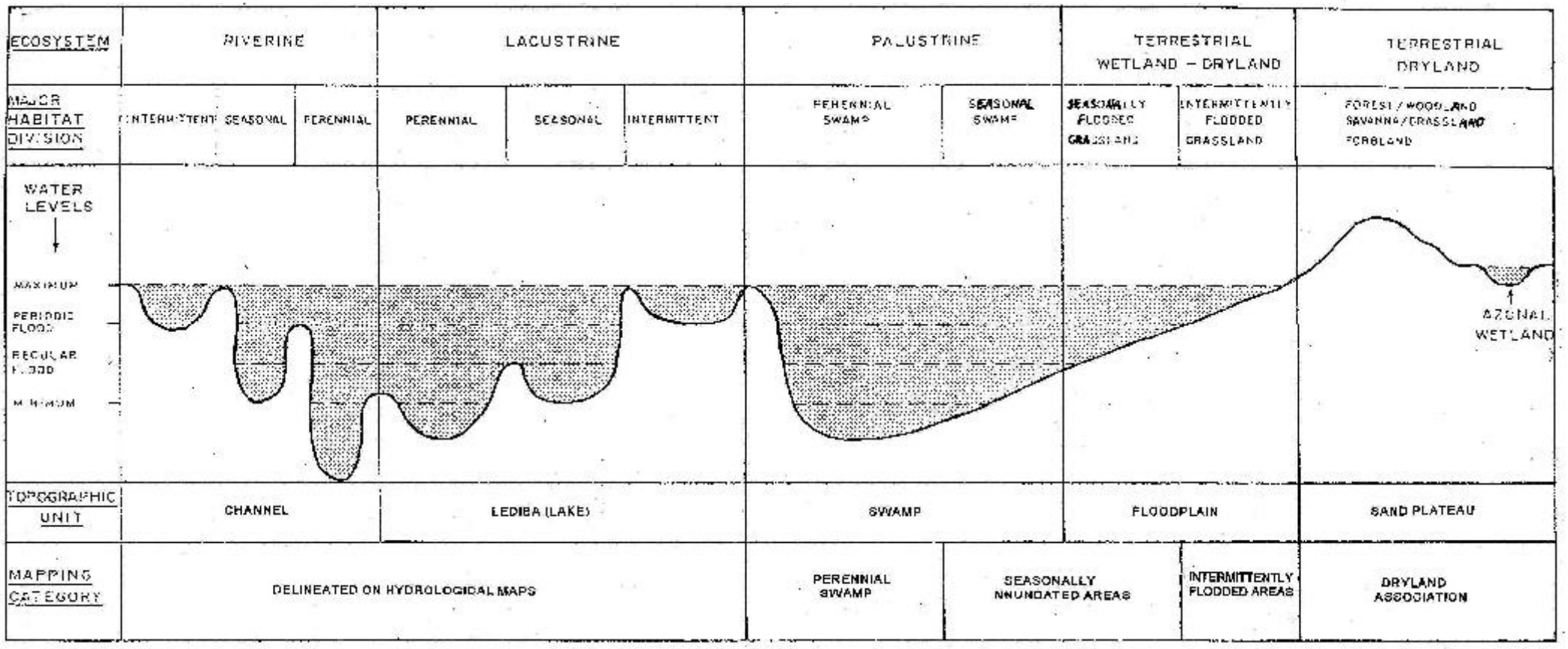

Figure 1.1. Schematic framework of wetland types (from P.A. Smith 1991, for Okavango vegetation).

b) Harper & Hawkesworth (1994) in reviewing the history of the biodiversity paradigm in biology, distinguished between genetic, organismal (the more complete term for population and species diversity) and ecological biodiversity. It is important to note that the term ecological biodiversity refers strictly to the biotic component of the landscape and excludes the non-living components. Using this terminology, ecological biodiversity equates to a stricter definition of an ecosystem in recognising the organisms (and interactions) responsible for processing matter and energy. It also refers to more complex entities as it extends beyond the terms of reference of the ecosystem concept to include processes such as pollination and ecological engineering.

c) Understanding of the ecology and biodiversity of parts of the biosphere, especially large physical entities such as the Lower Shire or Zambezi Delta, benefits considerably from a landscape perspective. This approach is especially useful if it is based on recent advances in landscape ecology (see Forman 1995) where the landscape is depicted as a mosaic of patches with a scale-dependent structure. The properties of these patches can be described in varying detail and used to summarise the structure of the landscape. A wealth of processes are generated within such a landscape mosaic. In a wetland of several hundred square kilometres these include both biological (specifically involving organisms) and biophysical processes (mainly water flow). Thus the properties of organismal biodiversity, in this case in the Zambezi Basin, are structured within a framework of the physical environment.

The relationships between biodiversity and wetland ecology centre around how populations of different organisms influence, and are in turn influenced by, ecological processes within and across patches of habitat in the landscape mosaic. This perspective generates many questions, including the nature of the associations of populations with different habitat patches and their activities within and across patches.

A perspective of how a diversity of different populations use the landscape mosaic introduces the issues of the geometry of patches and the nature of the boundaries separating different patches. This is a fundamental aspect of landscape structure and underpins any consideration of significant change by human agencies. Its relevance is highlighted by the widespread modification of landscapes by human activities. Concerns over fragmentation of the landscape require a thorough understanding of how such changes disrupt the biota in the landscape mosaic (Forman 1995; Turner *et al.* 1995). This is in addition to other effects on the biodiversity of African wetlands, such as introductions of exotic predators, over-utilization and pollution, as reviewed by Stiassny (1996). These considerations should not be limited to surface waters but also need to look at groundwaters (Marmonier *et al.* 1993).

1.3.2 **Sources and sinks**

At fine scales, ecologists have become interested in how populations of organisms respond to landscape boundaries and use the landscape mosaic – a function of the properties and geometries of different patches. Interest, and also increasingly conservation concerns, centre on how these phenomena influence the dynamics of different populations. One useful concept to illustrate these areas of ecology is that of sources and sinks (Pulliam 1988) which recognises that the interconnected populations of a species require habitat patches containing critical resources to survive and breed. Those patches containing resources sufficient to reproduce (thus supporting viable populations) are termed source habitats. Conversely those which allow a population to only exist but not reproduce are termed sink habitats. For example, in the case of wetland birds such as the Wattled Crane, a sink habitat may supply adequate food, but a lack of nest sites, high predation rates or insufficient prey to support fledging of chicks may prevent breeding.

Fish provide another good example of how sources and sinks have wider influences on metapopulations. (A metapopulation is a assemblage of discrete populations.) Many Zambezi river fishes spawn in the headwaters of Middle Zambezi catchments. For example, the dambos feeding the tributaries of the Deka and Matetsi rivers in northwest Zimbabwe are important breeding grounds for many fishes. These areas are seasonally inundated and the warm, shallow nutrient-rich waters support the fry until they grow sufficiently to survive in larger streams and channels (J. Minshull, pers. comm.). Management of river fisheries thus requires the maintenance of these source habitats along watersheds to replenish fish populations. Equal attention needs to be paid to maintaining fish migration routes along these and other tributaries of the Zambezi.

1.3.3 **Further developments in landscape ecology**

Cognisance of landscape patches and boundaries has been developed beyond the idea of sources and sinks into a more formalized theory of how the geometries and properties of neighbouring patches in a landscape mosaic influence populations (Wiens *et al*. 1993). Nonetheless, many of these models have yet to be tested against real world data on the patterns of abundance of species. As far as the Zambezi Basin is concerned, little (if any) consideration has been given to the subject of landscape mosaics, and certainly not to the issues of landscape structure and the dynamics of metapopulations.

With respect to wetlands, the disruption of a drainage system (especially through impoundment) not only disrupts major ecological processes inherent in the hydrological cycle, but also fragments what was originally a contiguous wetland. These effects on organismal biodiversity need greater recognition.

In Europe, attention has begun to focus on ecological links between riparian habitats (such as fringing woodlands) and aquatic habitats as evident in ecological processes across the landscape. These particular systems are susceptible to pollution and fragmentation from human disturbances, with impacts on water quality and nutrient cycling. In the Zambezi Basin, ecologists need to examine how fragmentation and losses of riparian woodland influences the ecology of neighbouring wetlands. For example, acute deforestation along the edges of the Lower Shire valley can be expected to reduce roosts and nesting sites for wetland birds. Such changes may perturb important source-sink habitat relationships. Large scale effects on water quality and nutrient cycling in such systems also need to be evaluated. For example, soil erosion following on the degradation of surrounding local catchments may adversely affect water quality in the Lower Shire.

Assessments, and especially inventories, of a wetland landscape need to consider such aspects of landscape structure alongside evaluating the status of organismal biodiversity, and future assessments of target taxa in the Zambezi Basin should do this. Meaningful understanding of how landscape fragmentation influences the species' status demands careful planning of research priorities and strategy. This type of research is intensive and obviously cannot be carried out at many different sites. More relevant and robust results may accrue from a focus on selected metapopulations in only one area, such as the Barotse floodplain.

An evaluation of landscape changes must pay careful attention to scale issues. At a subcontinental scale ! extending across the entire Zambezi Basin – we need to ask how widespread changes in the composition, and thus structure, of the landscape are affecting species. From this perspective, species are construed as metapopulations – each subpopulation lives in a geographically distinct patch of habitat of similar composition. In our example, all patches are wetlands, or closely associated with wetlands. Thus, wetland

birds such as ducks move between different wetlands in the region, but require critical wetlands (notably seasonally inundated pans) to breed.

Progress could be made by focusing on readily observed taxa for which sound taxonomies exist (e.g. birds, fish, butterflies, dragonflies) whose breeding habits readily exhibit the use of source and sink habitat patches. It is very likely that many other species might rely on source habitats (e.g. flowering plants), but these may require much more effort to identify and study. Such investigations require a foundation of natural history knowledge on what different organisms require to breed successfully – there may be critical thresholds in altering the structure and composition of a source habitat below which its relevance as breeding habitat declines rapidly. Research which focuses and elaborates on scientific understanding of the dynamics and structure of wetland landscapes could be structured as follows:

a) Landscape-level mapping of wetlands in the region, paying due consideration to seasonal wetlands (pans, dambos and watersheds). These maps need to identify and delineate source and sink habitats where constraints of scale permit.

b) Identification of indicator taxa, whose metapopulations are reliant on key source habitats for their long term survival, and more detailed studies of their resource requirements.

c) Monitoring of these indicator taxa would provide an early warning system of degradation and disruption of processes and/or parts of the landscape. This information could be applied to identify threats to biodiversity further afield and to the overall ecology of interconnected wetlands.

1.3.4 **A continental perspective**

It is critical to realise that no landscape is static – its patches of habitat change in space and time as their relative domination of area increases or decreases. Furthermore, the composition of different patches also changes. The net effect is an overall change to the environment and to conditions for the species present. At an extreme scale, consider the consequences of how changes to the Zambezi Basin overall, over hundreds of thousands of years, have influenced biodiversity. This should provide us with some insight into how processes within metapopulations at ecological scales (e.g. in source and sink habitats) generate large scale changes across a more extensive landscape at evolutionary scales.

The tectonically-induced disruptions of the Zambezi system, especially to its upper reaches, appear to have radically altered patterns of distribution of organismal biodiversity across the entire basin. Metapopulations of vertebrates were fragmented and cut off, and the eventual consequence has been an increase in organismal biodiversity as seen, for example, in the wetland antelopes. The lechwe (*Kobus leche*) was originally a single metapopulation, but links and thus gene flow between geographically separated subpopulations broke down perhaps hundreds (or even tens) of thousands of years ago. Fragmentation of the landscape over this period has had considerable impact on the original metapopulation. As seen with these aquatic antelope, the net effect has been an increase in organismal biodiversity at a landscape scale, effected through high rates of allopatric (having separate and exclusive areas of geographical distribution) speciation.

1.3.5 **Organismal biodiversity and ecological processes**

This relationship between the magnitude and properties of biodiversity and the two-way influence on ecological processes at a landscape scale is one of the more poorly understood, but more important, topics in ecology and landscape management. A critical question is how an overall (and often catastrophic) loss of organismal biodiversity alters the processing and transfer of energy and matter in the landscape. The subject has been recently reviewed (Lawton 1994; Mooney *et al*. 1995; Naeem *et al*. 1995; Tilman 1996), but understanding is limited by a lack of data. Too few studies have been done, so there is at present an insufficient range of data from the landscapes of the biosphere from which to draw an understanding.

The concern over wetlands also needs to focus on how changes to the landscape, and thus biodiversity, changes the quality and quantity of water. Nutrient cycling is of equal concern. With regard to the Zambezi wetlands, it is not currently possible to review how changes in the magnitude (overall species richness) and species composition of organismal biodiversity have, or will, change the properties of ecosystems at the landscape scale. The precautionary principle should be applied. Given concerns over water quality, and the timing of runoff, a study in the south west Cape of South Africa is instructive (Cowling *et al.* 1996). This identified that a major benefit of diverse fynbos habitats, compared to those dominated by exotic plants, is the maintenance of high water yield from mountain slopes. In this particular example, the management recommendation to maintain and restore fynbos is underpinned by a sound economic argument for maintaining mountain catchments to support lowland society and industry.

1.4 STRUCTURE OF THE REPORT

An explanation of the definitions used in the report (Section 1.2) is given in Chapter 1 along with an account of the conceptual base of biodiversity (Section 1.3). Following this, the physical features of the Zambezi River and its main tributaries from its source to the delta are described in Chapter 2, including a discussion of the palaeo-geography of the basin over the last few million years. It is felt that a comprehension of these processes over recent geological and evolutionary time is important in gaining an understanding of the biodiversity of the wetlands and in assessing its importance to conservation.

Chapter 3, in conjunction with the annotated bibliography in Appendix VI (a slightly more exclusive version, incorporating only references on biodiversity, is given on the accompanying disk), gives an overview of published and unpublished literature concerning the biodiversity of the Zambezi Basin wetlands. The four IUCN Wetlands Project areas receive particular emphasis. Major gaps in this knowledge are identified and discussed.

This assessment is followed by a preliminary attempt to identify possible conservation focal points – sites and species of particular interest – in Chapter 4. Chapter 5 gives an account of the effects of dams on the biology of the Zambezi and associated rivers, followed by brief descriptions of changes in the various wetlands over the last 100-150 years.

Expertise in wetland organismal biodiversity from the Zambezi Basin is described in Chapter 6 and listed in Appendix III, and gaps in such expertise are discussed.

A preliminary ecological stratification of the four IUCN project sites was to have been given in Chapter 7. Unfortunately, satellite imagery was not available in time, so the chapter only gives an outline of ecological mapping to date.

A preliminary assessment of the role and importance of the Zambezi Basin wetlands in regional biodiversity conservation based on existing knowledge is given in Chapter 8. The major conclusions from the study are outlined in Chapter 9 along with recommendations for future activities. Outputs are also related to those laid out in the Terms of Reference.

A proposal covering activities that could usefully be carried out in Phase 2 forms Chapter 10.

1.5 REFERENCES ON BIODIVERSITY CONCEPTS

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2. DESCRIPTION OF THE ZAMBEZI BASIN 9

2.1 PHYSICAL DESCRIPTION

2.1.1 **Introduction**

The Zambezi Basin lies across South Central Africa and drains into the Indian Ocean north of Beira (Figure 2.1). It is approximately 1.3 million km² in extent (Hughes & Hughes 1992) 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, being of Karoo age (120 million years) or older. 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 (see Section 2.2).

The Zambezi River is often divided into three distinct geographical sections – the Upper Zambezi, Middle Zambezi and the Lower Zambezi (Figure 2.2; Bell-Cross 1965a, 1972; Hughes & Hughes 1992; Main 1992). These are discussed more fully below. In this discussion the main geomorphological features of each section of relevance to biodiversity are highlighted, and brief mention is made of the major biological features. Although the Bangweulu Swamps and Lakes Malawi and Chilwa are included in the bibliography and reviewed as part of the biologically-defined or proto-Zambezi, they are not covered here.

2.1.2 **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, NW Zambia, through Angola and Barotseland to the Victoria Falls (Figure 2.2). It is at this latter point that the river markedly changes its character, ecology and typical flora and fauna. The Upper Zambezi, for the purposes of this discussion, 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.

The character of the initial section, from Mwinilunga to Cazombo in Angola, is of tall dense miombo woodland, rich in species with affinities to the moister Congo Basin. Swamp and gallery riverine forests are common. The flat nature of the landscape along the watershed has allowed some water-dependent species to move from one catchment to the other. After flowing south-west, the Zambezi turns due south downstream of Cazombo. And it is from here that the very extensive grassland areas, by far the largest expanse of natural grassland in the whole Zambezi Basin, start. These encompass most of the western tributaries all the way to the Cunene River and the Caprivi.

Downstream of the Angolan border in Barotseland, the river becomes larger and more consolidated, forming a series of floodplains which flood annually. Habitats are generally broad, and species composition changes to reflect the lower rainfall and less tropical conditions. South of Senanga, where the river turns to the south east, the floodplain abruptly narrows. The river is

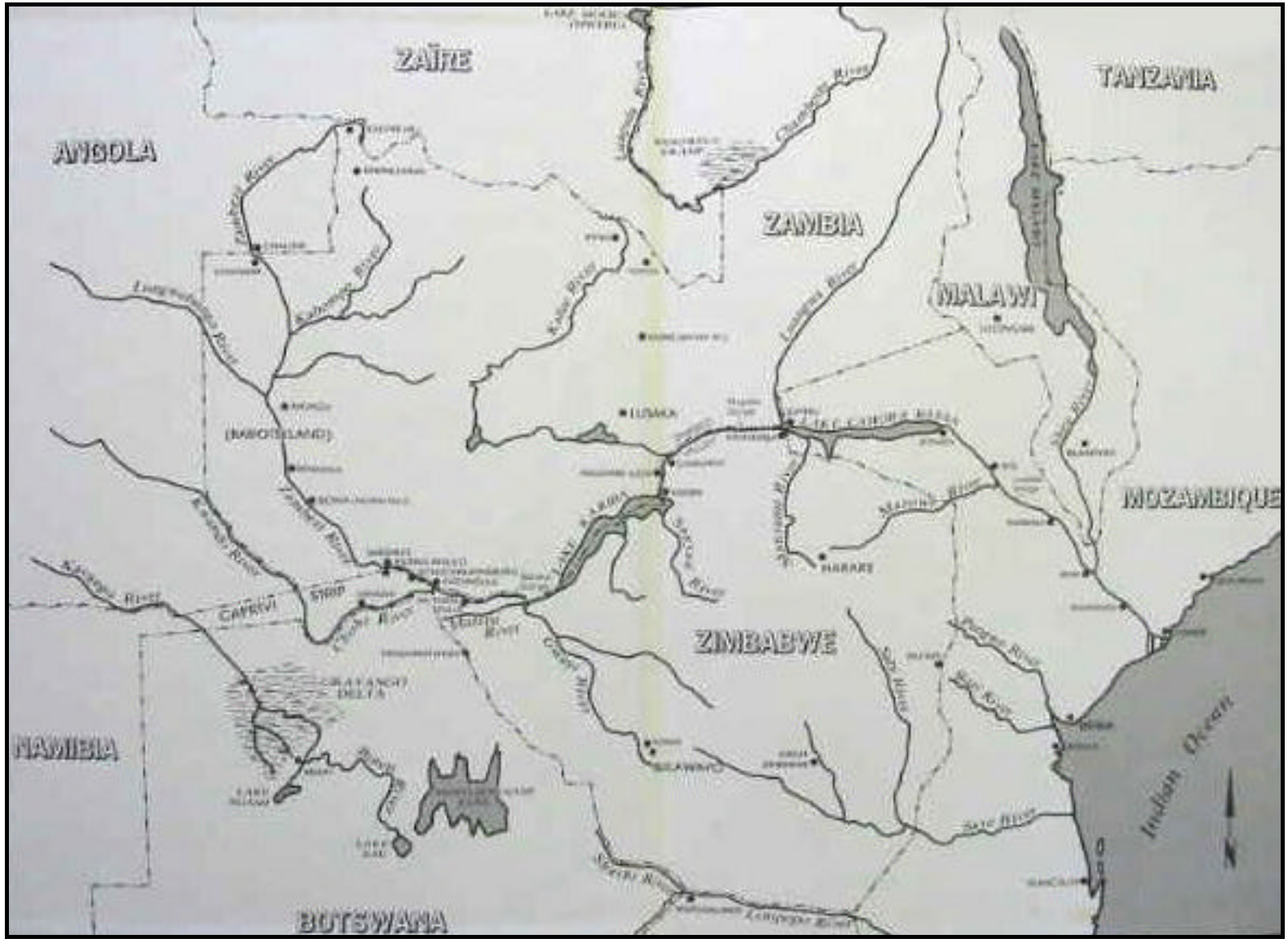


Figure 2.1. The Zambezi Basin (from M. Main 1992).

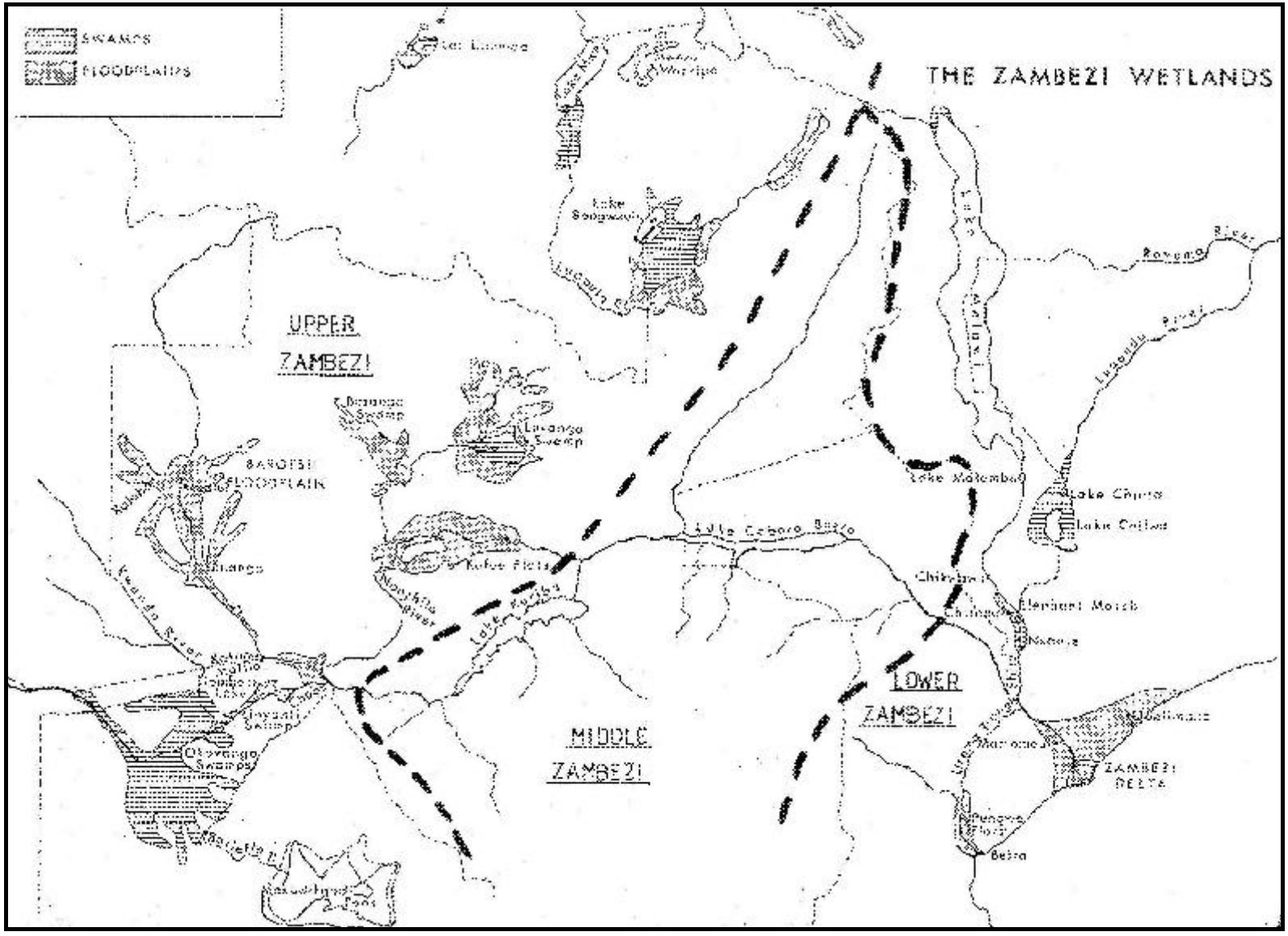


Figure 2.2. The Zambezi wetlands (drawn by D. Broadley, based on White 1983).

more channelled and flanked by plateaux of Kalahari sand covered in extensive semi-evergreen woodland, which typically support species of economic value such as *Baikiaea plurijuga* and *Pterocarpus angolensis*. The extent of wetland is much reduced and is confined primarily to dambo-type grasslands along the larger tributaries. In some areas pans are common.

At Katima Mulilo the Zambezi turns markedly to the east, and broad floodplains are again found all the way to Kazungula where it joins the Chobe River. This section has been the meeting place of various river systems – the Kafue, the Kwando and the Upper Zambezi – and was once the site of a large inland lake, Lake Caprivi, thousands of years ago. The Kwando River (in Angola, the Cuando), rising in the highlands of central Angola, flows southward into the Caprivi not far from Katima Mulilo, then forms a series of swamps – the Linyanti Swamps – along the border with Botswana. Downstream, the Kwando-Linyanti flows east towards the Chobe River, meeting it at the now dried-up Lake Liambezi. It is difficult to draw a distinction between the Kwando, Linyanti and Chobe rivers, and the Chobe is also characterised by bi-directional flow, depending on water levels and flooding from the main Zambezi.

From Kazungula to Victoria Falls the river is broad but without marked floodplains, flanked by dense, deciduous woodlands on Kalahari sand. At Katombora the Zambezi starts to cut into the underlying Karoo basalts, and then goes on to form the famous Victoria Falls 60 km downstream. Here it changes its character from a broad, slow river into a fast confined one. Its biology and associated fauna also change dramatically – the Falls are perhaps the main biogeographical barrier or disjunction of the whole basin.

The famous Okavango Swamps are a large inland delta formed where the Kavango/Okavango river system, which also rises in the highlands of central Angola, spreads out into the Kalahari sands in NW Botswana and mostly evaporates. Although not now directly linked hydrologically to the Zambezi Basin, except in years of exceptional flood through the Selinda Spillway, the two systems are still connected biologically. The Okavango has a similar ecology to that of the Linyanti Swamps, but is far more extensive with a more reliable and larger inflow. It is characterised by stands of papyrus reeds (*Cyperus papyrus*) and other aquatic grasses and sedges in the upper parts, while large tree- and palm-covered islands separated by wide vegetated channels characterise the lower reaches. The Okavango is the largest extent of perennial swamp within the Zambezi Basin.

Although the Kafue is now often regarded as part of the Middle Zambezi, some hundreds of thousands of years ago it was part of what is now the Upper Zambezi, with which geomorphologically and biologically it still has much in common. Rising in the Copperbelt of Zambia, it is characterised over much of its length by broad floodplains and swamps, such as the relatively poorly-known Lukanga and Busango swamps. The Kafue River is impounded at Itezhi-Tezhi Dam where it turns sharply to the east from its previous NE-SW orientation. At this point it used to continue to the south west until joining the Upper Zambezi near Kazungula. From Itezhi-Tezhi to the Kafue Gorge dam, just upstream from its confluence with the Middle Zambezi at Chirundu, the Kafue River forms a wide productive floodplain – the Kafue Flats – which have been the focus of many studies over the last 30 years. These studies were mostly in response to the construction of dams and consequent changes in flood regime, and make it one of the best-studied wetlands in the region.

2.1.3 **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, other people, including most ichthyologists, 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 (D. Broadley, pers. comm.; Bell-Cross 1972; Skelton 1994). 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. But 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.

The upper part of the Middle Zambezi consists of the Batoka Gorge, a deeply-incised gorge through basalt comprising a rheophilic (fast water) environment with little in the way of littoral habitat. A marked contrast to the broad, gently-flowing river above.

The construction of Lakes Kariba and Cabora Bassa has created extensive lacustrine and slow-water environments in what was a fast-flowing river. Littoral (shoreline and shallow water) and benthic (bottom-dwelling) habitats are now extensive, while previously they were very limited. Thus not only has the physical character changed significantly, but so have the flora and fauna. Fish species from the Upper Zambezi can now establish themselves in the newly-formed lacustrine environment, and it is perhaps only a matter of time before some of the biogeographical differences between the Upper and Mid/Lower Zambezi break down. The river is becoming biogeographically more homogeneous.

The stretch of river between Kariba and Cabora Bassa lies in what is thought to be (indirectly) a branch of the Great East African Rift Valley, flanked by escarpments around 50-100 km apart. There are a series of gorges along this stretch, for example Kariba, Mupata and at Cabora Bassa, which confine the river and greatly modify its ecology, but add to the diversity and ruggedness of its character. The annual floods are now no more, except perhaps locally where large tributaries join, owing to regulation by Kariba dam. The resulting changes to its ecology include reduced grassland and wetland vegetation, encroachment by trees, and over-utilization by large herbivores. The area has been the focus of many biological studies, primarily on large herbivores or vegetation. Most of this stretch of the river in both Zambia and Zimbabwe is conserved as National Park or controlled hunting area. The Lower Zambezi National Park in Zambia, despite its name, lies within the presently-defined Middle Zambezi.

Below Cabora Bassa the river has a similar fast-flowing and confined character as above the lake, hence inclusion within the Middle Zambezi in the present report rather than in the Lower Zambezi. Further biological evidence may help clarify this point in the future. This section contains still more gorges as the river cuts through the Karoo sandstones and basalt, and it is at some of these that the construction of other dams has been suggested. The area is hot and dry, with low open woodland with scattered baobab trees. Surprisingly little has been recorded on the biological features of this section – just a few collections from near Tete.

The Luangwa, a substantial tributary which joins the Zambezi at Zumbo at the head of Lake Cabora Bassa, forms a comparatively narrow valley with little development of wetland habitat or floodplain, although some plants and animals typical of wetlands are found there.

2.1.4 **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 old course of the Shire probably ran southward from its present confluence with the Zambezi at Caia, along the Urema trough in Gorongosa National Park (what is now Rio Mudha and Rio Mucombeze) to join the Pungwe, reaching the sea at Beira. Although the Zambezi now has probably little hydrological influence on, and is not influenced by, the former course of the Shire, biologically they are still joined – the alluvial and floodplain soils form a continuum. Thus any conservation activities should incorporate, or at least take cognisance of, the Gorongosa ecosystem right down to Beira. The wetlands from Quelimane to Beira form a series of interconnected swamps, grasslands and marshes – interconnected biologically but not necessarily hydrologically.

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 famous area of Marromeu with *Borassus* palm savanna and short grassland interspersed with creeks. This is what is often thought of as the Zambezi Delta, yet it is less than half of the total wetland area. And it is a moot point whether the Marromeu wetlands are now principally fed from the Zambezi, or from seepage and runoff from the Cheringoma plateau to the west.

Towards the Indian Ocean coast extensive areas of mangrove forest flank mud-lined tidal creeks, an environment obviously not found anywhere else in the Zambezi Basin. The coastal extent of the delta is at least 200 km, much more if the tidal creeks and inlets are added. Where the mangroves are interrupted by sandy beaches, low dune forest can be found above the high water mark.

Taken as a whole, the Zambezi Delta is not only the second largest wetland of the basin, but is perhaps the most diverse in terms of habitats, if adjacent non-wetland vegetation is included. The comparative lack of

development and settlement means that the area has one of the best conservation potentials in the region, yet it is perhaps the least known biologically.

2.2 PALAEOGEOGRAPHY OF THE ZAMBEZI BASIN

The modern course of the Zambezi River is relatively young, dating from the Pliocene (around 3-4 million years ago) or as recently as the mid-Pleistocene (1 million years ago). The date generally given is lower to mid-Pleistocene (1-2 million years ago). It has evolved through drainage capture and tectonic activity, and abrupt changes in direction and characteristics suggest that the Upper and Middle/Lower Zambezi evolved as separate river systems, only to be linked relatively recently (Thomas & Shaw 1988). There appear to be no clear dates for the various stages in its evolution, or agreement on the order in which they occurred. It is probable that what is sometimes looked upon as a string of individual events over this period was, in reality, a series of progressive switching of flow and drainage patterns corresponding to the known large climatic fluctuations which have occurred. Much of the discussion below on the Upper and Middle Zambezi draws on publications by Thomas and Shaw (e.g. Shaw 1988; Shaw & Thomas 1988; Shaw & Cooke 1986; Thomas & Shaw 1988, 1991) and on the popular account by Michael Main (1992); comments on the Lower Zambezi are more speculative and have not yet been substantiated by research (but see Tinley 1977).

2.2.1 **Upper Zambezi**

The proto-Upper Zambezi, the interconnected drainage system which existed before the formation of the modern Zambezi, was a large extensive system draining a sizable portion of the southern part of the Central African Plateau, possibly over millions of years. It included the proto-Chambeshi in northeast Zambia, the headwaters of the Kasai, the proto-Kafue, possibly the proto-Luangwa, the Kwando and the Okavango (Figures 2.3 and 2.6). Most of these rivers met in the vicinity of the present-day East Caprivi, and this large amount of water is thought to have flowed through the Okavango to the Makgadikgadi, through what is now the northern Kalahari, to the present-day Motloutse or Shashe rivers in eastern Botswana. From here it is believed to have flowed down the Limpopo to the sea. The Limpopo today is a large valley with little water, and it seems quite likely that it was carved by a much larger flow which has dried up over the last few million years.

However, about 5 million years ago there was a series of major tilting movements along the ‹Kalahari-Zimbabwe' axis in the vicinity of the Makgadikgadi, coupled with possible downwarping in the Okavango region, causing interruption of this flow (Figures 2.5 and 2.7). The result was ‹ponding up' of the waters of the Upper Zambezi to form the palaeo-lakes Makgadikgadi, Thamalakane and Caprivi. At some stage during various wet epochs, or possibly at many times, these lakes built up to cover large areas (palaeo-Lake Makgadikgadi has been estimated to cover over 80,000 km² and palaeo-Lake Caprivi 2,000 km²) and then overflowed at the lowest point ! which was in the Katombora area just downstream from the present Chobe-Zambezi confluence. This overflow assisted the capture of the waters of the proto-Upper Zambezi by the aggressive, backward-cutting Middle Zambezi (Figure 2.4). The river capture process was possibly essentially complete by about 0.5-1 million years ago, but there is still uncertainty over dates. Thomas & Shaw (1991) state that the development of the Batoka Gorge and Victoria Falls on the Middle Zambezi, fed by the vastly increased flows from the Upper Zambezi, was occurring rapidly during the middle Pleistocene, about 250,000 to 500,000 years ago, implying that river capture was perhaps not fully complete at that time. And Nugent (1990) gives evidence, based on the “Stony Ridge” (old alluvial deposits in the Mana Pools area dated to 125,000 years ago by reference to Middle Stone Age artifacts), of a

"cataclysmic" flooding event at that time. This he ascribes to the overflowing of the palaeo-lakes of the proto-Upper Zambezi and river capture. The various publications by Shaw, Thomas and co-workers on palaeo-lakes Makgadikgadi and Caprivi, suggest that they were still fairly full (although variable in height of the shoreline) even up to about 35,000 years ago. It is not clear how much of the water from the Upper Zambezi at this time was going into these lakes, and how much into the Middle Zambezi. What is clear, however, is that these vast palaeo-wetlands fluctuated greatly in extent through the Late Pleistocene primarily in response to large changes in climate, and not just to tectonic movements and shifting hydrological patterns.

Probably at some time prior to the capture of the Upper Zambezi, some of its other tributaries were captured by the Middle Zambezi or rivers draining into the Congo Basin, which would have the effect of reducing flows at the Caprivi confluences. The headwaters of the present-day Kasai were captured by the north-flowing proto-Kasai, which drains into the Congo River and flows out to the Atlantic. The Luapula, another tributary of the Congo, captured the Chambeshi in the vicinity of the present-day Bangweulu Swamps in NE Zambia (Figure 2.3). It is not clear if the swamps pre-date this capture, or are a result of ‹ponding' in a relatively flat landscape. A tributary of the Kafue, the one that now flows (in the opposite direction) through the Kafue Flats, was captured by a small tributary of the Middle Zambezi in the Kafue Gorge area. Owing to the flat or only gently undulating landscape, the waters of the Upper Kafue started to flow along this tributary in the vicinity of Itezhi-Tezhi, leaving the proto-Lower Kafue dry. Evidence for this can still be seen in the series of poorly-drained alluvial flats stretching from a 2 km-wide gap in the present-day Kafue-Zambezi watershed near the Itezhi-Tezhi dam to a point on the Zambezi just downstream of Katima Mulilo. The proto-Luangwa, for which evidence is much less convincing, was possibly captured by a tributary of the lower part of the Middle Zambezi much earlier. There is also evidence that a number of the westward-flowing tributaries of the present-day Gwayi River in NW Zimbabwe, which drain the Kalahari sands of Matabeleland, may also have flowed westwards into the palaeo-lakes of the Upper Zambezi (Figures 2.6 and 2.7). The existence of old lacustrine sediments (alluvium) in the Kazungula, Kazuma, Pandamatenga and Nata River areas (Figure 2.8) could only have come from much larger flows and larger catchments than at present.

The biological significance of the above discussion is that, in the fairly recent evolutionary past, large parts of the Central Africa Plateau were connected hydrologically, and wetland organisms had an easy means of dispersal across them. Although the floodplains may have been more stable over the hundreds of thousands of years involved, it is clear that the swamps and lacustrine environments fluctuated greatly in occurrence, extent and (probably) composition. Indeed, wetlands were possibly a lot more extensive some hundreds of thousands of years ago than they are now, and what we see today are the evolutionary results of that widespread distribution.

2.2.2 **Middle and Lower Zambezi**

There is much less evidence on the geomorphology and evolution of the lower parts of the Middle and Lower Zambezi than there is for the Upper. What is presented here for the Lower Zambezi is largely speculative and based on our interpretation, but seems to fit the patterns seen on the upper reaches. There appears to be no documented evidence on the matter, but Tinley (1977) alludes to this possibility.

Fig 2.3

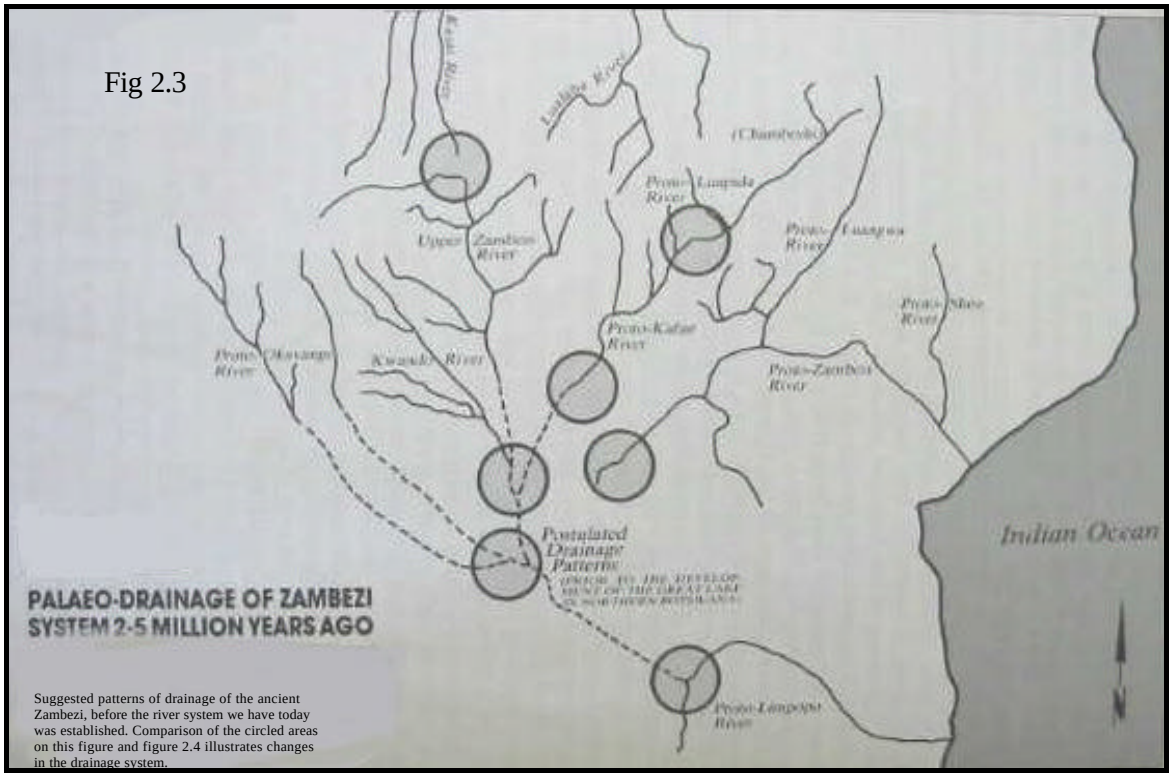
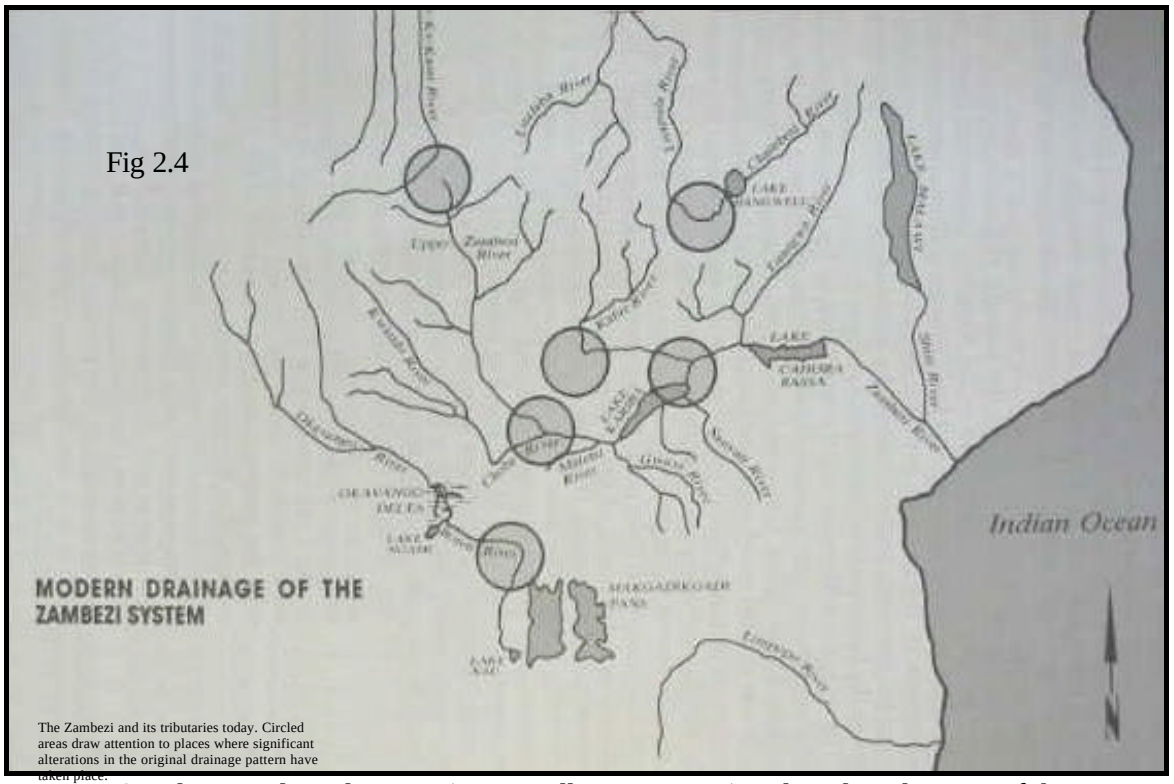


Fig 2.4



Figures 2.3 and 2.4. Palaeo-drainage (2 to 5 million years ago) and modern drainage of the Zambezi system (from M. Main 1992, pp.6-7, based on Bell Cross 1982).

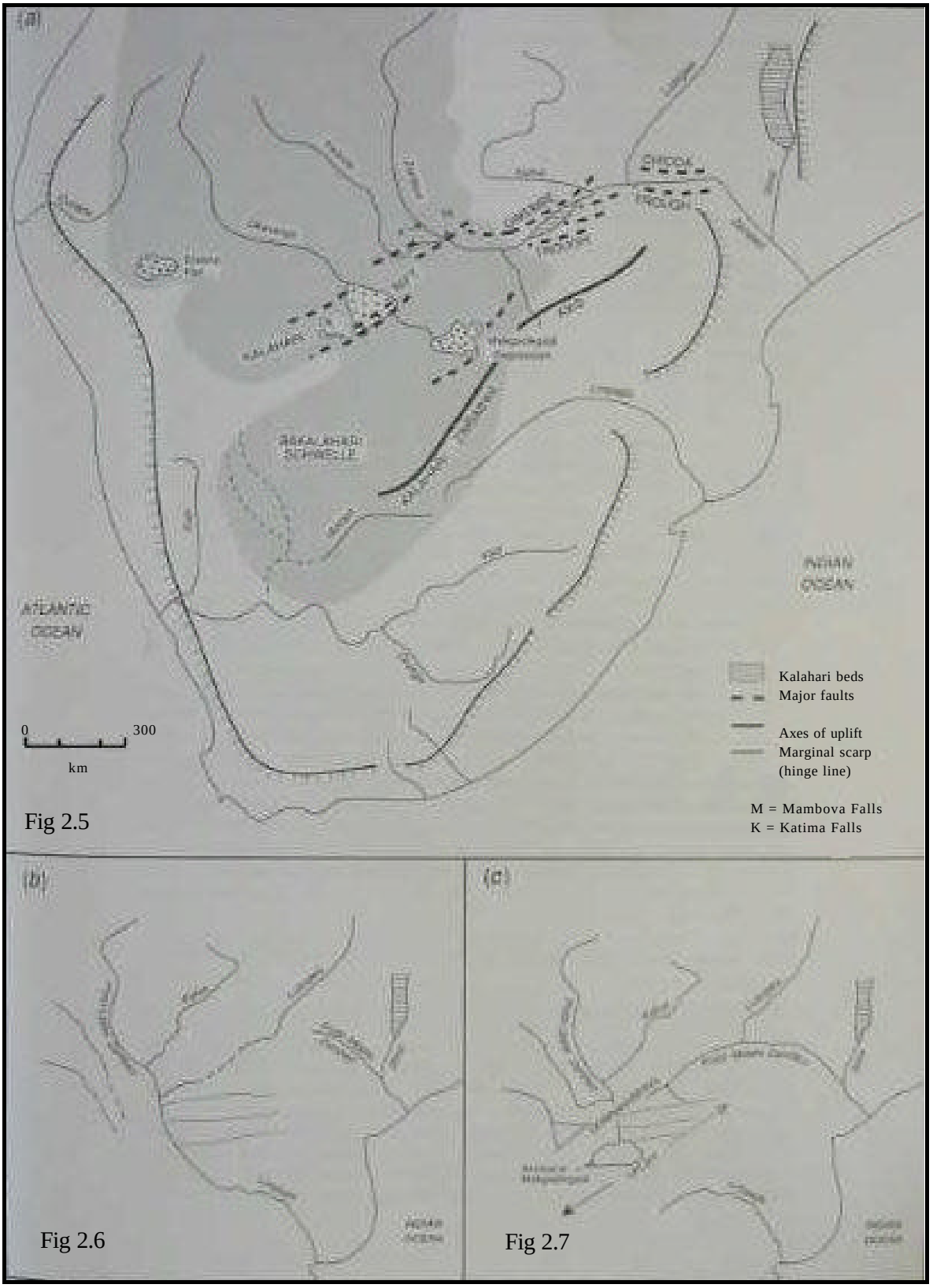


Figure 2.5. Drainage development in southern Africa: major modern drainage lines
Figure 2.6. Drainage development in southern Africa: after the division of Gondwanaland
Figure 2.7. Drainage development in southern Africa: prior to river capture of the Upper Zambezi in the Pleistocene (all from Thomas & Shaw 1991, p.35).

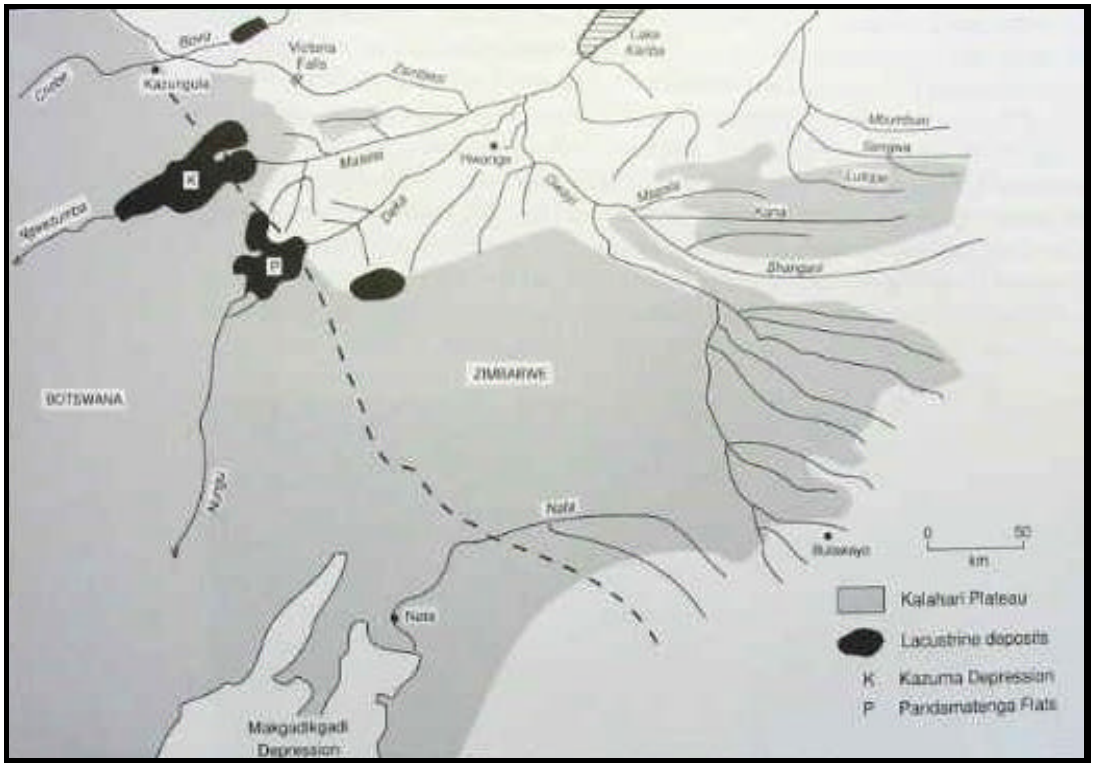


Figure 2.8. Pleistocene lacustrine deposits associated with the Zambezi in Botswana-western Zimbabwe (from Thomas & Shaw 1991, p.37).

It is not clear what role the formation of the Great East African Rift Valley has had on the Middle Zambezi. Although the fault-defined Zambezi Valley and the Gwembe and Chicoa troughs are sometimes stated to represent branches of the Rift, it is more likely that they represent lines of weakness around the Zimbabwe craton which fault more readily under tectonic stress (Stagman 1978, in Main 1992). The East African Rift is where the continent is beginning to pull apart as crustal plates move and the Zambezi troughs are probably linked to this tectonic instability, but are not incipient rifts themselves. The gorges at Kariba, Mupata and Cabora Bassa are formed in very old hard rocks, while Lupata gorge is also formed in hard rocks, but of younger age (120 million years). The suggested mechanism whereby the relatively young Zambezi River has cut into them, rather than finding a way around them, is that the rocks now exposed were previously covered in a thick layer of younger sedimentary rocks, over which the Zambezi flowed and carved its course following topography at that time. As the land uplifted (see Tinley 1977) the river cut down eventually reaching the older crystalline rocks. Having already carved its course, and the process of erosion being relatively slow, the Zambezi would then cut down equally into hard and soft rocks, but the incision through hard crystalline rocks would be more in the form of a gorge. The softer sedimentary surrounding rocks, meanwhile, have subsequently eroded away to leave a more gentle topography.

Nugent (1990) has studied the palaeo-geomorphology of the Mana Pools area in the Middle Zambezi and suggests that the deposits of older alluvium here predate the capture of the Upper Zambezi. With increased flow since the capture it appears the Middle Zambezi has been cutting into its bed (degrading) while previously it was depositing (aggrading). Some wetlands were probably present as the floodplain was well-developed. The floodplains and swamps of the Upper Zambezi form an efficient sediment trap, thus there is now little sediment available for deposition downstream.

Unlike the Middle Zambezi, Lake Malawi is part of the Great East African Rift Valley, and probably 1-2 million years old. During the Pleistocene (over the last 1 million years) lake levels fluctuated greatly owing to climatic fluctuations rather than tectonic activity, a phenomenon which continues today. In a very interesting paper, Owen *et al.* (1990) show that before 25,000 years ago the level of Lake Malawi was about 250-300 m lower than at present (the deepest part of the lake is now around 785 m, i.e. below sea level, while much of the southern portion is only 100 m deep). They go on to document changes over the period since then, and present evidence that the lake was 120 m lower than now around AD 1500-1850. Thereafter it filled rapidly, as Livingstone documented during his travels and others have done this century. A major biological consequence is the suggestion (Owen *et al.* 1990) that most of the 200 endemic "mbuna" rock-dwelling cichlid fish species have evolved since then, i.e. within the last 200 years. Such rapid cases of speciation, admittedly in a group with mating behaviour to enable rapid allopatric speciation, is remarkable. Much of the water in the Shire River is overflow from Lake Malawi, thus during the lengthy period of low lake levels it is likely that the wetlands of the Lower Shire were either non-existent, or significantly smaller in extent.

It has long been recognised that the Urema Trough in Mozambique, running all the way to the coast and including Gorongosa National Park, is an extension of the Rift Valley (Tinley 1977). Geological maps also show a broad belt of alluvial deposits running from the Lower Shire to Beira. A possible scenario is that the proto-Shire flowed from Lake Malawi, following the line of the Rift through the Shire and Urema grabens due south to Beira, being joined by the Pungwe soon before reaching the sea. The present Lower Zambezi, from Caia upstream to Cabora Bassa and beyond, was previously a large tributary. With successive river captures by this large tributary (e.g. of the Luangwa and possibly the Kafue), and the later major capture of the proto-Upper Zambezi, the quantity of water was sufficient (particularly during floods) for the tributary, the proto-Middle Zambezi, to "jump" across the poorly-defined Rift and exit to the sea near the present-day Chinde. The extensive alluvial deposits of the Zambezi Delta would have formed since this time. If this scenario is correct, the wetlands of the Zambezi Delta and of the Lower Shire are very recent in evolutionary terms and have not had much opportunity to develop a distinct fauna and flora. The wetlands of the Pungwe and the Rift, however, are likely to be much older, and it is here that species of restricted distribution might be found.

3. BIBLIOGRAPHY AND LITERATURE REVIEW 21

3.1 BIBLIOGRAPHIC DATABASE

3.1.1 **Introduction**

One of the problems facing science and development within the region is the disparate nature of much of the literature. While much has been published, its location is often obscure, and poor cataloguing and archiving of unpublished literature compounds its inaccessibility. Too many projects, whether in development, conservation or research, tend (at least in part) to "reinvent the wheel".

The documentation and review of available literature was the major component of this phase of the project. Hence, a strong effort was made to seek out and obtain much of the published and unpublished literature, principally scientific but also general studies, pertaining to the biodiversity and ecology of the wetlands of the Zambezi Basin. Vegetation maps were also included where appropriate.

3.1.2 **Criteria**

A discussion of the biodiversity of the wetlands of the Zambezi Basin will vary in breadth depending on how key terms – biodiversity, wetlands, Zambezi Basin – are defined. A broad interpretation of the word biodiversity, for instance, would necessitate much effort to obtain a comprehensive coverage and would also create a lack of focus in its handling and interpretation. A restrictive definition of the words wetlands and Zambezi Basin would result in some useful information being excluded. Thus a restrictive definition of the term biodiversity was adopted, but with a more liberal interpretation of the terms wetlands and Zambezi Basin (see Section 1.2).

Biodiversity is taken to mean the diversity of living organisms and ecological processes. Although genetic diversity is often included, in practice it does not feature significantly in regional literature on wild populations. Purely taxonomic literature (descriptions of new species, accounts of new records, revisions, monographs) was excluded unless of particular relevance to wetland biodiversity or ecology. Accounts of utilization of biodiversity were not included, nor were accounts of conservation projects or resource economics – overall the focus was quite tightly biological. A particular effort was made to cover biogeographical and palaeogeographical literature in order to obtain a good basis for the overall assessment and review (see Chapter 8).

Wetlands have often proved hard to define. The Ramsar definition is often not appropriate to the Zambezi situation owing to extensive, rarely wet, floodplains, the ecology of which is determined by excess moisture. A more practical definition is given by Breen (1991), based on soil and vegetation properties. In the case of the bibliography, the term wetland was taken to include seasonal floodplains as well as pans and dambos, although the literature search on the latter two was much less intensive. References solely concerning open water (e.g. fishery of Lake Kariba) were generally excluded.

In present-day geographical terms, the Zambezi Basin is not hard to define. However, confusion can arise over the status of Lake Malawi and of the Okavango swamps (which are occasionally linked to the Chobe in wet years via the Selinda Spillway and Savuti Channel). The former is often regarded as a separate entity. Biologically the Zambezi Basin is far less clearly defined, not least in that it is only a million years old or less. There is sufficient geomorphological and biological evidence (see Section 2.2) to suggest that the Kwando River, Okavango Swamps and Bangweulu Swamps were all part of the same system. Thus, in the bibliography, references to these areas have generally been included, although an exhaustive search has

not been made. Likewise, major references to Lake Malawi (particularly in regard to the endemic fish populations) have been included, as have major references on Lake Chilwa in southern Malawi, which technically is not connected to the Zambezi system. The Urema Trough (Gorongosa) and Pungwe Flats in Mozambique are not really part of the present Zambezi system, but are probably relics of the palaeo-Lower Zambezi. Major references to them have been included.

Although the scope covered all wetlands of the Zambezi Basin, a particular effort was made to cover all references pertaining to the four IUCN study areas – the Barotse floodplain, Chobe/Caprivi wetlands, the swamps of the Lower Shire and the Zambezi Delta.

All references cited in the report are given, with abstract, in the annotated bibliography (Appendix VI). The disk version accompanying this report contains slightly fewer references – only those strictly pertinent to the biodiversity of wetlands in the Zambezi Basin (i.e. it excludes palaeogeographical references and those solely covering historical events).

3.1.3 **Format**

All references were entered into a standard bibliographic database - ProCite for DOS, and later transferred to the database program Idealist. Various formats were created (journal, book, chapter in book, report, proceedings, thesis). Bibliographic data were entered in fields (author, title of paper, ISBN, etc.). A brief abstract covering the major content of the reference and its findings regarding biodiversity in the Zambezi Basin wetlands was written. The comment‹Not seen' in the abstract means that this reference has not been physically seen, only references to it. Lastly, a set of keywords (Appendix V) was developed and those appropriate to each reference entered. The references are sorted into alphabetical order by author, followed by date.

Retrieval in the accompanying Read-Only disk version can be by author, title, date, keyword, any word present in the full entry, including the abstract, or any combination. It is a relatively simple procedure to select all citations with "Mozambique" as a keyword, or "Mozambique" and "birds", or all citations with "Not seen" in the abstract.

A brief manual for use of the read-only disk version accompanying the report is given as Appendix IV, and is also included on the disk as a README file.

3.2 REVIEW OF PUBLISHED INFORMATION

3.2.1 **Introduction**

The knowledge of ecology and organismal biodiversity of the wetlands of the Zambezi Basin is very uneven, both geographically and in terms of species groups. As could be expected, research has focussed on charismatic or well-known species such as large mammals and birds, and those of economic interest such as large mammals and fish. There are some distinct geographical focal points, notably the Kafue Flats, Lake Kariba and Lake Malawi.

The major review work on organismal biodiversity in the Basin is probably the compilation "Biogeography and Ecology of Southern Africa" edited by Werger (1978), which covered broad vegetation zones, many species groups and some general topics. The various chapters cover the whole of Southern Africa, not just the Zambezi Basin, but in other published reviews or identification guides a major limitation is the use of

non-biological boundaries, in particular the Zambezi River itself. Comprehensive guides to the birds (Maclean 1993; Newman 1988), mammals (Smithers 1983; Skinner & Smithers 1991) and trees (Coates-Palgrave 1988) all use the Zambezi River as their northern boundary. The gradation in biological composition from the southern more arid and seasonal sub-tropical parts of the Zambezi Basin to the moister, northern, less-seasonal tropical parts is often not apparent because of this. However, Flora Zambesiaca, the regional flora and standard reference work on flowering plants and ferns, covers countries both north and south of the river (Caprivi, Botswana, Zambia, Zimbabwe, Malawi and Mozambique). These boundaries are also followed by Amphibia Zambesiaca (Poynton & Broadley 1985-88), the regional taxonomic review of amphibians, and will also be followed by Reptilia Zambesiaca (D. Broadley, in prep.).

This chapter will review available published information firstly by species group (Sections 3.2.2 to 3.2.7), and then for each of the three parts of the Zambezi ! Upper Zambezi, Middle Zambezi and Lower Zambezi ! with particular reference to the four project areas (Sections 3.2.8 to 3.2.10). The Upper Zambezi is that section from the source to Victoria Falls and includes, for the purposes of this review, the Bangweulu Swamps, Barotse floodplains, the floodplains of Chobe/East Caprivi, the Okavango Swamps and the Kafue Flats. The Middle Zambezi is from Victoria Falls to Tambara downstream from Tete in Mozambique, and includes Lakes Kariba and Cabora Bassa as well as the Luangwa Valley. The Lower Zambezi runs from Tambara via the Zambezi Delta to the sea, and the account includes Lakes Malawi and Chilwa, and the Shire Valley.

Summary data on available literature by species group and geographical area are shown in Table 3.1 and, a more detailed geographical breakdown is given in Table 3.2.

3.2.2 **Plants and vegetation**

The major vegetation study of the Zambezi Basin, putting it in an African context, is that by Frank White (1983). This study maps out major wetland areas comprising the Barotse floodplains, Busango and Lukango swamps, Kafue Flats and Lake Chilwa as edaphic (i.e. soil-determined) grassland mosaics with semi-aquatic vegetation. The Okavango and Chobe/Linyanti are mapped as swamp and aquatic vegetation. All form part of the Sudan-Zambezian phytochorion (a broad, evolutionary-linked plant species assemblage). The Zambezi Delta is mapped with coastal plant communities of the Zanzibar-Inhambane East African Coastal Mosaic, an error, even at the coarse scale of mapping. A basic floral division between plateau, savanna-type species and a low-altitude, moister coastal assemblage is suggested, a division which is also mirrored in other species groups, and not just for wetlands. The other major vegetation map is that compiled by Wild & Barbosa (1967), which gives more detail but is not dissimilar in pattern. This was, in turn, modelled on a vegetation map by Rattray & Wild (1962) for the then Federation of Rhodesia and Nyasaland.

Vegetation maps exist of individual countries (Barbosa 1970; Bekker & De Wit 1991; Edmonds 1976; Government of Malawi 1983; Pedro & Barbosa 1955; Rattray 1962; Weare & Yalala 1971), but often have no more detail than that given in the studies mentioned above. Surveys also exist for some areas including wetlands, e.g. Barotseland (Jeanes & Baars 1991a,b; Verboom & Brunt 1970a,b), Caprivi (Curson 1947; Hines 1997), Chobe (Blair-Rains & McKay 1968; Simpson 1975), much of the mid-Zambezi valley in Zimbabwe (Timberlake *et al.* 1993) and the northern Zambezi Delta (Barbosa 1952). However, there was no consistency in approach, methodology or map legend, thus comparisons between studies are difficult.

Table 3.1. Coverage by subject and geographical area of available biodiversity literature concerning the Zambezi Basin wetlands.

Group	Bar	Kaf	Cho	K/CB	LSh	Del	UZam	MZam	LZam	Z/SA	Total
vegetation	18	11	18	14	12	9	71	31	22	22	154
plants	16	8	25	28	5	4	69	44	10	24	146
large mammal	7	31	29	11	9	10	97	24	22	23	169
small mammal	2	2	5	3	9	-	13	9	13	17	52
birds	17	23	35	12	25	6	82	22	33	47	182
herps	5	2	9	6	17	6	23	10	24	19	75
fish	10	19	16	53	13	-	61	60	16	25	187
insects	-	4	12	10	3	1	36	15	8	23	87
crustacea	-	1	1	4	1	4	2	7	5	2	23
other inverts.	-	2	4	6	2	-	11	14	2	4	31
molluscs	-	1	4	4	1	-	7	10	4	4	24
phytoplankton	-	1	1	9	-	-	5	13	-	-	21
zooplankton	-	2	1	7	1	-	4	13	1	1	26
TOTAL FOR AREA	63	99	109	123	90	37	387	192	146	182	

Source: Bibliographic database on disk (not Appendix VI in report). Total number of references is 942.

Note: Figures should not be considered absolute owing to incomplete coverage, inconsistencies in search intensity, and inconsistencies in allocation of keywords. Categories are not mutually exclusive, so should not be added together.

UZam=Upper Zambezi; MZam=Middle Zambezi; LZam=Lower Zambezi; Z/SA=Zambezi Basin +Southern Africa; Bar=Barotse floodplains; Kaf=Kafue floodplains; Cho=Chobe/Caprivi; K/CB=Lakes Kariba + Cabora Bassa; LSh=Lower Shire; Del=Zambezi Delta

Table 3.2. Number of recorded biodiversity publications on wetlands from the Zambezi Basin by geographical unit.

Geographical unit	no. references	% of total
* Headwaters	7	0.7
Barotse floodplains	63	6.7
* Bangweulu swamps	36	3.8
Kafue floodplains	99	10.5
Chobe/Caprivi	109	11.6
* Okavango swamps	60	6.4
Lake Kariba	104	11.0
Lake Chivero	18	1.9
Mana floodplains	25	2.7
* Luangwa Valley	16	1.7
Cabora Bassa	20	2.1
* Lake Malawi	48	5.1
* Lake Chilwa	24	2.5
* Middle Shire	7	0.7
Lower Shire	90	9.6
Delta	37	3.9
Upper Zambezi [1]	387	41.1
Middle Zambezi [2]	192	20.4
Lower Zambezi [3]	146	15.5
* Zambezi Basin	121	12.8
* Southern Africa	66	7.0

Source: Bibliographic database on disk (not Appendix VI in report). Total number of references is 942.

Note: Many publications have substantial overlap and/or are not readily categorised. Categories are not mutually exclusive, therefore percentages do not add up to 100%. Figures are only indicative.

* Partial bibliographic search only.

1. Includes Bangweulu swamps, Kafue floodplains and Okavango swamps.
2. Includes Lakes Kariba, Cabora Bassa and Chivero and Luangwa valley.
3. Includes Lower Shire, but not Lakes Malawi and Chilwa or Middle Shire.

Vegetation or botanical studies of wetland areas have been carried out with varying degrees of detail and for varying purposes. They have often been of the general survey type for agricultural or development purposes, or have been done as an adjunct to other studies, e.g. impact assessments or large mammal conservation. Some of the more important cover the Bangweulu (Lawton 1963), Kavango (Bethune 1991), Okavango (Biggs 1976; P.A.Smith 1991; Tinley 1973), Kafue (Douthwaite & Van Lavieren 1977), Kariba lakeshore (Magadza 1970; Skarpe 1997), Mana floodplain (Dunham 1989; Müller & Pope 1982), Luangwa Valley (Astle *et al.* 1969; P.P.Smith 1997), Lake Chilwa (Howard-Williams & Walker 1974), Elephant Marsh (Howard-Williams 1973; J.Proctor 1977, 1981) and Gorongosa/Marromeu (Tinley 1977), while mangroves have been looked at by Moll & Werger (1978) and Santos & Soto (1992). Cole (1963) places dambos in a useful geomorphological context, stressing the dynamic nature of wetland vegetation in a changing landscape.

Studies on plants, other than vegetation surveys, are principally confined to checklists, some of which have been published but many of which probably sit in institutional archives or files. There are undoubtedly large holdings of plant specimens collected from wetlands in regional and northern hemisphere herbaria, but until such holdings are computerised and can be searched electronically it would be a Herculean task covering quite a few years to compile comprehensive checklists from this source. Plant lists, with varying comprehensiveness of coverage, exist for parts of Barotseland (Bingham 1990, 1996; Drummond unpublished [Nov. 1959]; Fanshawe 1968a-e, 1969, 1973a,b; Van Rensburg 1968a,b; Verboom 1970, 1981a,b; Verboom & Brunt 1970a,b), Botswana (Barnes & Turton 1994), Chobe (P.A.Smith, in prep.), Luangwa Valley (Astle *et al.* 1997; P.P.Smith 1997) and the swamps of the Shire (Blackmore *et al.* 1988).

Perhaps the major detailed plant ecological study of a Zambezi wetland is that by Ellenbroek (1987) for the Kafue Flats. This study looked at plant productivity as well as vegetation ecology, a topic otherwise only covered briefly by Thompson (1976b) for the Okavango. Howard-Williams (1972, 1973a, 1975a,b, 1979a,b) provides perhaps the only other study on vegetation dynamics and ecological processes operating in wetlands, although this is of Lake Chilwa in Malawi, technically just outside the Zambezi Basin. The book "Ecology and Management of African Wetland Vegetation", edited by Denny (1985), gives a scholarly treatment of vegetation ecology, dynamics, water plant biology, ecosystem structure and ecosystem functioning, as well as chapters on management, aquatic weeds and conservation. These treatments cover tropical Africa as a whole, not the Zambezi Basin in particular, although many of the examples are drawn from our area. In this book, Thompson *et al.* (1985) provide a very useful and comprehensive bibliography on African wetland plants and vegetation.

Aquatic weeds and their explosive invasion of newly-created water bodies, as well as the invasion of swamps with standing water, have given rise to a number of studies in the Zambezi Basin and efforts at control. Invasion by *Salvinia molesta* (water fern) has probably been the best documented, whether on Lake Kariba (Almeida 1972; Balinsky & James 1960; Boughey 1963; Kenmuir 1978; Mitchell 1964, 1967b, 1970; Schelpe 1961), Lake Cabora Bassa (Bond & Roberts 1978; Jackson & Davies 1976) or in the Chobe/Caprivi area (Bethune 1996; Edwards 1972; Edwards & Thomas 1977; Koch & Schlettwein 1983; Mitchell 1967a; Schlettwein & Bethune 1992; Schlettwein & Koch 1983; Smith 1969, 1985, 1993). In the Chobe, biological control has been successful using an introduced weevil, *Cyrtobagous singularis* (Bethune 1996; Proctor 1983; Schlettwein 1985; Schlettwein & Bethune 1992; Smith 1993), and on Lake Kariba weed populations have declined as water nutrient levels diminished (Marshall & Junor

1981; Mitchell & Rose 1979). Concerns over the water hyacinth (*Eichhornia crassipes*) in the Lower Shire (Anon. n.d; Blackmore *et al.* 1988) and Lake Chivero (Jarvis *et al.* 1982) have also been expressed.

It would appear that true wetland and aquatic plant species, those species confined to semi-permanently wet conditions, are quite widely distributed through the basin. There is little difference in vegetation structure and composition, given similar hydrological conditions, from Barotseland to the Delta. And species composition is not that different from wetlands in the rest of tropical Africa.

3.2.3 **Mammals**

For all the countries of the Zambezi Basin there are good, if now somewhat dated, taxonomic accounts of the mammal fauna (i.e. Ansell (1960a, 1978) for Zambia; Ansell & Dowsett (1988) for Malawi; Hill & Carter (1941) for Angola; Smithers (1971) for Botswana and Caprivi; Smithers & Wilson (1979) for Zimbabwe; Smithers & Tello (1976) for Mozambique). These studies, essentially the work of just two people (Frank Ansell and Reay Smithers), came out of studies of museum specimens and comprehensive collecting in the region through the 1950s and 1960s.

The distributions of larger mammals (over 50 kg) are generally well known, and it is fairly apparent from the literature that the ranges and numbers of quite a few species have contracted markedly over the last 100 years. The major reasons for this seem to be loss and modification of habitat and the rinderpest pan-zootic of 1896 which decimated many ungulate populations. Until its cessation in the early 1960s, the wholesale slaughter of wildlife for tsetse control also had a significant negative impact on numbers. Excessive Big Game hunting during the latter part of the last century, just before the colonial era, probably also had a marked effect in reducing larger mammals (rhino, elephant and plains game). What is much less known is the distribution of medium (1-50 kg) and, in particular, small mammals (<1 kg); this latter category includes shrews, bats and rodents. Species of bat new to the region are still being found, and our knowledge of them must be considered fragmentary. Of more relevance to wetland biodiversity, however, are rodents, many of which are found principally in grassland. Systematic collecting would undoubtedly yield many range extensions, as well as a clearer indication of relative abundance.

The most characteristic and important large mammals, at least from a wetland conservation viewpoint, are the semi-aquatic and water-demanding antelopes of the genera *Kobus* (waterbuck, puku, lechwe), *Tragelaphus* (sitatunga, bushbuck) and *Redunca* (reedbuck). In many respects the lechwe and sitatunga typify extensive wetlands. Much attention was paid to the three subspecies of lechwe (*Kobus leche*) ! black lechwe in the Bangweulu swamps, Kafue lechwe on the Kafue Flats, and red lechwe in the Chobe area and scattered through western Zambia ! with many studies on their status, distribution (Jeffrey *et al.* 1989), ecology (Williamson 1990, 1994), feeding (Rees 1976, 1978b,c) and breeding habits (Nefdt 1996).The major concerns driving these studies were the massive reduction in numbers of black lechwe, endemic to the Bangweulu swamps, up until the early 1960s due to hunting, and the threat to the Kafue lechwe, endemic to the Kafue Flats, posed by flooding from hydro-electric schemes. The Kafue lechwe in particular must be one of the best-studied African antelopes, especially considering its total population does not exceed 100,000 individuals.

The Barotse floodplains do not now have a particularly large or diverse large mammal fauna; there is a much higher diversity in the Chobe/Linyanti area, particularly on the Botswana side. In fact the concentration of elephants along the Chobe waterfront must be one of the highest in Africa, and there have been many studies on its impact (e.g. Sommerlatte 1976). The extensive floodplains of Marromeu at the

Zambezi Delta held large herds of buffalo (estimated at 55,500, Tello & Dutton 1979), and the conservation value of this area has been well documented.

The total number of references cited on mammals associated with wetlands is 193 of which 52 also cover small mammals. Geographically, most are derived from studies in Zambia, and the principal topics are taxonomy, distribution, reproductive behaviour and general ecology.

Although somewhat peripheral to wetlands, references to the dugong, a marine mammal, are included (Hughes 1971; Lopes 1936). The dugong is found along the Mozambique coast and can enter brackish water, but is generally absent from the Zambezi Delta possibly owing to sediment in the waters and a lack of its main food, marine eel-grass.

3.2.4 **Birds**

There are many publications from the region on birds, and good field guides exist for most areas (Benson & Benson 1977; Benson *et al.* 1971; Clancey 1996; Irwin 1987; Maclean 1993; Newman 1989; Newman *et al.* 1992). Checklists or atlases are available for some countries and areas (Belcher 1930; Benson & White 1957; Dowsett 1993; Harrison *et al.* 1977; Penry 1994; Smithers 1964; Winterbottom 1971). Amateur ornithologists are active and numerous in Zambia (although not apparently in Barotseland), Chobe/Caprivi, Zimbabwe and Malawi, but not in the central parts of Mozambique. From this group over the years have come many short articles in local journals or newsletters on new records, bird behaviour, breeding, etc. Bird distribution maps are generally available and reliable. Of the total of 182 references on birds, most come from the Chobe, Kafue and Lower Shire. A list of waterbird species from the Zambezi Basin is given in Table 3.3.

An annual waterbird census is carried out in many wetlands of the region published by what is now Wetlands International (Dodman & Taylor 1995, 1996; Perennou 1992, Taylor 1993; Taylor & Rose 1994). These give a good indication of distribution and status with something of a basin-wide perspective, very necessary with such mobile species. A number of studies have focussed on waterbirds (Douthwaite 1977, 1982b; Dowsett & De Vos 1965; Eriksson 1994; Hockey *et al.* 1986; Hustler 1997; Oatley & Prys-Jones 1986; Rowan 1968; Schulten 1974; Scott & Rose 1996; A.Williams 1991), which are both easily-viewed and good indicators of wetland health (see Table 3.4). Some are Palaearctic migrants.

A group of particular interest is the cranes. The International Crane Foundation in the USA has brought together considerable information (e.g. Beilfuss *et al.* 1996; Meine & Archibald 1996), particularly on the Wattled Crane, and is actively involved in survey work in the Zambezi Delta (R. Beilfuss, pers. comm.). The Wattled Crane appears as something of a "flagship" species for the Zambezi wetlands, and its status gives an indication of the health of large wetland ecosystems. There have been many studies on cranes and storks (Anon. 1995; Beilfuss 1995; Beilfuss & Allan 1996; Brown 1992; Dodman 1996a,b; Douthwaite 1974; Goodman 1992; Hines 1996; Holshausen 1996; Howard 1989; Howard & Aspinwall 1984; Kampamba & Pope 1996; Kamweneshe 1996; Katanekwa 1996; Konrad 1981, 1987; Malambo & Chabwela 1992; Mangubuli 1996; J.Williams 1987), mostly brief reports on status in particular countries or areas.

Table 3.3. Waterbird species in the Zambezi Basin (defined as birds that are ecologically dependent on wetlands).

common name	**scientific name**
Dabchick (Little Grebe)	*Tachybaptus ruficollis*
Great Crested Grebe	*Podiceps cristatus*
Great White Pelican	*Pelecanus onocrotalus*
Pink-backed (Grey) Pelican	*Pelecanus rufescens*
Reed (Long-tailed) Cormorant	*Phalacrocorax africanus*
White-breasted Cormorant	*Phalacrocorax carbo*
African Darter	*Anhinga melanogaster*
Grey Heron	*Ardea cinerea*
Black-headed Heron	*Ardea melanocephala*
Goliath Heron	*Ardea goliath*
Purple Heron	*Ardea purpurea*
Great White Egret (Heron)	*Egretta alba*
Little Egret	*Egretta garzetta*
Yellow-billed Egret	*Egretta intermedia*
Black Egret	*Egretta ardesiaca*
Slaty Egret	*Egretta vinaceigula*
Cattle Egret	*Bubulcus ibis*
Squacco Heron	*Ardeola ralloides*
Madagascar Squacco (Pond) Heron	*Ardeola idae*
Green-backed Heron	*Butorides striatus*
Rufous-bellied Heron	*Butorides rufiventris*
Black-crowned Night Heron	*Nycticorax nycticorax*
White-backed Night Heron	*Gorsachius leuconotus*
Little Bittern	*Ixobrychus minutus*
Dwarf Bittern (Rail Heron)	*Ixobrychus sturmii*
Bittern	*Botaurus stellaris*
Shoebill (Whale-headed Stork)	*Balaeniceps rex*

common name	**scientific name**
Hamerkop (Hammer-head Stork)	*Scopus umbretta*
White Stork	*Ciconia ciconia* (PM)
Black Stork	*Ciconia nigra*
Abdim's Stork	*Ciconia abdimii*
Woolly-necked Stork	*Ciconia episcopus*
Open-billed stork	*Anastomus lamelligerus*
Saddle-billed Stork	*Ephippiorhynchus senegalensis*
Marabou Stork	*Leptoptilos crumeniferus*
Yellow-billed Stork (Wood Ibis)	*Mycteria ibis*
Sacred Ibis	*Threskiornis aethiopicus*
Glossy Ibis	*Plegadis falcinellus*
Hadeda Ibis	*Bostrychia hagedash*
African Spoonbill	*Platalea alba*
Greater Flamingo	*Phoenicopterus ruber*
Lesser Flamingo	*Phoenicopterus minor*
White-faced Duck	*Dendrocygna viduata*
Fulvous Duck	*Dendrocygna bicolor*
White-backed Duck	*Thalassornis leuconotus*
Egyptian Goose	*Alopochen aegyptiacus*
Yellow-billed Duck	*Anas undulata*
African Black Duck	*Anas sparsa*
Cape Teal	*Anas capensis*
Hottentot Teal	*Anas hottentota*
Red-billed Teal	*Anas erythrorhyncha*
Pintail	*Anas acuta* (PM) (?)
Garganey	*Anas querquedula* (PM)(?)
European Shoveller	*Anas clypeata* (PM)(?)
Cape Shoveller	*Anas smithii*
Southern Pochard	*Netta erythrophthalma*
Pygmy Goose	*Nettapus auritus*

common name	**scientific name**
Knob-billed Duck (Knob-nosed Goose)	*Sarkidiornis melanotos*
Spur-winged Goose	*Plectropterus gambensis*
Maccoa Duck	*Oxyura maccoa* (?)
African Fish Eagle	*Haliaeetus vocifer*
European Marsh Harrier	*Circus aeruginosus* (PM)
African Marsh Harrier	*Circus ranivorus*
Osprey	*Pandion haliaetus*
Wattled Crane	*Bugeranus carunculatus*
Grey Crowned Crane	*Balearica regulorum*
African Water Rail	*Rallus caerulescens*
Corncrake	*Crex crex* (PM)
African Crake	*Crex egregia*
Black Crake	*Amaurornis flavirostris*
Spotted Crake	*Porzana porzana* (PM)
Baillon's Crake	*Porzana pusilla*
Striped Crake	*Aenigmatolimnas marginalis*
Red-chested Flufftail	*Sarothrura rufa*
Buff-spotted Flufftail	*Sarothrura elegans*
Streaky-breasted Flufftail	*Sarothrura boehmi*
White-winged Flufftail	*Sarothrura ayresi* (?)
Purple Gallinule (Swamp Hen)	*Porphyrio porphyrio*
Lesser Gallinule	*Porphyrio alleni*
Moorhen	*Gallinula chloropus*
Lesser Moorhen	*Gallinula angulata*
Red-knobbed Coot	*Fulica cristata*
African Finfoot	*Podica senegalensis*
African Jacana (Lily-trotter)	*Actophilornis africana*
Lesser Jacana	*Microparra capensis*
Painted Snipe	*Rostratula benghalensis*
European Oystercatcher	*Haematopus ostralegus* (PM)

common name	**scientific name**
Ringed Plover	*Charadrius hiaticula* (PM)
White-fronted Plover	*Charadrius marginatus*
Chestnut-banded Plover	*Charadrius pallidus* (?)
Kittlitz Plover	*Charadrius pecuarius*
Three-banded Plover	*Charadrius tricollaris*
Mongolian Plover (Lesser Sandplover)	*Charadrius mongolus* (PM)
Sand Plover (Greater Sandplover)	*Charadrius leschenaultii* (PM)
Caspian Plover	*Charadrius asiaticus* (PM)
Grey Plover	*Pluvialis squatarola* (PM)
Crowned Plover	*Vanellus coronatus*
Lesser Black-winged Plover	*Vanellus lugubris*
Blacksmith Plover	*Vanellus armatus*
White-crowned Plover	*Vanellus albiceps*
Senegal Wattled Plover	*Vanellus senegallus*
Long-toed (White-winged) Plover	*Vanellus crassirostris*
Ruddy Turnstone	*Arenaria interpres* (PM)
Terek Sandpiper	*Xenus cinereus* (PM)
Common Sandpiper	*Tringa hypoleucos* (PM)
Green Sandpiper	*Tringa ochropus* (PM)
Wood Sandpiper	*Tringa glareola* (PM)
Redshank	*Tringa totanus* (PM)
Marsh Sandpiper	*Tringa stagnatilis* (PM)
Greenshank	*Tringa nebularia* (PM)
Knot	*Calidris canutus* (PM)
Curlew Sandpiper	*Calidris ferruginea* (PM)
Little Stint	*Calidris minuta* (PM)
Sanderling	*Calidris alba* (PM)
Ruff/Reeve	*Philomachus pugnax* (PM)
Great Snipe	*Gallinago media* (PM)
Ethiopian Snipe	*Gallinago nigripennis*

common name	**scientific name**
Bar-tailed Godwit	*Limosa lapponica* (PM)
Curlew	*Numenius arquata* (PM)
Whimbrel	*Numenius phaeopus* (PM)
Grey Phalarope	*Phalaropus fulicarius* (PM)
Avocet	*Recurvirostra avosetta*
Black-winged Stilt	*Himantopus himantopus*
Crab Plover	*Dromas ardeola* (PM)
Spotted Dikkop (Cape Thick-knee)	*Burhinus capensis*
Water Dikkop (Thick-knee)	*Burhinus vermiculatus*
Red-winged Pratincole	*Glareola pratincola*
Black-winged Pratincole	*Glareola nordmanni* (PM)
Rock (White-collared) Pratincole	*Glareola nuchalis*
Lesser Black-backed Gull	*Larus fuscus* (PM)
Grey-headed Gull	*Larus cirrocephalus*
Gull-billed Tern	*Gelochelidon nilotica* (PM)
Caspian Tern	*Hydroprogne caspia*
Lesser Crested Tern	*Sterna,bengalensis* (PM)
Whiskered Tern	*Chlidonias hybridus*
White-winged Tern	*Chlidonias leucopterus* (PM)
African Skimmer	*Rynchops flavirostris*
Black Coucal	*Centropus bengalensis*
Coppery-tailed Coucal	*Centropus cupreicaudus*
Burchell's (White-browed) Coucal	*Centropus superciliosus*
Grass Owl	*Tyto capensis*
Marsh Owl	*Asio capensis*
Pel's Fishing Owl	*Scotopelia peli*
Natal (Swamp) Nightjar	*Caprimulgus natalensis*
Pied Kingfisher	*Ceryle rudis*
Giant Kingfisher	*Ceryle maxima*
Half-collared Kingfisher	*Alcedo semitorquata*

common name	**scientific name**
Malachite Kingfisher	*Alcedo cristata*
Mangrove Kingfisher	*Halcyon senegaloides*
Olive Bee-eater	*Merops superciliosus*
Blue-cheeked Bee-eater	*Merops persicus* (PM)
Carmine Bee-eater	*Merops nubicoides*
White-fronted Bee-eater	*Merops bullockoides*
European Sand Martin	*Riparia riparia* (PM)
African (Brown-throated) Sand Martin	*Riparia paludicola*
Banded Martin	*Riparia cincta*
Cape Reed (Lesser Swamp) Warbler	*Acrocephalus gracilirostris*
African Sedge (Little Rush) Warbler	*Bradvpterus baboecala*
Red-faced Cisticola	*Cisticola erythrops*
Black-backed Cisticola	*Cisticola galactotes*
Chirping Cisticola	*Cisticola pipiens*
African Pied Wagtail	*Motacilla aguimp*
Pink-throated Longclaw	*Macronyx ameliae*
Brown-throated Weaver	*Ploceus xanthopterus*
Red-headed Quelea	*Quelea erythrops*
Red Bishop	*Euplectes orix*
Red-shouldered Widow	*Euplectes axillaris*
Total 167 species	

Source: P.J. Mundy, 1997

NB. Waterfowl are generally considered to be all those families up to and including the African Skimmer, whereas waterbirds include any that are dependent on water.

(PM) Palaearctic Migrant; i.e. a species that breeds (in the northern summer) in Europe, Russia and Asia, but spends the northern winter in Africa as a non-breeding migrant.

Table 3.4. Distribution of duck and geese species in some wetlands of the Zambezi Basin.

Species	Barotse	Chobe-Caprivi	Lower Shire	Zambezi Delta
Fulvous Whistling Duck	X	X	X	X
White-faced Whistling Duck	X	X	X	X
White-backed Duck	X	X	X	X
Egyptian Goose	X	X	X	X
Spur-winged Goose	gambensis	niger	gambensis	gambensis
Knob-nosed Duck	X	X	X	X
Pygmy Goose	X	X	X	X
Cape Teal	X	X		
Yellow-billed Duck	X	X	X	X
Black Duck		X	X	
Red-billed Teal	X	X	X	X
Hottentot Teal	X	X	X	X
Cape Shoveller		X		
Southern Pochard	X	X	X	X
Pintail (PM)		v		
Garganey (PM)				
European Shoveller (PM)				
Maccoa Duck		v		

Source: P.J. Mundy (pers. comm).

PM - Palaearctic Migrant
X - occurs regularly
v - vagrant

Much of the south-central and southern African breeding populations of the Rock Pratincole, African Skimmer and Carmine Bee-eater are found along the Zambezi river. There have been a few studies on the biology of these birds and species of similar status (e.g. Benson *et al.* 1971; Benson & Irwin 1965; Coppinger *et al.* 1988; Hanmer 1977b, 1982; Mundy *et al.* 1994; Randall 1994a; Simmons 1996; Stowe & Becker 1992; Williams *et al.* 1989).

Conservation concerns and sites of particular interest have been comparatively well documented (Collar *et al.* 1994; Collar & Stuart 1985; Stuart & Collar 1988) such that it is fairly clear which the priority species (Table 4.1).

Studies on fish-eating birds, much more common now since the construction of Lakes Kariba and Cabora Bassa, show that Reed Cormorants are perhaps the most abundant and, together with Darters, account for 85% of the 1460 tons of fish removed annually by birds from Lake Kariba (Hustler 1991, 1997).

The major conservation issues for birds are seen as (a) agricultural development, especially for sugar cane, (b) hunting and poaching, and (c) human-induced changes in flood regime through their impact on fish (particularly for the Delta). Although pollutants (including excessive nutrients) are not yet a major problem, they may well become so as wetlands act as a sink. Many studies have been done on the effects of DDT on birds (Douthwaite & Tingle 1994; Douthwaite 1982a, 1992; Douthwaite *et al.* 1992) in the mid-Zambezi valley and Okavango areas. Residues from spraying were found to have an adverse effect, but this is considered only temporary (see Chapter 5).

3.2.5 **Reptiles and amphibians**

Reptiles and amphibians are a relatively small group, comparatively well known over much of the region. Knowledge on them has been well synthesised. The major taxonomic work on the amphibians is Amphibia Zambesiaca (Poynton & Broadley 1985-88, in five parts), and a similar work for reptiles is in preparation (D. Broadley, pers. comm.). There are also herpetofauna checklists available for Botswana (Auerbach 1987), Zambia (Broadley 1971), Mwinilunga District at the Zambezi source (Broadley 1991), Namibia (Channing & Griffin 1993; Griffin & Channing 1991), West Caprivi (Brown & Jones 1994), Lake Chilwa in Malawi (Dudley 1978), Lochinvar National Park on the Kafue Flats (Simbotwe & Patterson 1983) and Malawi (Stevens 1974, Stewart 1967; Sweeney 1961).

Wetland-associated species and subspecies are listed by catchment or wetland in Table 3.5. Total species number is 160, comprising 101 reptiles and 59 amphibians (D. Broadley, pers. comm.). It is apparent that there is a marked difference in herpetofauna between areas of the Upper Zambezi (or proto-Upper Zambezi) and that of the Lower Zambezi (Table 3.6), with only one third of the total species being found in one or more catchments of both. This is strong support for the biological division of the Zambezi Basin into upper and lower sections, and is presumably a result of the relatively recent river capture process described in Section 2.2. Some of the frog species from Mozambique have lowland distributions and are found from Kenya to Natal, while such large reptiles as the Nile crocodile, monitor lizard (*Varanus niloticus*) and the python (*Python sebae*) are almost cosmopolitan in Africa.

The Caprivi, Okavango and much of the Shire Valley have been comparatively well collected. However, there is a great paucity of collected specimens from both Barotseland and the Zambezi Delta, and further investigation may well clarify some biogeographic issues as well as greatly expanding current species lists for those areas. Bell-Cross (1965d) reports on movement of fish species from the Congo to the Zambezi catchments at Mwinilunga by utilizing seasonal pools, and undoubtedly amphibians can do the same. There are very few typical wetland reptile or amphibian species in the Middle Zambezi (Victoria Falls to Tambara) ! what wetlands there were have now been flooded and the floodplains of Kariba and Cabora Bassa are far too young to have developed a wetland herpetofauna.

Table 3.5. Checklist of the reptiles and amphibians of the Zambezi Basin wetlands.

Taxon	Zhw	Bar	Cho	Kaf	Oko	Del	LSh	Pun	S	U	B	C
CHELONII (tortoises/terrapins)												
PELOMEDUSIDAE												
Pelusios nanus	X											
Pelusios subniger							X	X				
Pelusios bechuanicus		X	X	X	X							
Pelusios rhodesianus		X	X	X	X						X	
Pelusios castanoides						X	X	X				X
Pelusios sinuatus				X		X	X	X				
TRIONYCHIDAE												
Cycloderma frenatum							X	X				X
SQUAMATA (scaled reptiles)												
SAURIA (lizards)												
AGAMIDAE												
Agama mossambica						X	X	X				X
CHAMAELEONIDAE												
Chamaeleo dilepis	X	X	X	X	X		X	X		X	X	
GEKKONIDAE												
Lygodactylus capensis	X	X	X	X	X	X	X	X				
Lygodactylus chobiensis		X	X	X	X							
Hemidactylus mabouia	X		X		X	X	X	X				
Hemidactylus platycephalus						X	X	X				
SCINCIDAE												
Sepsina angolensis		X										
Typhlacontias gracilis		X	X		X							
Mabuya m. maculilabris	X	X							X	X		
Mabuya capensis		X										
Mabuya variegata punctulata		X	X									
Mabuya varia	X	X	X	X	X		X	X	X	X		X
Mabuya striata	X	X	X	X	X	X	X	X		X	X	X
Eumecia anchietae	X	X		P						X		
Lygosoma afrum						X	X	X				X

Taxon	Zhw	Bar	Cho	Kaf	Oko	Del	LSh	Pun	S	U	B	C
Lygosoma sundevallii		X	X	X	X							
Panaspis wahlbergii	X	X	X		X	X		X		X	X	
Typhlosaurus lineatus jappi		X										
LACERTIDAE												
Ichnotropis capensis	X	X	X		X		X			X		
Ichnotropis squamulosa					X		X	X				
GERRHOSAURIDAE												
Gerrhosaurus m. major							X	X				X
Gerrhosaurus multilineatus	X	X										
Gerrhosaurus flavigularis							X	X				
Tetradactylus ellenbergeri	X	X										
VARANIDAE												
Varanus niloticus	X	X	X	X	X	X	X	X	X	X	X	X
AMPHISBAENIA AMPHISBAENIDAE												
Zygaspis nigra		X										
Zygaspis quadrifrons	X	X	X		X		X			X	X	
Chirindia swynnertoni								X				
Monopeltis rhodesiana							X					
Dalophia ellenbergeri		X										
Dalophia pistillum		X						X				
SERPENTES (snakes) TYPHLOPIDAE												
Typhlops l. lineolatus	X	X										
LEPTOTYPHLOPIDAE												
Leptotyphlops pungwensis								X				
Leptotyphlops scutifrons					X		X	X				
PYTHONIDAE												
Python sebae	P	X	X	X	X	P	P	P	X	X	X	X
VIPERIDAE												
Causus rhombeatus	X	X		X	X					X	X	

Taxon	Zhw	Bar	Cho	Kaf	Oko	Del	LSh	Pun	S	U	B	C
Causus bilineatus	X	X									X	
Causus defilippii						X	X	X				
Proatheris superciliaris						X	X	X				X
Bitis g. gabonica	X			X				X				
Bitis a. arietans	X	X	X	X	X	X			X	X		X
ATRACTASPIDIDAE												
Atractaspis congica	X	X										
Atractaspis bibronii			X		X		X	X		X	X	
Amblyodipsas p. polylepis		X	X		X						X	X
Amblyodipsas ventrimaculatus		X	X									
Xenocalamus mechowii		X	X		X							
Hypoptophis wilsoni		X								X		
Aparallactus lunulatus							X	X	X			
Aparallactus capensis		X						X		X		
ELAPIDAE												
Elapsoidea semiannulata		X										
Elapsoidea boulengeri		X	X	X	X		X	X				
Naja a. annulifera							X	X				
Naja a. anchietae		X	X	X	X							
Naja n. nigricollis	X	X	X							X		
Naja mossambica			X	X	X		X					X
COLUBRIDAE												
Lycodonomorphus obscuriventris						X	X	X				
Lamprophis fuliginosus	X	X	X	X	X	X	X	X		X		X
Mehelya capensis		X	X					X				
Mehelya nyassae		X						X		X		
Lycophidion multimaculatum	X	X	X							X		
Lycophidion c. capense			X	X		X	X	X				
Lycophidion nanum								X				
Grayia ornata	X											
Grayia tholloni	X											
Natriciteres olivacea		X	X	X	X	X	X	X	X	X	X	X
Limnophis bangweolicus		X	X		X						X	

Taxon	Zhw	Bar	Cho	Kaf	Oko	Del	LSh	Pun	S	U	B	C
Hemirhagerrhis nototaenia			X	X			X		X	X		
Psammophylax v. variabilis		X	X									
Psammophylax tritaeniatus	X			X							X	
Rhamphiophis acutus acutus	X										X	
Rhamphiophis acutus jappi		X										
Dromophis lineatus		X		P					X		X	
Psammophis jallae		X										
Psammophis s. subtaeniatus			X		X							
Psammophis s. orientalis							X	X				X
Psammophis phillipsii	X	X	X	X	X	X	X	X	X	X	X	X
Psammophis angolensis		X								X		
Meizodon s. semiornata				X		X	X	X				X
Prosymna angolensis		X	X									
Prosymna a. ambigua	X									X		
Prosymna stuhlmannii							X	X				
Philothamnus angolensis	X	X	X		X	X	X	X	X	X		X
Philothamnus hoplogaster	X	X		X		X	X	X		X		
Philothamnus ornatus	X	X	X		X						X	
Philothamnus heterolepidotus	X	X							X	X		
Philothamnus semivariegatus	X	X	X	X	X	X	X	X	X	X	X	
Crotaphopeltis hotamboeia	X	X	X	X	X	X	X	X	X	X	X	X
Crotaphopeltis barotseensis		X			X							
Telescopus semiannulatus		X	X	X	X			X		X		
Dispholidus t. typus	X	X	X	X	X	X				X	X	
Thelotornis capensis oatesii	X	X	X	X	X		X			X		
Thelotornis c. mossambicana								X				
Dasypeltis scabra	X	X	X	X	X	X	X	X	X	X	X	X
CROCODYLIA (crocodiles) CROCODYLIDAE												
Crocodylus niloticus		X	X	X	X	X	X	X	X	X	X	X
AMPHIBIA (amphibians) **ANURA** (frogs & toads)												
PIPIDAE												
Xenopus muelleri		X	X		X	X	X	X	X			X
Xenopus laevis petersii	X	X	X	X	X					X		

Taxon	Zhw	Bar	Cho	Kaf	Oko	Del	LSh	Pun	S	U	B	C
BUFONIDAE												
Bufo gutturalis	X	X	X	X	X	X	X	X		X		
Bufo garmani			X	X								
Bufo poweri			X		X							
Bufo maculatus			X		X		X					
Bufo lemairii		X	X		X					X		
Bufo fenoulheti			X									
Bufo kavangensis					X							
Bufo beiranus		X						X				
MICROHYLIDAE												
Phrynomantis bifasciatus			X	X	X		X					X
Phrynomantis affinis		X										
Breviceps mossambicus/ adspersus	X	X			X							
Breviceps poweri		X		X			X					X
HEMISOTIDAE												
Hemisus marmoratus			X	X		X	X					
Hemisus guineensis microps		X	X		X							
Hemisus guineensis broadleyi								X				
RANIDAE												
Pyxicephalus adspersus			X		X							
Pyxicephalus edulis		X		X			X	X				X
Tomopterna cryptotis		X	X	X	X		X	X				X
Hildebrandtia ornata		X		X				X				
Hylarana galamensis						X		X	X		X	X
Ptychadena subpunctata	X	X	X		X							
Ptychadena oxyrhyncha			X		X	X		X	X	X		
Ptychadena anchietae			X	X				X		X		
Ptychadena obscura	X									X		
Ptychadena mascareniensis			X	X	X		X		X	X		X
Ptychadena porosissima	X	X								X		
Ptychadena grandisonae	X	X	X							X		
Ptychadena upembae		X								X		

Taxon	Zhw	Bar	Cho	Kaf	Oko	Del	LSh	Pun	S	U	B	C
Ptychadena uzungwensis	X	X								X		
Ptychadena taenioscelis	X	X			X					X		X
Ptychadena guibei	X	X	X					X		X		X
Ptychadena mossambica			X	X	X			X				X
Ptychadena schillukorum							X	X	X	X		X
Ptychadena mapacha			X									
Phrynobatrachus acridoides						X	X	X	X			X
Phrynobatrachus natalensis	X	X	X	X	X				X	X		X
Phrynobatrachus mababiensis	X	X	X	X	X			X	X			X
HYPEROLIIDAE												
Leptopelis mossambicus						X	X	X				
Leptopelis broadleyi								X				
Leptopelis bocagii	X	X		X								
Kassina maculata						X	X	X				
Kassina kuvangensis	X	X										
Kassina senegalensis	X	X	X	X	X				X	X		X
Afrixalus delicatus						X		X				
Afrixalus crotalus							X					
Afrixalus wittei	X	X								X		
Afrixalus fornasinii						X	X	X				
Hyperolius tuberilinguis						X	X	X				
Hyperolius argus						X	X	X				
Hyperolius pusillus						X	X	X				
Hyperolius nasutus	X	X	X	X				X				
Hyperolius marmoratus taeniatus						X	X	X				
Hyperolius m. albofasciatus							X					
Hyperolius m. pyrrhodictyon				X								
Hyperolius m. alborufus	X											
Hyperolius m. aposematicus		X										
Hyperolius angolensis		X	X		X							

Source: D.G. Broadley (pers. comm.)

Key: ZHW(1)=Zambezi headwaters; BAR(2)=Barotse floodplain; CHO(3)=Sesheke-Chobe floodplain; KAF(4)=Kafue Flats; OKO(5)=Okavango Delta; DEL(6)=Zambezi Delta; SHR(7)=Lower Shire Valley; PUN(8)=Pungwe Flats. Distribution of taxa in extralimital wetlands is indicated in the four columns on the right: S=Sudan (White Nile swamps); U=Lac Upemba, Zaïre; B=Lake Bangweulu swamps, Zambia; C=Lake Chilwa basin, Malawi; P=species probably present.

Table 3.6. Summary of species richness (including subspecies) for groups of reptiles and amphibians of the Zambezi Basin wetlands (acronyms as in Table 3.5).

Group	number of species								
	Zhw	Bar	Cho	Kaf	Oko	Del	LSh	Pun	Total
Chelonii (tortoises/terrapins)	1	2	2	2	2	3	4	4	7
Sauria (lizards)	12	18	12	8	12	8	13	13	25
Amphisbaenia (amphisbaenians)	1	4	1	-	1	-	2	2	6
Serpentes (snakes)	25	39	29	22	24	16	24	29	62
Crocodylia (crocodiles)	-	1	1	1	1	1	1	1	1
Amphibia (frogs/toads)	18	28	26	18	21	14	20	25	59
TOTAL	57	92	71	52	61	41	64	74	160

Source: D. Broadley (pers. comm.).

3.2.6 **Fish**

Fish are a group of significant economic importance. Much of the literature (although not cited here) concerns fisheries rather than fish. The majority of the published papers and reports fall into one of two broad categories ! taxonomic studies and checklists on the one hand, and fishery-related studies on the other. The latter category includes fish productivity and changes in composition and ecology resulting from dams and species introductions. Studies on changes resulting from dam construction have mostly commenced after the event ! there do not appear to have been many pre-impoundment studies. This review concentrates on fish of the Zambezi river and associated wetlands rather than pelagic species of large lakes such as Kariba, Cabora Bassa and Lake Malawi.

Fish taxonomy is comparatively well known, and regional (Skelton 1993) and national identification manuals are available (Jackson 1961a for Zambia; Jubb 1961 and Bell-Cross & Minshull 1988 for Zimbabwe; Tweddle n.d. for Malawi). Lists of the fish of the Zambezi Basin are found in Bell-Cross (1965a, 1972), Bowmaker *et al.* (1978), Maar (1960) and Skelton (1994). National or regional checklists have been compiled for Zambia (Bell-Cross & Kaoma 1971; Mortimer 1965), Namibia (Bethune & Roberts 1991, Holtzhausen 1991), the Middle Zambezi (Jackson 1961c), Zimbabwe (Minshull 1987) and Malawi (Jackson 1961b). Checklists are also available for Barotseland (Bell-Cross 1974a; Jubb 1958), Kavango River (Bethune 1991), East Caprivi (Van der Waal & Skelton 1984), Lake Liambezi (Van der Waal 1980, 1985), Kafue (Chapman *et al.* 1971; Cowx & Kapasa 1995; Dudley 1976; University of Idaho 1971; R.Williams 1971), Lake Kariba (Balon 1974a; Karenge & Kolding 1995a; Kenmuir 1989; Marshall *et al.* 1982), Lake Chivero (Marshall 1982b; Munro 1966), Cabora Bassa (Jackson & Ribbink 1975; Vostradovsky 1986), Lake Malawi (Eccles & Trewavas 1989; Greenwood 1981; Jackson & Rogers 1976; Konings 1990; Lewis *et al.* 1986; Regan 1921), Lake Chilwa (Department of Biology 1996) and the Lower Shire (Dudley *et al.* 1991; Tweddle *et al.* 1979;

Table 3.7. Distribution of freshwater dispersant fish species in various parts of the (palaeo-) Zambezi catchment (excluding Lake Malawi).

Species	Okavango	Kafue	Upper Zambezi	M & L Zambezi	Pungwe/ Buzi
Protopterus amphibius				X	
Protopterus annectens				X	X
Hippopotamyrus ansorgii	X		X	X	X
Hippopotamyrus discorhynchus	X		X	X	X
Marcusenius macrolepidotus	X	X	X	X	X
Mormyrops anguilloides				X	X
Mormyrops lacerda	X	X	X		
Mormyrops longirostris				X	X
Petrocephalus catostoma	X	X	X	X	X
Pollimyrus castelnaui	X	X	X		
Paramormyrops jacksoni			X		
Kneria angolensis	?		X		
Kneria auriculata				X	X
Kneria polli		X	X		
Parakneria fortuita	X				
Parakneria mossambica					X
Barbus afrohamiltoni				X	X
Barbus afrovernayi	X	X	X		
Barbus annectens				X	X
Barbus atkinsoni				X	
Barbus barnardi	X	X	X		
Barbus barotseensis	X	X	X		
Barbus bellcrossi			X		
Barbus bifrenatus	X	X	X		
Barbus brevidorsalis		X	X		
Barbus choloensis				X	
Barbus codringtonii	X		X		
Barbus dorsolineatus		X	X		
Barbus eutaenia	X	X	X	X	X
Barbus fasciolatus	X	X	X	X	

Species	Okavango	Kafue	Upper Zambezi	M & L Zambezi	Pungwe/ Buzi
Barbus haasianus	X	X	X	X	X
Barbus kerstenii	X	X	X	X	
Barbus lineomaculatus	X	X	X	X	X
Barbus macrotaenia				X	
Barbus manicensis				X	X
Barbus marequensis		X		X	X
Barbus mattozi			X		
Barbus miolepis		X	X	X	
Barbus multilineatus	X	X	X	X	
Barbus neefi		X	X		
Barbus paludinosus	X		X	X	X
Barbus poechii	X	X	X		
Barbus radiatus	X	X	X	X	X
Barbus thamalakanensis	X		X		
Barbus toppini				X	X
Barbus trimaculatus	?			X	X
Barbus unitaeniatus	X	X	X	X	
Barbus viviparus				X	X
Coptostomabarbus wittei	X	X	X		
Labeo altivelis				X	X
Labeo congoro				X	X
Labeo cylindricus	X	X	X	X	X
Labeo lunatus	X		X		
Labeo molybdinus				X	X
Mesobola brevianalis	X		X		
Opsaridium zambezense	X		X	X	X
Opsaridium sp.				X	
Varicorhinus nastus				X	X
Varicorhinus pungweensis				X	X
Distichodus mossambicus				X	X
Distichodus schenga				X	X
Hemigrammocharax machodoi	X	X	X		
Hemigrammocharax multifasciatus	X	X	X		

Species	**Okavango**	**Kafue**	**Upper Zambezi**	**M & L Zambezi**	**Pungwe/ Buzi**
Nannocharax macropterus	X	X	X		
Brycinus imberi				X	X
Brycinus lateralis	X	X	X	X	X
Hemigrammopetersius barnardi				X	X
Hydrocynus vittatus	X		X	X	X
Micralestes acutidens	X	X	X	X	X
Rhabdalestes maunensis	X	X	X		
Hepsetus odoe	X	X	X		
Parauchenoglanis ngamensis	X		X		
Amarginops hildae					X
Schilbe intermedius	X	X	X	X	X
Schilbe yangambianus			X		
Amphilius laticaudatus					X
Amphilius natalensis				X	
Amphilius uranoscopus	X	X	X	X	X
Leptoglanis cf. dorae	X	X			
Leptoglanis rotundiceps		X	X	X	X
Clariallabes platyprosopos	X		X		
Clarias gariepinus	X	X	X	X	X
Clarias liocephalus	X	X	X		
Clarias ngamensis	X	X	X	X	
Clarias stappersii	X	X	X		
Clarias theodorae	X	X	X	X	
Heterobranchus longifilis				X	
Malapterurus electicus				X	X
Chiloglanis emarginatus				X	X
Chiloglanis fasciatus	X				
Chiloglanis neumanni		X	X	X	X
Chiloglanis pretoriae				X	X
Synodontis leopardinus	X		X		
Synodontis macrostigma	X	X	X		
Synodontis macrostoma	X		X		
Synodontis nebulosus				X	X

Species	Okavango	Kafue	Upper Zambezi	M & L Zambezi	Pungwe/ Buzi
Synodontis nigromaculatus	X		X		
Synodontis thamalakanensis	X		X		
Synodontis vanderwaali	X		X		
Synodontis woosnami	X		X		
Synodontis zambezensis				X	X
Aplocheilichthys johnstoni	X	X	X	X	X
Aplocheilichthys hutereaui	X	X	X	X	X
Aplocheilichthys katangae	X	X	X	X	X
Hypsopanchax jubbi			X		
Nothobranchius kafuensis		X			
Nothobranchius kuhntae					X
Nothobranchius orthonotus				X	X
Nothobranchius rachovii				X	X
Nothobranchius sp.			X		
Aethiomastacembelus frenatus	X	X	X		
Aethiomastacembelus shiranus				X	
Aethiomastacembelus vanderwaali	X		X		
Astaotilapia calliptera				X	X
Chetia gracilis	X				
Hemichromis elongatus	X		X		
Oreochromis andersonii	X	X	X		
Oreochromis macrochir	X	X	X	X	
Oreochromis mortimeri				X	
Oreochromis mossambicus				X	X
Oreochromis placidus				X	X
Oreochromis shiranus				X	
Pharyngochromis acuticeps	X	X	X	X	
Pseudocrenilabrus philander	X	X	X	X	X
Sargochromis carlottae	X	X	X		
Sargochromis codringtonii	X	X	X	X	
Sargochromis giardi	X	X	X		
Sargochromis greenwoodi	X	X	X		
Sargochromis mortimeri		X	X		

Species	Okavango	Kafue	Upper Zambezi	M & L Zambezi	Pungwe/ Buzi
Serranochromis altus	X		X		
Serranochromis angusticeps	X	X	X		
Serranochromis longimanus	X		X		
Serranochromis macrocephalus	X	X	X		
Serranochromis robustus jallae	X	X	X		
Serranochromis thunbergi	X	X	X		
Tilapia rendalli	X	X	X	X	X
Tilapia ruweti	X		X		
Tilapia sparrmanii	X	X	X	X	X
Ctenopoma intermedium	X	X	X	X	X
Ctenopoma multispine	X	X	X	X	X
TOTAL (n=140)	82	65	91	77	61

Source: P.H. Skelton (1994).

Tweddle & Willoughby 1979a,b). There appears to be no publication on the fish of the Lower Zambezi proper and Zambezi Delta.

A checklist of freshwater fishes of southern Africa has been produced by Skelton (1994), sub-divided by catchments (see also Bowmaker *et al.* 1978). A modified version, covering catchments of the proto-Upper and Lower Zambezi systems but excluding Lake Malawi, is shown in Table 3.7. Of the 140 species recorded, 59 (42%) are found exclusively in the Upper Zambezi (above Victoria Falls) and 43 (31%) exclusively in the Middle and Lower Zambezi, including the Pungwe/Buzi system. The separation of the two faunal assemblages is very marked, and supports the separation of the Zambezi Basin into two biogeographical zones. From the literature, however, it is clear that the fish fauna of the Lower Zambezi, excluding that of the Lower Shire, is not at all well known.

Although the Zambezi itself is a perennial river, it used to undergo marked changes in level owing to flooding. Prior to the construction of Kariba and Cabora Bassa dams annual floods were a major biological feature, in particular of the Lower Zambezi. The fish fauna was adapted to this, with rheophilic species (those living in flowing waters) predominating in the middle and lower sections (Bowmaker *et al.* 1978). Fish species adapted to slow-moving water conditions were confined to occasional pools and the broad floodplains of the Upper Zambezi. Lakes Kariba and Cabora Bassa have created, in effect, extensive habitats for those Upper Zambezi species as well as a new habitat for pelagic (open water) species. Changes in fish species composition, fish productivity and limnology of these man-made lakes forms a substantial part of the literature, both in formal publications and unpublished reports. The main focus has been Lake Kariba (chapters in Balon & Coche 1974; chapters in Moreau 1997; Balon 1971b, 1972, 1973; Begg 1973; Bowmaker 1960a; Coche 1971; Harding 1964; Jackson 1964; Karenge & Kolding 1995a,b; Kenmuir 1978; Magadza 1995a; Marshall 1991). Studies or assessments have also been made for the Kafue floodplains in response to the dams at Kafue Gorge and Itezhi-Tezhi (Carey 1971; Chipungu

1981; Cowx & Kapasa 1995; Dudley 1974, 1976, 1979; Lagler *et al.* 1971; Munyanga & Chipungu 1982; University of Michigan 1971; R.Williams 1971), the Lower Shire marshes since the hydro-electric schemes upstream (Cantrell 1979; Dudley *et al.* 1991; Willoughby & Tweddle 1978b) and Lake Cabora Bassa (Bernacsek & Lopes 1984a,b; Davies *et al.* 1975; Gliwicz 1984; Jackson & Davies 1976; Jackson & Rogers 1976).

Previously, Lake Malawi contained the only pelagic habitat in the basin and has developed its own unique fish fauna (Bootsma & Hecky 1993; Coulter *et al.* 1986; Fryer 1959; Fryer & Iles 1972; McKaye *et al.* 1985; Reinthal 1993; Ribbink 1991; G.Turner 1995; Tweddle 1992). Much concern has been expressed on the conservation of this unique ecosystem and on the effects of over-fishing and threat of introduction of pelagic species, of which there are hardly any at present, such as kapenta or the Lake Tanganyika sardine (*Limnothrissa miodon*), which occupies a similar niche in Lake Tanganyika.

Also of conservation concern is the fact that most of the tributary rivers of the Middle Zambezi, as well as the main river itself, have been dammed so that flows are much more regulated and rheophilic habitats lost. Pollution of Lake Chivero (formerly Lake McIlwaine) associated with the large urban and industrial centre of Harare has been the focus of many studies (papers in Thornton 1982; Hillman 1996; Magadza 1994; Marshall 1995; Moyo 1997, Munro 1966).

Some studies have been done on the effects of spraying of DDT, deltamethrin and endosulfan on fish populations, particularly in the Sebungwe area of the Middle Zambezi in Zimbabwe (Douthwaite & Tingle 1994; Matthiessen 1985; Mhlanga *et al.* 1986) and in the Okavango swamps (Fox & Matthiessen 1982; Merron 1986, 1992; Russell-Smith 1976), but also in Barotseland (Magadza 1978a). There appears to be a marked effect through reproductive failure, as well as direct kills with endosulfan. The effects of DDT are insidious and build up in the food chain. Unfortunately, there are no baseline data available prior to tsetse control.

Information on fisheries, catches as well as biology, is good for the East Caprivi (Van der Waal 1980, 1990, 1991), Kafue Flats, Lake Kariba, Lake Malawi, Lake Chilwa (Kalk *et al.* 1979) and the Lower Shire (various papers by Tweddle and Willoughby). Some information also exists for the Barotse floodplains (Bell-Cross 1971, 1974a; Kelley 1969).

3.2.7 **Invertebrates**

Despite being the largest and most diverse biological group, in terms of published literature invertebrates are one of the smallest. By far the majority of references are taxonomic, lists of specimens collected or checklists. There is very little information available on ecology, function or production. No attempt was made here to cover the invertebrate literature relating to medical or agricultural pests (mosquitoes, ticks, flukes, etc.).

Invertebrates cover many disparate groups. Here, emphasis has been placed on wetland or grassland-associated groups such as Odonata (dragonflies and damselflies), Lepidoptera (moths and butterflies), Orthoptera (grasshoppers and crickets), freshwater molluscs (snails) and aquatic crustacea (zooplankton and shrimps) as more than half of the literature cited is concerned exclusively with these groups. Other partially wetland groups with some coverage in the literature are Trichoptera (caddis flies), Coleoptera (beetles), Isoptera (termites) and arachnids (spiders and scorpions). Soil fauna, sometimes termed a ‹new frontier' in biology, only appears to have been looked at by Dangerfield (1993, 1997). A subjective summary of extent of available information by geographical area is given in Table 3.8.

Table 3.8. Extent of knowledge on various invertebrate groups within the wetlands of the Zambezi Basin.

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	Mwini-lunga	Barotse-land	Chobe	Okavango	Lower Shire	Zambezi Delta
Lepidoptera ! butterflies	*		***	***	*	
Lepidoptera ! moths	*		*	*	*	
Odonata	*		***	***	**	*
Trichoptera	*		?	?		
Orthoptera	?	?	**	**	?	
Coleoptera			*	*		*
Isoptera			*	*		
Arachnida			*	*		

Source: M. Fitzpatrick (pers. comm.)

*** very well covered
** fairly well covered
* limited coverage
? degree of coverage unknown or speculative

Regional lists and identification guides are available for butterflies (Pennington 1978; Pinhey 1965; Van Son 1949), hawk moths (Pinhey 1962a), Emperor moths (Pinhey 1972a), Trichoptera or caddis flies (Scott 1983), termites (Coaton & Sheasby 1973-78) and freshwater molluscs (Appleton 1979, 1996), while national lists are available for butterflies (Botswana - Pinhey 1968b, 1971, 1972c, 1974b; Malawi - Gifford 1965), hawkmoths (Zambia - M.Mitchell 1973), the Acridoidea group of grasshoppers (Botswana - Johnsen 1990; Zambia - Johnsen 1982; Mozambique [all Orthoptera] - Ferreira 1964a; Malawi - Whellan 1975), dragonflies (Zambia - Pinhey 1961; Botswana - Pinhey 1976; Malawi - Pinhey 1966; Mozambique - Pinhey 1981) and molluscs (Mozambique - Azevedo *et al.* 1961). Zooplankton lists are available for Lake Kariba (Marshall 1997) and Lake Malawi (Fryer 1957a-c), while general lists of freshwater invertebrates have been compiled for Namibia (Curtis 1991), the Kafue Flats (Carey 1967, 1971), Lake Kariba (Machena & Kautsky 1988) and Lake Chivero (Marshall 1982a, Munro 1966; Thornton & Taussig 1982). The freshwater molluscs of the East Caprivi have been surveyed in detail (Brown *et al.* 1992). Reviews of butterflies (Pinhey 1978b), freshwater invertebrates (Harrison 1978), dragonflies (Pinhey 1978a) and freshwater molluscs (Brown 1978) for southern Africa were published in Werger (1978).

Shrimps (marine crustacea) are a major economic resource for Mozambique. One of the most important areas for them is the Sofala Bank associated with the mouth of the proto-Lower Zambezi at Beira, south of the present Zambezi Delta. Concerns have been expressed over the effects of flood control by Cabora Bassa dam on productivity (Da Silva 1986; Gammelsrod 1992), with a suggestion that controlled water release could enhance shrimp production.

Weevils of the genus *Cyrtobagous* have been successfully used to control the aquatic weed *Salvinia molesta* in the Chobe-Caprivi area (Proctor 1983; Schlettwein 1985), one of the very few cases of biological control for aquatic weeds within the basin. A weevil (*Neochatina* sp.) has been used on Lake Chivero to control the water hyacinth (*Eichhornia crassipes*).

An important environmental concern in the literature has been the spraying of the insecticides DDT and endosulfan for tsetse control in the Okavango and the Sebungwe region in Zimbabwe (Douthwaite & Tingle 1994; Russell-Smith 1976; Russell-Smith & Ruckert 1981). Although undoubted successes have been achieved in controlling the tsetse fly (*Glossina morsitans*), undesirable side effects have occurred in the reduction of populations of other organisms.

As mentioned above, ecological aspects of invertebrates have not been comprehensively addressed. Eccles (1985), Irvine (1995b) and Turner (1982) have looked at the well-known lakefly (*Chaoborus* species) of Lake Malawi and its importance for fisheries, and at the ecology of other zooplankton components (Irvine *et al.* 1995), while Marshall (1997) has made a study of zooplankton ecology in Lake Kariba and also monitored changes in the benthic (bottom-dwelling) fauna of Lake Chivero (Marshall 1995). The effects of termites on shaping floodplain geography have been studied in the Okavango area (McCarthy *et al.* 1997, Dangerfield *et al.* 1997). Invertebrate conservation, apart from shrimps which are of major economic importance, has only been addressed for Lake Malawi (Eccles 1985) and perhaps the Okavango, where there is also an endemic spider (Lamoral 1981).

Out of 781 species of butterflies in southern Africa (Pennington 1978), 16 are confined to wetlands (M. Fitzpatrick, pers. comm.), listed in Table 4.4. Lepidoptera distribution is often dominated by the distribution of the food plant on which the caterpillar feeds, but information on these links is still patchy.

Odonata are generally restricted to water as the eggs are laid there and the larval stage is aquatic. Owing to the efforts of one man in the 1960-70s ! Elliot Pinhey from the Natural History Museum in Bulawayo ! this insect group is probably the best known of all (Pinhey 1951, 1958, 1961, 1962c, 1963, 1964, 1966, 1967, 1972b, 1974a, 1976, 1978, 1979, 1981). They have been particularly well-studied in the Okavango and Chobe areas, and also quite well in Mwinilunga at the Zambezi headwaters, where species of Congolian affinity are found. It would be interesting to see if species composition of this group shows a disjunction between Upper and Lower Zambezi, as has been noted for both fish and reptiles/amphibians.

3.2.8 **Upper Zambezi**

The Upper Zambezi and biologically-associated systems of the Bangweulu, Kafue and Okavango (Figure 2.2), are described in Section 2.1.2. The present section will bring out the major aspects of the biodiversity literature related to the various parts of the Upper Zambezi region. The Barotse floodplains and Chobe/East Caprivi areas, two of the four IUCN Wetland Project sites, are given particular attention.

The Upper Zambezi floodplains, roughly from the Zambezi-Luena confluence in north east Angola down to Livingstone/Victoria Falls, have received a surprisingly limited amount of biological attention, which has

principally been in the form of broad biological surveys and checklists. The main groups covered have been plants (checklists), large mammals (lists, taxonomy, conservation, surveys, census), birds (lists, surveys, conservation), reptiles and amphibians (checklists, taxonomy, biogeography), fish (checklists, biogeography, ecology of a few individual species, fisheries) and dragonflies (taxonomy, checklists, biogeography). The large distances and general inaccessibility of much of the area owing to seasonal flooding have probably been major limitations to more detailed work.

A series of district-level vegetation surveys carried out in Zambia by Fanshawe in the 1960s (Fanshawe 1968-73) using a basic but standard classification system based on that developed by Trapnell & Clothier in their 1937 survey, gives a good indication of plant species composition. The vegetation maps of White (1983), Wild & Barbosa (1967), Barbosa (1970) and Edmonds (1976), give the broad distribution of types.

Mwinilunga

Some of the more biologically interesting publications of the Upper Zambezi concern the Zambezi headwaters at Mwinilunga in north western Zambia, an area which has seen considerable biological collecting in the past (Bell-Cross 1974a; Bingham 1994; Broadley 1991; Pinhey 1964). It is here that both flora and fauna include genera and species more typical of the Congo Basin (or Guineo-Congolian Region), and species diversity for many groups is higher than elsewhere in the Zambezian Region owing, in part, to it being a mixture of species from the two. This is probably a result of species extinctions in the more arid Zambezian Region during the Pleistocene and earlier dry periods; species may have retreated to the more moist Congolian Region, from which perhaps some have returned in subsequent moist periods. The flat landscape now allows some species to migrate with relative ease across the watershed from one catchment to the other (see Bell-Cross 1965d regarding fish).

Bangweulu Swamps

The Bangweulu Swamps, although not now part of the present-day Zambezi Basin, were, biologically-speaking, in the geologically-recent past. The literature for this area has not been fully investigated, but publications concerning wetland biodiversity that have direct relevance to the Zambezi Basin are noted. Most of the studies have been on the black lechwe (*Kobus leche smithemani*), an endemic semi-aquatic antelope that was, until recently, threatened with possible extinction. Four studies (Allen 1963; Grimsdell & Bell 1972a-c, 1975; Howard *et al.* 1984; Thirgood *et al.* 1992, 1994) have focussed primarily on status and conservation. Other topics of interest have been pollen analysis (Lawton 1959, 1963), surveys of large wetland birds such as storks and cranes (Howard & Aspinwall 1984; Kamweneshe 1996), sitatunga ecology (Manning 1975) and limnology (Bowmaker 1960b; Magadza 1985; Thomasson 1955; Toews 1975).

Barotse floodplains

The extent of floodplains and associated grasslands of the Upper Zambezi in Barotseland is difficult to determine. Much of the area is comparatively flat and open, floodplain grades into dambo, annually flooded areas into those only rarely flooded, and it is difficult to separate those wetlands influenced by the Zambezi from those fed solely by their own catchments. For the purposes of this review, the Barotse wetlands are taken to be those from Lukulu, about 180 km downstream of where the Zambezi river re-enters Zambia, to just below the town of Senanga; it includes the Liuwa Plain National Park, the Luena Flats, the Barotse Floodplain and wetlands associated with the Lungwebungu river. This area is one of the four IUCN Wetland Project sites.

Given the extent and the biological importance of the area, it is surprising how few biodiversity studies have been carried out. This may, in part, be due to problems of accessibility. For much of the year it is not possible to access large areas except by boat. Apart from general vegetation surveys, it is the birdlife and fish that are best covered in the literature.

As is seen elsewhere, the first biodiversity-related studies of an area focus on broad resource inventory with particular emphasis on potentially economic resources (timber, grazing, arable soils) and taxonomic studies (notes on collecting trips and descriptions of new species). This stage is later followed by preliminary checklists, especially of birds, mammals and fish. Published biodiversity studies of Barotseland have not yet progressed much beyond this, the major exceptions being a series of studies on fish biology by Winemiller and Kelso-Winemiller (1991, 1993, 1994, 1996).

Following the pioneering vegetation survey by Trapnell (Trapnell & Clothier 1937; Trapnell *et al.* 1950), Fanshawe produced a series of district-level reports giving plant species composition for each vegetation type (Fanshawe 1968-73). The next major work was the two-volume ecological survey of the whole of Western Province by Verboom & Brunt (1970a,b), which covers all but the northernmost parts of the Barotse floodplains. Verboom & Brunt's ecological survey focussed on vegetation resources for cattle production, and includes Fanshawe's species lists, a classification of vegetation, and preliminary lists of some of the fauna. This report was based on detailed ecological surveys carried out by Verboom in the early 1960s culminating in an earlier report (Verboom 1965, now generally unavailable) and other publications (Verboom 1966, 1970). Some of Verboom's data are incorporated in a publication on grasslands of Zambia (Verboom 1981a,b) which places the Barotse grasslands in a Zambian context. A plant checklist of parts of Western Province has been compiled by Bingham (1996), based in part on an earlier ethno-botanical survey of Senanga West District (Bingham 1990).

The Kalahari sands of Barotseland are the centre of diversity of "underground trees" (White 1976), species closely related to large trees but which have diminished in size with the very dwarfed trunk effectively underground ! an adaptation to seasonal waterlogging of their habitat and consequent inhibited rooting ability, and also to fire.

The great importance of the rangeland resource was the justification for a detailed landscape and vegetation survey of Western Province (Jeanes & Baars 1991a,b; Baars 1996) and the production of an excellent landscape-guided vegetation map at scale 1:500,000, the best seen for any wetland area. The Zambezi or Barotse floodplain itself, however, is classified as just one type. Frost (1992) gives an account of the ecological effects of fire on the area's rangelands. An overview of the ecology and natural resources of Western Province was given by Van Gils (1988), while Van Oosten (1989) gives an annotated bibliography of all literature on the Province.

Publications on ornithology are principally accounts of birds seen or collections (Aspinwall 1979; Bell-Cross 1974b; Benson & Irwin 1967; Coppinger *et al.* 1988; Dowsett 1966b, 1969; Traylor 1965; Traylor & Hart 1965; Williams *et al.* 1989; Winterbottom 1942, 1943).

D. Broadley (pers. comm.) considers the wetlands of the Upper Zambezi to be an important centre of diversity for reptiles and, particularly, amphibians owing to its long-term environmental stability and extent. Although the herpetofauna is poorly known, there are quite a few publications describing collections or new species from the Barotse floodplains (Angel 1920, 1921; Broadley 1971; Peracca 1910; Roux 1907). The status of crocodiles was looked at by Cott (1961) many years ago.

Pinhey (1961) mentions many dragonflies from Barotseland in his Zambian checklist, otherwise there appears to be nothing published on the invertebrates of the wetlands.

The fisheries of the Barotse floodplains are another major economic activity. These have been described by Bell-Cross (1971, 1974a) and in various FAO publications (e.g. Kelley 1968). Studies on tigerfish have been carried out (Bell-Cross 1965b; Winemiller & Kelso-Winemiller 1994), and in recent years a series of studies have been done on the ecology of other important fish species (Winemiller 1991; Winemiller & Kelso-Winemiller 1996). Fish species lists are given by Bell-Cross (1965a, 1974a) and Jackson (1961a), while Jubb (1958) provides notes on a collection of fish from the area.

The only formally-protected part of the Barotse floodplains is the Liuwa Plain National Park in the north west of Western Province. A descriptive list of the larger mammals is available (Benson 1969), while Osborne (1975) gives a checklist of the birds. Animal censuses have been carried out by Connant (1975) and Tembo & Saiwana (1991). Muleta *et al.* (1996) outline some of the ecological characteristics of the area, showing that populations are seasonal. Red lechwe and wild dog are also present (E. Chileshe, pers. comm.). Bird species of particular conservation concern are the Crowned Crane (Katanekwa 1996) and Wattled Crane (Dodman 1996a).

Kafue Basin

The Kafue Basin (including the Lukanga and Busanga Swamps, parts of the Kafue National Park, Lake Itezhi-Tezhi and the Kafue Flats) is often considered part of the Middle Zambezi, into which it flows below Kariba. However, the great majority of the system, all that above the Kafue Gorge, was part of the proto-Upper Zambezi; geomorphologically and biologically the Kafue can be considered part of the Upper Zambezi, and is treated as such here.

The Kafue, particularly the Kafue Flats (that section from Itezhi-Tezhi to the Kafue Gorge) is perhaps the most studied of all the Zambezi wetlands, with a total of 99 references relating to its ecology and biodiversity. The two main reasons for this are probably (a) its proximity to the major urban centre of Lusaka where many researchers were based, and, more pertinently, (b) the great concern raised by conservationists when plans to drastically change the flooding regime with the construction of dams at Itezhi-Tezhi and Kafue Gorge threatened fisheries and the only population of the endemic Kafue lechwe (*Kobus leche kafuensis*). The majority of the studies have focussed on the status, conservation, ecology, feeding and breeding of the lechwe (e.g. Ansell 1964; Bell *et al.* 1973; Chabwela & Ellenbroek 1990; Jeffery *et al.* 1990; Nefdt 1996; Rees 1976, 1978a-d; Robinette & Child 1964; Sayer & Van Lavieren 1975; Schuster 1976, 1977, 1980) and on the status and changes to fish populations since dam construction (e.g. Chapman *et al.* 1971; Chipungu 1981; Cowx & Kapasa 1995; R.Dudley 1974, 1976, 1979; Kapetsky 1974; Lagler *et al.* 1971; Muyanga & Chipungu 1982; R.Williams 1971). Conservationists have also been concerned about the effects of flood control on waterbirds and cranes, particularly the Wattled Crane, and this has given rise to a number of surveys and studies (Dodman 1996b; Douthwaite 1977, 1982b; Dowsett 1966a; Howard 1989; Howard & Aspinwall 1984; Konrad 1987). Limnology has been studied by, amongst others, Carey (1967, 1971) and Magadza (1977b). Ellenbroek (1987) carried out a very detailed study of plant ecology, including productivity ! the only such study (except for Lake Chilwa) for a wetland in the basin.

General reviews of the ecology of the Kafue Flats are given by Handlos (1977, 1982) and Howard (1985), while an earlier study (FAO 1968) includes a vegetation survey (Van Rensburg 1968b). Vegetation has also been studied by Douthwaite & Van Lavieren (1977). The proceedings of a multi-disciplinary

symposium on the Kafue has been published (Howard & Williams 1982, presumably an edited version of Williams & Howard 1977), while various conservation projects are reviewed by Jeffery (1992) and Mwenya & Kaweche (1982). Two major bibliographies on the Kafue Basin have ben produced (Turner 1983, Nefdt 199?), but both now seem hard to obtain.

Upstream of the Itezhi-Tezhi dam the extensive Kafue National Park has been the focus of a few scattered studies on large mammals (Dowsett 1966c; Hanks *et al.* 1969; B.Mitchell *et al.* n.d.) and two on plants (Mitchell 1963; Hanks 1969), but surprisingly nothing on birds. Also surprising is the paucity of published information on the Busanga and Lukanga Swamps on the upper reaches of the Kafue (but see Grimsdell & Bell 1972; Seagrief 1962). Attempts are now being made to study the Lukanga Swamps in more detail (H. Chabwela, pers. comm.).

Floodplains and swamps of Chobe/Caprivi

This area, the next of the IUCN Wetland Project sites, is a meeting point of various drainage systems ! the Upper Zambezi, the Kwando and, indirectly, the Okavango. During the Pleistocene the proto-Kafue probably also flowed through, and the East Caprivi was the site of a large lake, Lake Caprivi (Shaw & Thomas 1988; see Section 2.2). The area is now a confusing mix of alluvium and sands of differing ages and origins. Hydrologically the swamps and floodplains have differing origins but do interconnect, and the whole complex is somewhat unstable ecologically. The Kwando has limited swamps associated with the lower reaches as it passes across the Caprivi Strip, swamps which become more extensive as the river turns to the north east and effectively becomes the Linyanti. At this point the Selinda Spillway connects an arm of the Okavango to the Linyanti, but water only rarely moves between the two systems, in either direction depending on flood levels. The Linyanti flows sluggishly here, at least in recent years, and can flow into Lake Liambezi, which is now dry. Flowing into the former Lake Liambezi from the other side is the Chobe River, a bi-directional river which in recent years has mostly flowed to the west. The Chobe is fed by floodwaters of the Zambezi, although historically it has flowed from Lake Liambezi eastwards to the Zambezi. On the west bank of the main Zambezi below Katima Mulilo are floodplains inundated for a few months each year by the Zambezi floods. The biodiversity of the swamps and floodplains differ, but any attempt to clearly separate them is bound to be artificial.

Biodiversity concerns have been addressed better in this area than any other Zambezi Basin wetland, except for perhaps the Kafue Flats and Lake Kariba shoreline. The Botswana Chobe waterfront in particular, has been intensively studied. Blair-Rains & McKay (1968) carried out a study of northern Botswana which covered the Chobe area including the so-called Chobe enclave opposite Lake Liambezi. Their study, similar to that done by Verboom & Brunt (1970a) in Barotseland, focussed on the dryland areas, and very little of the study area can be considered wetland or grassland. At the same time, an ecological survey focussing on wildlife concerns was being carried out by FAO (Child 1968b). Out of this survey also came various publications on the behaviour and ecology of lechwe and puku (Child 1975; Child & Von Richter 1969; Von Richter & Osterburg 1977). Later consultancy studies for development planning (e.g. Deloitte & Touche 1991) have drawn heavily on these earlier publications. Hunter (1991) provides a review of ecological literature on Botswana's wetlands from a wildlife perspective, and cites many of the Chobe studies.

An environmental profile of the Caprivi has recently been published (Mendelsohn & Roberts 1997) covering a literature review, vegetation map and assessment of land use change as determined from airphotos. Brown & Jones (1994) have compiled a socio-ecological survey of the West Caprivi, including

the Kavango River, with comprehensive lists of plants, fish, reptiles, amphibians, birds and mammals, which is of value in assessing biodiversity in the Caprivi.

The vegetation maps of Botswana (Bekker & De Wit 1991; Weare & Yalala 1971) provide very little information on the vegetation of the Chobe area, while the existing vegetation map of Namibia (Giess 1971) does not cover the Caprivi at all. The detailed vegetation map by Hines (in Mendelsohn & Roberts 1997) based on satellite and aerial photos, shows 32 species-defined vegetation types for the Eastern Caprivi, 14 of which are floodplain types. Coulson (1992) produced an unpublished vegetation map of the Kwando/Linyanti area, and Simpson (1975) carried out a detailed vegetation survey of part of the Chobe waterfront. The earliest published account of the ecology of these wetland areas was by Curson (1947) who describes the vegetation of the East Caprivi and gives a detailed plant list. Schlettwein *et al.* (1991) also describe the vegetation and include a list of wetland plants, while P.A. Smith (pers. comm.) is compiling a preliminary plant checklist of Botswana wetland areas from his own collections. He has already prepared an unpublished preliminary checklist of wetland plants from Botswana (Smith 1984).

Some years ago there were major concerns in both Botswana and the Caprivi over the rapid spread of the aquatic weed *Salvinia molesta* and its possible effect on fisheries and biodiversity, particularly if it reached the Okavango. Early reports documented its spread and ecology (Edwards 1972; Edwards & Thomas 1977; Koch & Schlettwein 1983; Mitchell 1967a, 1968; Schlettwein & Koch 1983; Smith 1969, 1985), while later publications focussed on its successful control using an introduced weevil (Bethune 1996; Proctor 1983; Schlettwein 1985; Schlettwein & Bethune 1992; Smith 1993).

In 1991 a special edition of Madoqua, a Namibian biological journal, was published on the status and conservation of Namibia's wetlands (Simmons, Brown & Griffin 1991). One of the papers (Schlettwein *et al.* 1991) was on the flora and fauna of the East Caprivi wetlands, said to cover 500 km² and by far the most extensive in the country. A checklist of wetland plants is included, and the paper also describes the large decrease in wildlife numbers since 1980, particularly of sitatunga and lechwe. National reviews of various wetland groups (fish ! Holtzhausen 1991; Bethune & Roberts 1991; wetland-associated mammals ! Griffin & Grobler 1991; reptiles and amphibians ! Griffin & Channing 1991; freshwater invertebrates ! Curtis 1991) are also included.

The greatest number of publications on the biodiversity of the Chobe/Caprivi wetlands concerns birds, although most are of an anecdotal nature (sightings, behaviour, breeding records) rather than formal studies. Some publications include checklists (Haacke *et al.* 1971 ! which lists 260 species from the East Caprivi; Hines 1996; Irwin *et al.* 1969 ! which lists 460 species from Chobe; Koen 1988; Smithers 1964). Particular bird species of note are the endangered Slaty Egret (Benson *et al.* 1971), African Skimmer (Coppinger *et al.* 1988; Randall 1994a), Rock Pratincole (Williams *et al.* 1989) and various cranes (Brown 1992; Hines 1996; Williams 1987).

The Chobe area has a comparatively rich herpetofauna containing 71 species out of a total of 160 recorded for the wetlands of the Zambezi Basin (D. Broadley, pers. comm.), but this is possibly a result of more intensive collecting. Reviews and lists of the herpetofauna are found in Channing & Griffin (1993), Griffin (1995) and Griffin & Channing (1991), while some species accounts and new records for the area have been published (Branch *et al.* 1994; Broadley 1977; Channing 1989).

As with other wetlands, fish are a major resource. The ichthyofauna of the Chobe/Caprivi area is probably typical of much of the Upper Zambezi, for which checklists have been compiled (Bell-Cross 1965a, 1974a;

Skelton 1994). Specific lists for the East Caprivi have been compiled by Bethune & Roberts (1991), Holtzhausen (1991) and Van der Waal & Skelton (1984), but not for the Botswana side. Between 59 and 74 species are recorded; only one of them is endemic (Holtzhausen 1991). The Kavango River appears to have a higher fish diversity. The fisheries of the area are described by Tvedten *et al.* (1994) and Van der Waal (1990).

A detailed study of the freshwater snails of the Kavango and East Caprivi (Brown *et al.* 1992) lists 20 species from the latter area, while another study on the freshwater macro-invertebrates of Namibia (Curtis 1991) lists 127 species from the East Caprivi. These are the most detailed studies on molluscs available for any wetland area in the basin with the exception of Lake Chivero. The extensive series of publications on dragonflies by Pinhey does not specifically cover the Caprivi area, but he collected in the Chobe and any records would be incorporated in larger lists (Pinhey 1961, 1962c, 1967, 1976). Soil fauna are briefly described for the Moremi and Chobe areas by Dangerfield (1993, 1997).

Parts of the Chobe/Linyanti/Kwando area are protected for wildlife, particularly on the Botswana side, while the Zambezi floodplains of the East Caprivi are without protection. A major cause for concern in recent years has been the impact of elephant on vegetation, especially along the Chobe waterfront (Sommerlatte 1976; Wackernagel 1993; Joos-Vandewalle 1988). The loss of tree cover there has been reported by Parry & Blyther (1991). Numbers of large mammals in the Caprivi as determined by aerial census are given in Rodwell *et al.* (1995), but numbers are very low compared to those in Botswana. There is free-movement, however, of many species across the boundary.

On the Botswana side there have been a number of studies of mammal species associated with wetlands such as lechwe (Williamson 1979, 1981, 1990, 1994), sitatunga (Williamson 1986) and bushbuck (Simpson 1974a-c; Addy 199?), as well as those studies mentioned earlier. Migration and species changes of large mammal populations have been looked at by Sheppe & Haas (1976); the same authors also looked at population changes in small rodents in floodplain grasslands in Chobe and Kafue (Sheppe & Haas 1981).

One of the more interesting and well documented aspects of the instability of the Chobe/Caprivi wetlands is the appearance and disappearance of Lake Liambezi. Curson (1947) does not seem to mention its existence, just marking it as a swamp on the map, although he does refer to marked changes in extent of flooding and settlement compared to Livingstone's time (1857). The lake was surveyed in detail in the 1970s (Seaman *et al.* 1978) as being 101 km² in extent, shallow and reed-fringed. Data on zooplankton, phytoplankton and fish are given in this study, while Van der Waal (1976, 1980) gives a detailed account of the fishery. Lake Liambezi supported 43 species of fish with a production of 74-157 kg/ha. By 1985 the lake had completely dried up and a major protein source was lost (Grobler & Ferreira 1990). The exposed peat beds have now been almost totally destroyed by burning, and today the old lake bed is a large expanse of bare ground and grass with few scattered clumps of *Phragmites* reeds. Only bleached freshwater snail shells remain to show what it was. Presumably the drying out is a natural phenomenon; it is postulated that the lake only appears after exceptionally high floods from the Zambezi fill it, after which it can be maintained by lesser annual inflows (Grobler & Ferreira 1990). Blockage of inflow channels by wetland vegetation, and the lack of hippo activity to keep them open, may mean refilling of Lake Liambezi is now less likely.

Okavango

As with the Bangweulu and Kafue Basin, the Okavango (the lower Kavango/Okavango River and the Okavango Swamps, including parts of Moremi) is not generally considered part of the Zambezi Basin. Hydrologically, however, the two are occasionally linked by floodwaters through the Selinda Spillway or Savuti Channel, and biologically the basins are inter-linked ! the proto-Upper Zambezi probably flowed through the East Caprivi to the Okavango, then down to palaeo-Lake Makgadikgadi (Shaw 1985, 1988; see Section 2.2).

The Okavango swamps and adjacent alluvial areas have been the subject of many studies, starting with UNDP/FAO projects in the early 1970s. Some of these studies had their principal focus in the Chobe area and were discussed earlier. References covered here primarily relate to general ecology, impacts of insecticide spraying (the Okavango has been a major focus of research), palaeo-geomorphology and some on the effects of organisms on land form and hydrology, a topic apparently not looked at anywhere else in the Zambezi Basin.

Studies on general ecology and vegetation include Biggs (1976, 1979), Smith (1976, 199?) and Tinley (1973). Many aspects of the ecology of the Okavango were covered by the Okavango Symposium (Botswana Society 1976), and a summary of ecological literature has also been produced (Hunter 1991). Scudder *et al.* (1993) carried out a very detailed impact assessment of the possible environmental effects of changing hydrology through dredging, an assessment which could act as a model for other studies in the region. There have been a series of studies on the biology, ecology and behaviour of a range of larger mammals. Of particular note and relevance to other wetlands are those of Lent (1969) on the red lechwe and Games (1983, 1984) on sitatunga. Dragonflies have been studied by Balinsky (1967) and Pinhey (1967, 1976), who also lists the butterflies of Ngamiland (Pinhey 1968a,b, 1971, 1972c, 1974b).

The effects of tsetse control practices on biodiversity have been a major environmental concern over the years. Results of tree ring-barking to destroy tsetse habitat in the 1950s can still be seen (Tinley 1973), but wildlife populations, despite large-scale hunting, did not greatly diminish (Child 1968b; Child *et al.* 1969). Ground and aerial spraying of DDT or endosulfan in the 1970s gave rise to documented kills of fish and aquatic invertebrates (Fox & Matthiessen 1982; Merron 1992; Russell-Smith 1976; Russell-Smith & Ruckert 1981).

As mentioned in Section 2.2, the hydrology and drainage patterns of the Okavango/Chobe area have seen radical changes over the past million or so years in response to pluvial periods, tectonic movement and river capture. A series of papers by Shaw and Thomas (Shaw 1984, 1985, 1988; Shaw & Cooke 1986; Shaw & Thomas 1988; Thomas & Shaw 1988) have documented some of these changes and elucidated possible pattern and causation.

A series of interesting studies have been carried out by McCarthy, Ellery, Dangerfield and others (Dangerfield *et al.* 1997; Ellery *et al.* 1989, 1997; McCarthy 1992; McCarthy *et al.* 1988, 1997) on factors causing hydrological change in the Okavango Swamps. Changes in land level caused by tectonic movement, sediment build-up, peat fires or termitaria, can cause marked changes in drainage. Likewise, blockages caused by build up of plant material can force new channels to form. These studies have great value in understanding other swamps. A major conclusion is that hydrology and drainage patterns are not fixed so that conservation efforts must not be predicated on maintaining the status quo, but should ensure that ecological processes can continue to function at a landscape level.

3.2.9 **Middle Zambezi**

A general outline of the Middle Zambezi is given in Section 2.1.3. This section will briefly review the biodiversity literature for the Middle Zambezi between Victoria Falls and Tambara below Tete in Mozambique, including Lakes Kariba and Cabora Bassa, the section of the Kafue river below Kafue Gorge, some of the major tributaries, and Lake Chivero near Harare. None of the IUCN Wetland Project sites are located in the Middle Zambezi.

The two major points coming out of a review of the biodiversity literature are (a) there are no extensive wetlands associated with this section of the Zambezi, and (b) that its biology and ecology are dominated by the presence of large dams. The literature is dominated by research pertaining to Lakes Kariba (104 references) and Cabora Bassa (20 references). The former is perhaps the best studied man-made lake on the continent. The main topics of concern have been fish and fisheries, limnology, changes in ecology since dam construction and large mammal ecology.

Lake Kariba

Even prior to the filling of Lake Kariba in 1958, the flooding of the Gwembe Valley and the drastic changes in flood regime downstream, concerns were expressed on the potential major impacts on the ecology of the Middle Zambezi. Such concerns ranged from the immediate loss of wildlife through drowning (which stimulated the initiation of Operation Noah and wildlife translocation ! Child 1968a, Junor 1960), explosive increases in aquatic weeds, restrictions on fish impoundments upstream, loss of wetland and other special habitats along with their associated species, and the effects on riparian and alluvial ecology through modified flood regime. All wetland habitat in the former Gwembe Valley was lost, but there appears to be no documented case of actual species loss, although it has to be recognised that pre-impoundment studies were very limited. Modification to downstream environments and ecology were noted in later years (Attwell 1970; Begg 1973; Dunham 1989; Jarman 1968, 1972a) ! banks were more eroded, certain species such as the tree *Faidherbia albida*, dependent on occasional floods for establishment, were not replacing themselves satisfactorily, and wildlife (especially elephant and impala) had continual access to riparian vegetation thus over-exploiting it. Although widely referred to, such effects have not been well documented ! again probably owing to the lack of pre-impoundment studies. The sudden increase of aquatic weeds ! *Eichhornia crassipes* (water hyacinth), *Salvinia molesta* (water fern) and *Pistia stratiotes* (water lettuce) in particular ! caused much concern in the early 1960s (e.g. Almeida 1972; Boughey 1963; Marshall & Junor 1981), but with time and the flushing of nutrients from the system, the infestation dissipated and is now not considered a problem.

Although some habitats have been lost, new ones have been created. Buffalo have adapted well to floodplain grasslands at Matusadonha on the Kariba shoreline (Taylor 1985), and the creation of pelagic (open water) habitats and introduction of kapenta or the Lake Tanganyika sardine (*Limnothrissa miodon*, Bell-Cross & Bell-Cross 1971) has given rise to a large commercial fishing industry. There have been various studies on the change in fish species composition (Balon 1971b, 1973, 1975; Bowmaker *et al.* 1978; Coke 1968; Harding 1964; Jackson 1965; Jubb 1960; Karenge & Kolding 1995a; Kenmuir 1984, 1989; Marshall 1991; Sanyanga 1995).

Fish composition and biology is comparatively well-known (Balon 1971a,c, 1974a, 1975; Jackson 1961c; Karenge & Kolding 1995b; Kenmuir 1989; Matthes 1968; S.Mitchell 1976), and the limnology of the lake has been studied by various authors (Boon 1984; Kautsky & Kiibus 1997; Machena & Kautsky 1988; McLachlan 1969a,b, 1970; McLachlan & McLachlan 1971). Aquatic and shoreline plants have received some attention (Boughey 1963; Bowmaker 1973a,b; Machena 1989, 1997; Magadza 1970; D.Mitchell

1969a,b; Skarpe 1997). The phytoplankton of Kariba is better studied than that of any other part of the basin (Cronberg 1997; Hancock 1979, 1985; King & Thomas 1985; Ramberg 1987; Thomasson 1965, 1980), but zooplankton has received less detailed attention (Green 1985; Magadza 1980; Marshall 1997). The feeding ecology of waterbirds has been studied by Birkhead (1978), Donnelly & Hustler (1986) and Hustler (1991, 1997), while crocodiles have been looked at by Games & Moreau (1997). Most of the available information on the ecology and limnology of Lake Kariba has been summarised in three compiled books (Balon & Coche 1974; Kenmuir 1978; Moreau 1997), and a bibliography up to 1968 is available (Coche 1971).

The disjunctions in fish species composition between the Upper and Middle Zambezi have been documented by Balon (1974b), Bell-Cross & Kaoma (1971), Bell-Cross & Minshull (1988), Bowmaker *et al.* (1978) and Jackson (1961c), and show Victoria Falls to be a major zoogeographical barrier. The formation of Lake Kariba has resulted in invasion of the Middle Zambezi, which previously had limited slow water habitat, by some Upper Zambezi species (Balon 1971b; Bell-Cross & Kaoma 1971; Sanyanga & Feresu 1994). Disappearance of eels from the upper reaches of the Middle Zambezi was considered a likely effect of dam formation (Jubb 1960), as eels breed downstream then move back upstream but would not be able to by-pass Kariba dam wall. However, these fears have not come about as eels do manage to return (Balon 1975), presumably over the dam wall.

Pollution of the lake by pesticides used in agriculture and for tsetse control has been a source of concern and given rise to various studies looking at levels and possible effects on birds (Douthwaite 1992; Douthwaite *et al.* 1992; Matthiessen 1985), fish (Mhlanga *et al.* 1986), crocodiles (Phelps *et al.* 1989; Wessels *et al.* 1977) and in sediments or water (Berg & Kautsky 1994; Zaranyika *et al.* 1994).

Lake Chivero

Lake Chivero, formerly Lake McIlwaine, is a man-made lake on the upper catchment of the Manyame river which flows into Lake Cabora Bassa. It is close to the city of Harare, which both draws much of its water supply and deposits much of its waste into the lake. There have been many studies on Chivero, principally owing to its immense economic importance to the capital but also to its intrinsic interest as a tropical man-made lake undergoing eutrophication (nutrient enrichment). These studies have been brought together in two books (Thornton *et al.* 1982; Moyo 1997) and much knowledge has been gained on limnology and ecology, such as changes in fish, mollusc, zooplankton and aquatic weed populations, resulting from unrestricted nutrient inflow. These findings are of significant interest to other parts of the basin where urbanisation and pollution are increasing.

Mana floodplains

A large portion of the stretch of the Zambezi from Kariba to Cabora Bassa is conserved or used for wildlife, and the area contains substantial populations of various species of large mammal. Changes in flood regime, as mentioned above, have caused changes in ecology (Attwell 1970; Dunham 1989), large mammal distribution and in fish breeding patterns (Kenmuir 1976). Apart from the Mana floodplains, there are no wetlands of consequence along this stretch.

In the early 1980s there were proposals to build a new dam at Mupata Gorge, downstream from Mana Pools in Zimbabwe, or at Batoka Gorge some 80 km downstream from Victoria Falls. A dam at Mupata Gorge would flood most of the remaining floodplain of the Middle Zambezi (Du Toit 1994) and there was much debate on the schemes. One of the outcomes of the public pressure raised was the gazetting of Mana Pools National Park and the Sapi/Chewore Safari Areas as a World Heritage Site. An environmental

impact study was carried out for both schemes (Du Toit 1982, 1983) which looked at various species groups and vegetation (Müller & Pope 1982). The negative environmental impact of the Mupata scheme was considered excessive, and later the Batoka scheme was selected. A detailed environmental impact assessment for the latter is now underway.

Most biological studies of this stretch of the Zambezi Valley have concerned dryland species and areas. Studies that did involve floodplain ecology include those by Dunham (1986, 1990, 1994) on productivity of herbaceous vegetation, elephant movements and the effects of drought on large mammals, and those by Alvord *et al.* (1982), Dunham (1989) and Guy (1977) on vegetation.

Kafue river

Most of the literature on the Kafue river, which is considered biologically as part of the Upper Zambezi, is discussed in Section 3.2.7. There are no substantive wetlands along the Lower Kafue below the Kafue Gorge. However, Magadza (1977b, 1978b, 1992) has studied macrophytes, molluscs and the limnology of the Kafue Gorge dam.

Luangwa Valley

The Luangwa Valley, much of which is protected as National Park or Game Management Areas, does not contain any extensive wetlands, but is a rich wildlife area. Detailed studies have been carried out on the vegetation (Astle *et al.* 1969, 1997; Smith 1997) and on some mammal populations (Attwell 1963; Berry 1973). Dodman (1996a) mentions the importance of the Luangwa wetlands for the Grey Crowned Crane, while Scott (1993) gives a checklist of the birds from the National Parks area. reports of mortality of hippo and other wildlife from a serious outbreak of anthrax in the Luangwa Valley some years ago (M.J. Bingham, pers. comm.) do not appear to have been published.

Lake Cabora Bassa

Lake Cabora Bassa, formed by the damming in December 1974 of the Middle Zambezi at the Cabora Bassa Gorge upstream from Tete in Mozambique, is 2265 km² in extent, about 50% the size of Lake Kariba. Many concerns were voiced at the time, and since, over the impacts it might have on downstream ecology (Anon. 1975; Davies 1975a,b; Davies *et al.* 1975; Hall & Davies 1974; Tinley 1975; Tinley & Sousa Dias 1973). Some pre-impoundment studies were carried out (Davies *et al.* 1975; Hall *et al.* 1976, 1977; Tinley & Sousa Dias 1973), but these were hampered by lack of interest from the authorities at that time and the rapidly-changing political scene. Mozambican independence came soon after, and the regional political situation made post-impoundment studies difficult, although some were carried out (Bond *et al.* 1978; Bond & Roberts 1978; Jackson & Davies 1976; Jackson & Rogers 1976).

In particular, it was the effect on fish populations in Lake Cabora Bassa that were looked at. As with Lake Kariba, there was an explosive increase in aquatic weeds as the lake rose, fed by the high nutrient status of the waters (Bond & Roberts 1978). Since formation of the lake, the major concerns have been on the potential fishery (Bernacsek & Lopes 1984a,b; Gliwicz 1984; Jackson 1975; Vostradovsky 1984, 1986) and on the impacts of flood regulation on downstream ecology, bird and mammal populations (see Section 3.2.10, Zambezi Delta). The limnology of the new lake has been looked at only by Bond *et al.* (1978).

There is a short section of the Zambezi below Cabora Bassa before the gorge at Tambara is reached and the Lower Zambezi begins. The main town is Tete, through which various collecting expeditions have passed, thus some accounts exist of specimens collected (Broadley 1963; Chace 1953; Lawrence 1953; Lawrence & Loveridge 1953; Loveridge 1953a,b; Peters & Loveridge 1953; Thomas & Wroughton

1908) as well as historical accounts of large mammals (e.g. Decle 1974; Kirk 1864; Letcher 1987; Maughan 1914; Peters 1852; Tabler 1963; Vaughan-Kirby 1899). Some studies of physical and chemical parameters of the waters have been done by Hall *et al.* (1976, 1977).

3.2.10 **Lower Zambezi, Lake Malawi and the Shire Valley**

This very heterogenous area extends downstream from the Lupata Gorge above Tambara to the ocean at Chinde, where the broad Zambezi Delta ! an IUCN Wetlands Project site ! extends from Quelimane in the north to the grasslands of Marromeu in the south (Section 2.1.4 and Figure 2.2). The area also covers the Lower Shire from the Kapuchira Falls near Blantyre including the Elephant and Ndinde Marshes, another IUCN Wetlands Project site, to its confluence with the Zambezi at Mutarara. For the sake of completeness, major references to Lake Malawi, Lake Malombe and Lake Chilwa (technically not part of the Zambezi system) and the Middle Shire are briefly reviewed, although Lake Malawi is unique and has little biological connection to the rest of the basin.

Lake Malawi

There has been much published on the biodiversity of Lake Malawi, principally on its fisheries and, in particular, on the endemic cichlid fish. Biologically the lake is unique and although full species lists are not available it is estimated that 99% of the fish fauna of Lakes Malawi and Malombe is endemic (B. Marshall, pers. comm.). Many publications cover fish composition and taxonomy (e.g. Eccles & Trewavas 1989; Fryer 1959; Fryer & Iles 1972; Greenwood 1961, 1981: Jackson & Ribbink 1975; Konings 1990; Lewis *et al.* 1986; Owen *et al.* 1990; Regan 1921; Ribbink 1991; Ribbink *et al.* 1983; Trewavas 1983; Tweddle *et al.* 1995), fishery (e.g. papers in Menz 1995; Jackson *et al.* 1963; Lowe 1952; Ricardo-Bertram *et al.* 1942; G.Turner 1995; J.Turner 1977a,b, 1982; G.Turner *et al.* 1995) and conservation (Bootsma & Hecky 1993; Coulter *et al.* 1986; Eccles 1985; Fryer 1972; McKaye *et al.* 1985; Munthali 1997; Reinthal 1993; Tweddle 1992).

The fish group of major biological and conservation interest are the rock-dwelling cichlids or "mbuna". The total number of species is still not known, and many are restricted to just a small portion of the lake. Species are threatened by over-collection for aquaria, by pollution, by the ecological consequences of over-fishing of other species, and by the ecological consequences of introduction of other fish species, including ones indigenous to Lake Malawi but not to that habitat or locality (Reinthal 1993).

Lakes Malawi and Malombe are being over-fished; the changes in fish composition and abundance in Lake Malombe have been documented by Tweddle *et al.* (1995), while the effects of trawling in Lake Malawi are documented by J.Turner (1977a,b) and G.Turner *et al.* (1995). Some years ago there were plans to introduce the Lake Tanganyika sardine (*Limnothrissa miodon*), a pelagic species now well-established in Lake Kariba, into what was considered a vacant niche in Lake Malawi (J.Turner 1982). Studies (Eccles 1985; McKaye *et al.* 1985; Ribbink 1991) suggested that this would greatly diminish the lake fly population, and thus have marked ecological repercussions on the endemic fish fauna.

A comprehensive bibliography on fish, fisheries and limnology for Malawi, covering publications up to 1986, has been compiled (Tweddle & Mkoko 1986), as has one on fish taxonomy and evolution (Tweddle 1995?).

Lake Chilwa

Lake Chilwa is a shallow lake which supports an important fishing industry. Although sitting in its own drainage system with no outflow (an endorheic lake), and not being part of the Zambezi Basin, it has many

biological similarities to the Zambezi Basin and supports extensive wetland areas. The lake level fluctuates with climate, thus the extent of open water and wetland can change dramatically. Its ecology and fishery have been intensively studied, culminating in a book (Kalk *et al.* 1979). Many of the resulting publications focus on wetland vegetation and its ecology (Howard-Williams 1973a, 1975a,b, 1977, 1979a,b; Howard-Williams & Walker 1974). Lake Chilwa must be one of the best studied wetlands in the region, the studies looking at dynamics and processes, not just documenting composition. Recently, interest has been expressed in making Lake Chilwa a Ramsar site, which has resulted in various publications on its biodiversity (Department of Biology, University of Malawi 1996; Wilson & Van Zegeren n.d.).

Middle Shire

The Middle Shire has limited wetlands associated with it (Blackmore *et al.* 1988). However, the biodiversity of sections or components, particularly Liwonde National Park, are fairly well documented (e.g. Morgan-Davies *et al.* 1984; Blackmore *et al.* 1988). The Kapuchira Falls forms a major biological boundary with the Lower Shire, one which also marks a disjunction in the fish fauna (Tweddle *et al.* 1979; Tweddle & Willoughby 1979a,b).

Lower Shire wetlands

The Lower Shire valley extends from Kapuchira Falls near Blantyre in Malawi to the Shire-Zambezi confluence near Mutarara in Mozambique. The major wetlands in this area are the Elephant and Ndinde Marshes, the latter partially (about 20%) in Mozambique. Both marshes form the core of the Lower Shire IUCN Wetland Project site. Much of the review below comes from Cornell Dudley (pers. comm.).

These marshes, along with those of Lake Chilwa further north, are the most important wetlands in Malawi. Thus it is surprising that compared with Lake Chilwa (Kalk *et al.* 1979), little biological investigation has been undertaken, with the exception of fisheries research and bird recording. The importance of the Elephant Marsh for wildlife may have been recognised early when it was established in 1897 as one of the then Nyasaland's first two Game Reserves (Hayes 1978). Today, the Elephant Marsh contains little but hippos and crocodiles (Ansell & Dowsett 1988).

During the 1940s and 1950s, a number of biological expeditions passed through the area but, as their main goal was the highlands of the interior, little was collected in the Lower Shire (Brass 1953; Chace 1953; Lawrence 1953; Lawrence & Loveridge 1953; Loveridge 1953a,b). Technical Officers of the Colonial Service stationed near Zomba concentrated on the upland environments. However, Sweeney spent many years in the Lower Shire as a cotton entomologist and had an unstinting interest in all aspects of zoology (Sweeney 1959, 1960, 1961, 1970a,b, 1971).

Most early biological collections were, unfortunately, poorly documented simply noting that the specimen was collected from the "Shire Valley", the "Lower Shire Valley", or a town nearby such as Port Herald (now Nsanje) or Chikwawa. Owing to the limited extent of wetland, and the rapid transition to woodland and other vegetation types, even quarter-degree grid square citations can have limited ecological value. The only plant studies clearly from the marshes are those of Blackmore *et al.* (1988), Howard-Williams (1973b) and Proctor (1977, 1981), and the animal collections of Loveridge (1953a,b), Tweddle (n.d.) and Tweddle & Willoughby (1979a,b).

The bats of this prt of Malawi have been fairly well studied (Happold & Happold 1989, 1997; Happold *et al.* 1987) and the importance of the Shire-Ruo confluence area for this group is shown (Happold &

Happold 1997). Details of rodent species and ecology from adjacent dryland areas such as Liwonde and Lengwe National Parks have also been recorded, but are not listed here.

Birds of parts of the Lower Shire have been comparatively well studied, although a comprehensive checklist does not seem to be available. Benson & Benson (1948) record birds from low-lying areas, including waterbirds, and Long (1956, 1960, 1961a,b, 1967, 1973a, 1974) records many species in the Nsanje area over many years. Hanmer, based at the SUCOMA sugar estates near Nchalo, did bird netting for many years and has recorded various species new to the area or Malawi. These findings have been presented in a series of papers and notes, mostly in the journal Nyala (e.g. Hanmer 1977b, 1979a,b, 1981a,b, 1982, 1985, 1986, 1989). Counts of waterbirds on the Elephant Marsh are given by Perennou (1992).

A checklist of reptiles and amphibians for southeastern Malawi has been compiled (Stevens 1974), and there are taxonomic accounts on various genera and reports on collecting trips (Broadley 1990, 1995; Cott 1934; Loveridge 1953a,b; B.Mitchell 1946).

Fish and fisheries play a major role in the economy of the Lower Shire. The ichthyofauna of the area differs markedly from that of the Middle and Upper Shire, and comprehensive checklists are available (Tweddle *et al.* 1977; Tweddle & Willoughby 1979a,b). The fisheries have also been well studied (Anon. n.d.; Hastings 1973; Willoughby 1979) along with the biology of some major fish species (Willoughby & Tweddle 1978a,b).

As with other areas, some of the resource inventories and surveys have been precipitated by planned developments, either agricultural (e.g. Anon. n.d.; Hunting Technical Services 1957; NEDECO 1960; Stobbs 1971) or for hydropower (Blackmore *et al.* 1988; Cantrell 1979; C.Dudley 1979; R.Dudley *et al.* 1991).

Conflicts between humans and wildlife have given rise to concerns which are now being addressed by conservation bodies. Hippo damage crops grown on the floodplains, but have now been reduced to very low numbers. Recent hippo censuses suggest a total of 450 animals (Mkanda 1994; Mulders 1995), while others discuss the effects of crop damage by hippo (Jamusana 1994). Crocodiles are also present in the Lower Shire, although not in large numbers (Bruessow 1989; Mphande 1987; Mulders 1995). The results of the survey by Mphande give much higher figures for the Elephant Marsh than the others.

Biodiversity of the Lengwe National Park has been the focus of various studies (e.g. Hall-Martin & Drummond 1980; Sherry & Sherry 1984), but only at its margins can the park be considered to include wetland habitats.

Lower Zambezi

There appears to be little published information on biodiversity relating specifically to that part of the Lower Zambezi between Tambara and Mopeia where the Delta proper starts, although it is likely various collecting records are from this stretch (e.g. Azevedo *et al.* 1961; Cott 1932, 1934; Hanmer 1976; Pinhey 1981; Smithers & Tello 1976). Studies have also been carried out on water quality (Hall *et al.* 1977).

Zambezi Delta

The Zambezi Delta, an IUCN Wetland Project site, is an extensive area of wetland, grassland and riparian or floodplain vegetation. In two parts, it extends in a broad triangle from Mopeia some 120 km upstream

of the mouth down the Rio Cuacula to Quelimane in the north, while the southern (sometimes termed western) section covers the seasonally-wet grasslands of Marromeu which extend to the sea. Effectively, and biologically, the southern section also stretches along the base of the Cheringoma Plateau all the way to Beira. For much of this extent, however, the moisture is probably derived from seepage from the plateau and rarely from the Zambezi River.

The main ecological study of the Lower Zambezi wetlands was carried out by Tinley, who published a masterly overview of the Gorongosa system from Gorongosa Mountain across the rift valley and the Cheringoma Plateau to Marromeu and the ocean (Tinley 1977, 1994). There have been no other such studies of this calibre and breadth for any other part of the basin. Various popular articles or papers have also been written on the potential or feared effects of the construction of Cabora Bassa dam, its effects on ecology, bird life and mammal populations (Anon. 1975, 1995; Davies 1975b; Davies *et al.* 1975; Singini 1996; Tinley 1975). Historical accounts of the large mammals of the Lower Zambezi, which give an indication of composition and abundance, include those by Decle (1974), Kirk (1864), Peters (1852), Tabler (1963) and Vaughan-Kirby (1896, 1899).

The vegetation of Zambézia Province, north of the river, has been mapped by Barbosa (1952). The vegetation maps of White (1983) and Wild & Barbosa (1967) do not do the delta area justice, and fail to differentiate grassland and swampland from tree savanna, lumping all under "formations on alluvium". Even Barbosa's (1952) more detailed map does not differentiate units within the wetland area. Tinley (1977) describes the vegetation of both Gorongosa and Marromeu, while Barbosa (1968) gives a brief account of the latter.

Various reports were compiled by government bodies and by consultants from 1950 to the early 1970s as part of plans to develop the Zambezi Basin in Mozambique for hydro-power, agriculture and settlement (e.g. Gabinete do Plano de Zambéze 1973, 1975; Missâo de Fomento e Povoamento do Zambéze 1961). These studies often included some basic information on soils, vegetation, etc, but cannot be considered biodiversity studies.

Both Gorongosa and Marromeu are well-known for their wildlife populations, the latter principally for the large herds of buffalo (estimated at 55,500 in 1979, Tello & Dutton 1979). There have been a series of good aerial censuses of the large mammals (Anderson *et al.* 1990; Cumming *et al.* 1994; Dutton *et al.* 1994; Tello & Dutton 1979; Tinley 1969), which show how this population was decimated during and immediately after the civil war. Estimates in 1994 were around 2350 (Cumming *et al.* 1994), but the population appears to be now slowly recovering. Waterbuck were affected more seriously (Anderson *et al.* 1990), declining from around 48,000 in 1978 (Tello & Dutton 1979) to only 143 in 1994 (Cumming *et al.* 1994). Tinley (1977) also includes lists of larger mammals (>5 kg) from the Gorongosa ecosystem (it is not clear which of these are from Marromeu), important animal dispersers of woody plant seeds, and plant species eaten by various mammals. It is not possible to list confidently all the mammal species found in wetland habitats along the Lower Zambezi from the quarter-degree grid square maps of Smithers & Tello (1976), but it could be as high as 70. Small mammals, in particular, have not been well collected from the area, in part owing to difficulties in access. Museum collecting trips earlier this century list both reptiles and amphibians (Cott 1932, 1934, 1935; Parker 1931) and mammals (Thomas & Wroughton 1907). Some of the species of reptile and amphibians restricted to the lower parts of the Zambezi and Shire are described by Broadley (1967, 1990, 1997), Poynton (1985) and Stevens (1973).

The main bird guide to Mozambique (Clancey 1996) only extends as far north as the Zambezi River, while an unpublished Mozambique checklist (Mikkola n.d.) is incomplete. Hanmer (1976) has done some bird netting near Mopeia and has made a preliminary checklist of that area.

The apparent drying out, or changed hydrology, of the Marromeu grasslands has given rise to concerns in recent years on the conservation status of the Wattled Crane, a charismatic threatened species of the Zambezi Basin, which holds about 95% of the world population. (Anon. 1975; Beilfuss 1995). Regular surveys have been carried out by the International Crane Foundation in conjunction with the Natural History Museum in Maputo (Beilfuss & Allan 1996; Goodman 1992; Singini 1996) which showed a population of around 2750 birds in 1992, about 20% of the world population. The conjunction of important populations of waterbirds, large mammals and diverse vegetation in this extensive wetland area has given rise to many calls for its designation as a wetland site of international significance under the Ramsar convention (Anderson *et al*. 1990; Singini 1996).

Surprisingly, there appear to be no studies on the ichthyofauna of this part of the Zambezi, in contrast to most of the rest of the basin. Lists are only available for the Middle Zambezi and Cabora Bassa (see Section 3.2.9) and the Lower Shire (see above).

Some lists of invertebrate groups based on museum collections of molluscs (Azevedo *et al*. 1961; Braga 1952), Orthoptera (grasshoppers - Ferreira 1964a) and various Coleoptera groups (beetles - Ferreira 1963) have been published. It is not clear how comprehensive these lists are, or how relevant they are to the Zambezi wetlands. That economically-important marine invertebrate group, the shrimps, have been the focus of three studies on the Sofala Bank off the Zambezi Mouth (Da Silva 1986; Gammelsrod 1992a,b; Silva 1989). The study by Gammelsrod showed that shrimp production varies with wet season river flow, and annual production could be increased by controlled water release from Cabora Bassa.

Although there is some literature on dugongs off the Mozambique coast (Hughes 1971; Lopes 1936), it appears that this animal is rarely found off the Delta owing to murky waters and a lack of sea-grass beds on which it feeds.

3.3 GAPS IN KNOWLEDGE

The identification of gaps in knowledge can be a value-prone exercise. It is a reflection of what is felt should be known (i.e. the objectives of knowledge) as much as it is a reflection of what is already known. The above review of published information suggests that sufficient knowledge for sound conservation planning or management is only available for a few species and for just a few parts of the Zambezi Basin ! that, in practice, the gaps are of a greater magnitude than our current knowledge. In this section, the gaps identified are those which, from a biological or conservation perspective, need to be addressed with some priority if sound advice on conservation is to be given. Such advice is predicated on an adequate knowledge of:

1) the basic taxonomy of the group (i.e. how many species, what do they look like?),
2) the geographical and ecological distribution of species,
3) what role each species plays where it occurs (therefore what happens if it is removed?),
4) what factors might cause changes in its current status.

The gaps are discussed under these four headings for the Zambezi Basin as a whole, followed by a summary of knowledge gaps specifically for the four project sites. Major priorities are outlined.

3.3.1 **Taxonomy**

Flowering plant taxonomy is comparatively well known, and the regional flora is about 70% complete. Most genera or species complexes with significant residual confusion are not of great ecological significance. There are adequate identification guides to the woody flora (at least south of the Zambezi and for Zambia), but for the herbaceous species the lack of general works is a major impediment. Algae are very poorly known; it is believed there are many more species than recorded to date.

Mammal taxonomy is well known, although occasional new species of bats are still encountered. The evolutionary relationships are not always clear, something which can be clarified these days using molecular techniques (although this doesn't seem to have been done for any wetland species), and the question of when does a variety become a sub-species or a sub-species a full species (e.g. with lechwe antelope) sometimes needs to be answered. Identification manuals are adequate to good. Likewise, bird taxonomy has been well documented and good identification guides exist for all areas.

Amphibian taxonomy has been very well studied for the whole Zambezi Basin, with a good series of identification manuals. Further collecting could lead to species concepts being challenged, but reliable names can now be given. Reptile taxonomy is being written up, and is in hand at a regional level. As with amphibians, names can reliably be given to virtually all specimens; those that do not clearly fit are recognised as such. Fish taxonomy is in a similar state with good national and regional identification guides.

The invertebrate groups, with very few exceptions (butterflies, dragonflies, termites, freshwater mussels) present a quite different case, being only superficially known. Identification manuals are only available for very few groups. It is not clear for almost all invertebrate groups even approximately how many species there are in the basin; there are likely to be tens of thousands of species still undescribed. Given the magnitude of the task and the acute shortage of invertebrate taxonomic skills worldwide, it would seem most appropriate to focus attention on those groups that are already partially known and/or which have good biological indicator value. A particular priority would be freshwater invertebrates that can be used to monitor water quality and also, perhaps, zooplankton owing to its economic importance for fisheries. Field identification manuals need to be prepared for these groups.

3.3.2 **Distribution**

As was mentioned in the review section above (Section 3.2), herbaceous plant species seem widely distributed through the swamps and waters of the Zambezi Basin, although species of the seasonally-flooded grasslands can be more localised on a regional scale. The disjunction between species of the Upper and Middle/Lower Zambezi, so noticeable with fish, is also apparent with parts of the woody flora. Few detailed plant checklists for wetland areas are available (e.g. Chobe, Lower Shire) and there is a partial checklist for the Barotse floodplains. The major gap in our knowledge is a series of systematic checklists which would enable comparisons between areas to be made, and which would also give a indication of distribution basin-wide along with conservation status. From these a regional checklist could be compiled with distribution and status noted by catchment. The priority areas from which data are severely lacking at present are the Lower Zambezi and Zambezi Delta. A more comprehensive compilation is required for the very extensive Barotseland area.

Vegetation maps exist for much of Barotseland, the Chobe/Caprivi area, the Okavango and the Kafue. Although not completely compatible, they are all based on remote sensing and sufficiently rigorous to allow meaningful comparisons to be made. What is missing are similar maps for the Lower Shire and, particularly, for the broad Zambezi Delta region. Taking a basin-wide perspective, it is also necessary to carry out similar vegetation surveys of the Bangweulu, Lukango and Busango Swamps. An ecological/vegetation map of all the wetlands of the basin with a common legend would enable realistic comparisons between wetlands to be made. At present it is not possible to answer the question, for example, of whether the Lukanga, Okavango and Delta swamps are similar in composition and ecology.

The distribution of large mammals is generally well documented, but there are large gaps in our knowledge of the distribution of medium-sized and small mammals, especially nocturnal species. Some areas have been well collected, others hardly at all. Systematic collecting in the latter is a priority. These data will also assist in elucidating some minor taxonomic problems, but most importantly from a conservation perspective they will give indications of (a) conservation status and (b) ecological distribution (i.e. in what habitats are the species found).

Bird distributions are generally well known although certain wetland areas appear to be greatly under-recorded, e.g. the Lukanga Swamps and the Zambezi Delta, while new records from some wetland areas are continually turning up (e.g. Chobe and the Lower Shire). Given the charismatic nature of birds in conservation, priority should be given to compiling checklists for under-recorded areas.

Reptiles and amphibians are well-documented but our knowledge of distribution, and particularly status, is much more limited. Areas of particular biogeographical and ecological interest that are grossly under-recorded are the Barotse floodplains and the Lower Zambezi and Zambezi Delta. Creating checklists for these areas is a priority, and will allow for more meaningful biogeographical analysis to be done to help elucidate evolutionary and ecological differences across the basin, thus gaining greater insight into its biological history.

Fish checklists are available for virtually the whole of the Zambezi, section by section, except, surprisingly, for the Lower Zambezi and the Delta. A major priority is to compile a good checklist of the fish from the Delta area, unless such a list can be found in the archives in Maputo or the J.L.B. Smith Institute of Ichthyology in Grahamstown. As with reptiles, this would enable biogeographic and ecological comparisons to be made across the basin and would, of course, provide baseline data against which any changes resulting from future dam construction could be measured.

As can be surmised from what was mentioned above on invertebrate taxonomy, it is difficult to compile checklists if the taxonomy has not yet been sorted out or species described. We have very limited knowledge of what is where, and that only for a very few groups. The priorities for wetlands in practical terms would be to focus on (a) those groups that are comparatively well known (e.g. butterflies, dragonflies, freshwater molluscs) and (b) those groups which are of significant ecological indicator value, in particular for water quality (i.e. freshwater macro-invertebrates). Checklists of butterflies, dragonflies and molluscs from presently under-collected areas (Barotse floodplains and the Zambezi Delta) would, as mentioned before, enable comparisons to be made across the basin, while checklists of freshwater invertebrates from carefully selected sections of the Zambezi could form the basis for monitoring of changes in water quality due to urban, industrial or agricultural pollution.

3.3.3 **Ecological roles**

Of major importance in conservation is to determine what are the major species in terms of function and processes ! "keystone species" which are essential to maintain the ecosystem. Others, however, state that all species present in an ecosystem have a vital role to play. In both cases it is necessary to determine (a) what those roles are, and (b) what will happen if species are removed or lost. The primary and most unequivocal way to determine this is by experimental intervention, but it appears there have been no studies of this type carried out in the wetlands of the Zambezi Basin. What we have are descriptive accounts, some of which have tackled these questions of ecological role with great rigour and insight. The best studied areas have been Lake Kariba, Lake Chivero and Lake Chilwa from a limnological and fish/fishery perspective (e.g. Howard-Williams 1973a; Thornton 1982), the Kafue Flats from a terrestrial ecological perspective (Ellenbroek 1987), and the Gorongosa/Marromeu region from a landscape perspective (Tinley 1977).

On the plant side, the role of aquatic weeds, particularly *Salvinia molesta* on Lake Kariba, has been fairly well studied, as has the role of grasses on the Kafue Flats. Elsewhere there have been very few studies. For example, despite much attention being given to *Salvinia* control in the Chobe area it is not clear (or at least not documented) what effects invasion of this species have had on biodiversity (but see Fox & Watt 1976), and whether this has reversed since control. Recent reports (R. Beilfuss, pers. comm.), suggesting invasion of many parts of the Lower Zambezi wetlands by aquatic weed species reiterate the necessity for a better understanding of their role and effects in the functioning of wetland ecosystems. As flowering plants are the major primary producers of all wetland and littoral ecosystems (although not always in open water systems) this gap in our knowledge is of major significance and needs to be addressed if we are to effectively conserve wetland processes (see Thompson 1976b). In addition, there is growing evidence of the role of swamp and sudd (floating) vegetation in altering hydrology in wetlands, both in flow rates and flow patterns ! this is also a priority area for investigation. Major plant species presumably of significant ecological importance in the wetlands include *Cyperus papyrus* (papyrus), *Phragmites* spp. (reeds), *Vossia* sp., *Nymphaea* spp. (water lilies) as well as a multitude of other aquatic grass and sedge species.

Only the various lechwe sub-species have been studied in great depth amongst the mammals, although insights have been gained within the Zambezi Basin on a few other species (e.g. buffalo, puku, sitatunga). Details of lechwe ecology are sufficient to give us an indication of their role in wetland ecosystems. The biology and ecology of some bird species has been documented sufficiently for decisions on conservation management to be comparatively confidently made. The species include the Wattled Crane, fish-feeding birds such as Reed Cormorants and Darters, and some species of duck. Apart from the Nile crocodile, the biology and ecology of reptiles and amphibians has not been studied in the basin. There have been good studies on the biology and ecology of various fish species in Barotseland, Lakes Kariba and Malawi, and in the Lower Shire.

The two best-studied invertebrates by far are the tsetse fly and mosquito, although the former is not particularly associated with wetlands. Literature on these species is not covered here. Agricultural and livestock pests such as ticks have received much attention ! mostly from the point of view of destruction rather than conservation. Marine shrimps have been the focus of some studies in Mozambique. Otherwise, there have been very few studies on the biology and ecology of freshwater or terrestrial invertebrates.

As can be seen, the gaps in our knowledge are vast and not readily filled. It is not easy to decide which should be the priority areas, but in practice attention should focus on ecosystem processes and threatened species. Priority species that have determining ecological roles include papyrus, reeds, hippo (given their important role in keeping channels open), termites (see papers by Dangerfield and McCarthy), phytoplankton, zooplankton and some fish species. In terms of geographical area, the places that should have priority are the Barotse floodplains which, being comparatively stable, should be that much easier to understand, and the Zambezi Delta which is the wetland most affected by control of natural flood regime (except, perhaps, for the Kafue Flats and the Mana floodplain) and is also the least understood.

3.3.4 **Threats and concerns**

Wetlands, particularly swamps and marshes, are not stable environments. They fluctuate in extent and distribution depending on natural phenomena such as climatic cycles and channel blockages, as well as from human activities such as dams, drainage and pollution. Floodplains, however, are more stable. Therefore, changes in status and distribution of species should be expected; indeed most species are adapted to such changes. Our knowledge of threats and concerns to biodiversity must be predicated on these features, not on a belief that all change is detrimental. Within the basin it is the processes and functions that need to be maintained, not necessarily the distribution and status of all species.

What little information we have on changes in distribution or status of wetland species is almost entirely based on observation rather than experimental studies. However, some of these observational studies have given good insights into possible factors as they looked in detail at changes following major perturbations to a system (e.g. dam construction, drought, fire). But most have limitations owing to lack of baseline information from before the major perturbation occurred. Changes in status, and reasonably good indications as to what this might result from, are documented for some fish and freshwater invertebrates after dam construction, flood control or drought (Lakes Liambezi, Kariba, Cabora Bassa and Chilwa, and the Kafue Flats) or eutrophication (Lake Chivero). They have also been documented for large mammals resulting from hunting or loss of habitat (e.g. lechwe - Bangweulu, Upper Zambezi; hippos - Lower Shire; buffalo and others - Marromeu), for birds resulting from habitat modification (e.g. Wattled Crane, Reed Cormorants on Kariba) or toxins (DDT used in tsetse control), and for aquatic weeds resulting from the creation of new habitat (Lakes Kariba and Cabora Bassa). What is not clearly understood, and is of particular importance for conservation, is what effects control of natural flooding through the construction of large dams have on habitat function, hence species composition and status. This should be a major priority for research, albeit a very complex one to study.

In practical terms, it is unrealistic to expect research into the conservation status of all species. Instead attention should be focussed on particular charismatic species such as the Wattled Crane, Slaty Egret, African Skimmer and puku, and on restricted vegetation types such as riparian forest. Attention should also be given to potential indicator groups such as amphibians, which are known to be good indicators of water quality, dragonflies which are indicators of wetland health, and papyrus, an indicator of perennial swamp. More thought needs to be given to this component and the priorities.

3.3.5 **Barotse floodplain**

The major knowledge gaps in organismal biodiversity for the broadly-defined Barotse floodplains are (a) a comprehensive annotated checklist of flowering plants, preferably with vernacular names and uses (the existing partial one by Bingham (1990) should be built upon), (b) the compilation of a comprehensive checklist of the birds, supplemented with additional field observations, (c) a checklist of the reptiles and amphibians based on detailed collecting, and (d) the collation of dragonfly and butterfly records in order to compile a checklist.

The identification of indicator species for monitoring floodplain health in the face of land use change is also a priority. The length of flooded period appears to be a major ecological determinant. This should be followed by research into the basic biology and ecology of these species in order to be able to more confidently ascribe changes in status to particular components of ecosystem change.

3.3.6 **Chobe/Caprivi**

Major gaps in knowledge for this area include (a) a comprehensive checklist of flowering plants which could be readily produced from existing scattered records plus minimum additional collecting, (b) the status and distribution of small mammals, and (c) aspects of the conservation biology of bird species of concern from the Upper Zambezi.

The Chobe/Caprivi area (or, alternatively, the Okavango) is a good place to carry out research into wetland functions owing to the availability of good basic information, good infrastructure and communications, and recent initiatives on these aspects. The limitations include the rather unstable nature of the system and the diversity of processes operating, both currently and historically, making it difficult to disentangle cause and effect. The replicability to more straightforward systems would also be equivocal. Priority components in such ecological research include determination of the role of hippo in keeping channels open, and research into factors affecting channel blockage and the hydrology of the area.

3.3.7 **Lower Shire**

Major gaps in knowledge here are (a) a detailed vegetation map of the wetland and immediately adjacent areas, (b) a bird checklist which could be essentially compiled from existing records with minimum additional fieldwork, (c) a study of freshwater macro-invertebrates including molluscs, and (d) a biodiversity survey of the Mozambique sections of the Ndinde Marsh which appear more intact than the sections in Malawi.

Research is required to identify which are the major components of biodiversity remaining in the Lower Shire, and to determine whether the wetland system is still functioning as an entity ! we need to know whether, owing to intensive land use and historic fluctuations in flow, the system has now broken down. Attention should be given, in particular, to those sections of Ndinde Marsh in Mozambique.

3.3.8 **Zambezi Delta**

Compared to the other sites there are major gaps in knowledge for the Zambezi Delta. However, the priorities are considered to be (a) a comprehensive vegetation survey of the broad delta region, (b) an annotated checklist of flowering plants by habitat type, (c) a checklist of small and medium-sized mammals, (d) a checklist of fish species based on detailed collecting, (e) a checklist of the birds based on fieldwork, (f) a checklist of the reptiles and amphibians based on specimen collecting, (g) a checklist of the dragonflies and butterflies, and (h) investigation into the conservation biology of the Wattled Crane and other threatened bird species.

The major research priority is to determine the effects of control of natural floods by Cabora Bassa, and any future dams, on biodiversity in terms of species composition, status and ecological processes. The extent and periodicity (frequency) of flooding need to be looked at, along with the source of water in wetlands at present (how much is from the Zambezi, how much from elsewhere?). Given proposals to control or modify flooding further, the Zambezi Delta would be a good site for a detailed biodiversity monitoring plot. Other priority research should address the distribution of aquatic weeds in the delta, their ecology and effects on wetland biodiversity.

3.4 SUMMARY

Most of the available published information on organismal biodiversity of the wetlands and lakes of the Zambezi Basin has been brought together and an overview obtained. The literature is very uneven in its coverage, both between groups and geographically (Tables 3.1 and 3.2). The majority of the accounts are of a descriptive nature (species lists, collecting notes, surveys, taxonomic studies, etc.) with few looking in detail at the ecology of individual species ! the main exceptions being those pertaining to the Kafue Flats and Lakes Kariba and Chivero. Hardly any experimental studies appear to have been carried out in the Zambezi wetlands, although various descriptive studies have been done on changes in biodiversity and ecology following major environmental perturbations such as dam construction.

The best studied groups are the large mammals, birds and fish, while reasonable information exists on reptile, amphibian, dragonfly, freshwater mollusc and plant distributions, but not on their biology or ecology. Taxonomy is good for all these groups. Hardly any attention has been given to invertebrates. Geographically the best known areas are the Chobe/Caprivi floodplains and swamps, the Okavango Swamps, the Kafue Flats, Lakes Kariba and Chivero, Lakes Malawi and Chilwa, and, for some groups, the Lower Shire. The major under-studied areas are the Barotse floodplains and, in particular, the Zambezi Delta.

Priority topics for future studies include:

1. Vegetation surveys of the Delta and Lower Shire,

2. Checklists of plants, birds, reptiles and amphibians for the Barotse floodplains and Zambezi Delta,

3. A checklist of the fish of the Zambezi Delta,

4. Comparison of catchment-level lists of woody plants, fish, reptiles, amphibians, dragonflies and freshwater molluscs from a biogeographical perspective,

5. Research into the taxonomy, distribution and ecology of freshwater macro-invertebrates as indicators of water quality,

6. Research into the interactions of species and vegetation on wetland hydrology and function in the Chobe/Caprivi area,

7. Research into the limits of resilience of wetland composition and function in the Lower Shire,

8. Research into the effects of changed flooding regime on biodiversity in the Zambezi Delta.

4. SITES AND SPECIES OF CONCERN

4.1 INTRODUCTION

The prevailing paradigm of thought among conservation biologists is that the entire, or substantial parts, of ecosystems should be conserved. This ensures that the ecological processes necessary to maintain it continue to function, as will natural selection and evolutionary pressures. Quite where one can draw the physical boundaries of ecosystems, particularly between such an extensive set of interconnected systems as the Zambezi wetlands, is a moot point. Most such systems, however defined, would be very extensive landscapes; likewise, for reliable conservation of larger mammals, particularly elephant and some bird species, extensive areas are required.

Nevertheless, the gazetting of large areas for conservation under the exclusive-use principle, with its high management requirements in terms of time, expertise and funding, is not normally a feasible option in southern Africa today. Even conservation areas where people are allowed to live and utilize resources require experienced management, energy and commitment if conservation objectives are to be achieved in the long-term. Conventional conservation wisdom often states that some controlled consumptive utilization is possible within areas being conserved for their biodiversity, but experience shows us that the necessary control is often too difficult to enforce (T. Müller, pers. comm.). Important components of the biodiversity (processes as well as species) are lost or heavily modified over a period of time without managers becoming aware of it.

For effective, practical, biodiversity conservation it would appear that a network of small protected areas may be necessary, areas where almost all forms of consumptive utilization are not allowed. Such areas, or sites, also act as focal points for conservation efforts. In the same way particular species, sometimes called “flagship species”, can be identified. The general public finds it far easier to understand conservation if it is focussed on relatively small, visible areas or on particular charismatic species. In a way, these are the “pegs” on which to hang the conservation umbrella. A compromise between ensuring scientific objectives, long-term survival of populations, habitats and ecological processes, and public acceptability is often required.

Given the fragmented environment of much of the Zambezi Basin, especially those areas with good water supplies, it is becoming daily more important to identify small conservation sites which retain a good assemblage of species and can maintain the ecological processes necessary for their continued survival. Yet, being small, they do not represent a major loss of land or resources to the people living around them. This section attempts to identify some such sites and species within the wetlands of the Zambezi Basin, with particular reference to the four project sites. Sites are defined as areas of only a few hectares to a few square kilometres, not larger.

4.2 SITES OF INTEREST OR CONCERN

Regional and local expertise did not, in most cases, clearly identify sites of conservation concern or particular sites of importance under severe threat. In part this may reflect a situation where wetland organisms are fairly widely distributed through any given wetland, or through the basin as a whole, and where the major threats are general or diffuse in nature, rather than site-specific. Or it may reflect a lack of knowledge on distribution of organisms in the wetlands ! one can only identify species of particular interest if one knows something of that organism's distribution in a national or international context.

Suggestions that were made are briefly discussed below by wetland area. No specific survey with the aim of identifying such sites has been done, apart from that discussed in Timberlake (1996) for parts of the Zambezi Valley in Zimbabwe.

4.2.1 **Barotse floodplains**

The floodplains are generally extensive grasslands with occasional clumps of trees on higher ground. Some of the clumps (about 1 to 2 ha in size) contain large trees of a range of species, particularly in the south western floodplains. Such areas are termed termitaria savanna by Fanshawe (1969a). Although too small individually to be sustainable for long-term conservation, a site or area incorporating a series of such clumps would be of conservation interest. In addition to tree species, it is likely they are of significance in the conservation of bird, small mammal and invertebrate populations.

From the 1:500,000 vegetation map of Western Province (Jeanes & Baars 1991a) the restricted vegetation types of the area (unfortunately the map doesn't cover the upper parts of Barotseland) are Floodplain Grasslands with *Echinochloa* and *Oryza* (type F1) and Wet Pan Grassland with Mixed Species (type P1). These units should be looked at from the viewpoint of identifying suitable conservation sites. A vegetation type under threat from commercial rice production is the Seepage Wetland found in the large tributaries of the Zambezi, e.g. the Lui. The status and vulnerability of these areas should be investigated further.

Near Mongu are a series of nutrient-enriched springs at the foot of the escarpment, areas now virtually completely cultivated for vegetables. Despite cultivation they contain various unusual plant species such as ground orchids. If good examples of this habitat can be found they should be given conservation priority. It is likely that very few remain with original vegetation as they are prime sites for cultivation.

Scattered throughout the Barotse floodplains are swamp forests, locally termed butoya. These forests typically fringe backwaters on more clay-rich soils and are dominated by *Syzygium guineense* subsp. *barotsense*, a species which is not at all unusual but not often found forming a small forest. The unusual tree *Anthocleista liebrechtsiana* is sometimes also found. Such areas are threatened by heavy demands for wood, and good examples should be conserved. One well-developed swamp forest at Sinungu (15°45'S, 23°2'E) containing *Syzygium owariense*, *Gardenia imperialis* and the fern *Lygodium microphyllum* is of particular note (M. Bingham, pers. comm.).

4.2.2 **Chobe/Caprivi**

Parts of the Kwando and Linyanti swamps are conserved in National Parks on the Namibian side, while the land use pressures on the Botswana side are minimal as the area is cattle-free and mostly used for wildlife. The Kwando swamps, in particular, appear in good condition. No particular ‹focal points' were noted.

Elephant have severely damaged or destroyed much of the riparian waterfront along the Chobe River in Botswana. To the east of Kasane is Commissioner's Kop and the Kasane Rapids. A survey in the 1970s revealed some interesting plant species (including aquatic plants of the family Podostemaceae) not found elsewhere in Botswana, birds (Rock Pratincole, African Finfoot) and Sharpe's grysbok (P.A. Smith, pers. comm.). This would appear to be an area of conservation interest despite potential damage by elephant, infrastructural developments and tourism, if it is still in reasonable condition. Hot springs, also unique for Botswana, are situated nearby and contain an unusual assemblage of plants, but may have been damaged by a commercial irrigation scheme.

Further downstream is the Lesoma fossil river valley, a tributary of the Zambezi which in part forms the Botswana/Zimbabwe border. The spring at Lesoma (natural springs are rare in Botswana), which supported some unusual plant species, has possibly been destroyed by elephant (P.J. Smith, pers. comm.). At the Lesoma/Zambezi confluence the clay deposits are colonised by stands of the tree *Acacia kirkii*, a very unusual vegetation type. These areas are possible potential conservation sites.

4.2.3 **Lower Shire**

Most of the Elephant and Ndinde marshes in Malawi have been heavily utilized by people over the last 40 years, and little of particular interest for biodiversity conservation has been noted. However, the Shire Valley ranch (south of SUCOMA at Nchalo) still retains much of its woody cover although grazed by livestock. One section (Section A) contains some wetland vegetation. The Mozambique side of the Ndinde Marsh contains extensive stands of apparently little-utilized woodlands and marsh vegetation, and a selection of these should be identified both for conservation and to act as benchmark sites to indicate previous condition (I. Mapaure, pers. comm.). Within the Elephant Marsh an area between Muona and Chiromo on the eastern side was identified from the air as being more or less intact and possibly worthy of conservation (I. Mapaure, pers. comm.).

Various traditional grave sites are present near the marshes and still support large trees, perhaps providing an indication of previous vegetative cover (I. Mapaure, pers. comm.). However, extensive cutting of shrubs and regenerating woody growth means that these sites are greatly modified habitats, and of limited conservation value in the long term.

4.2.4 **Zambezi Delta**

The Zambezi Delta comprises an integrated system of wetlands, which are vast and only locally utilized. They are also poorly known from a biodiversity perspective. The wetlands of Marromeu, including the associated forests and woodlands of the Cheringoma plateau and also the coastal mangroves and dune communities, represent one of the best environmental/ecological transects in southern Africa. Perhaps because of this, no particular conservation ‹focal points' have been noted. The whole area is of major international conservation significance from the viewpoints of habitat diversity, vegetation types, plants, mammals and birds (see Chapter 8).

4.2.5 **Other wetlands in the Zambezi Basin**

Upper Zambezi

Many wetland (particularly swamp) species are found throughout the basin in suitable habitats. However, the headwaters of the Zambezi is the one area which contains species not found elsewhere in the basin (see Section 8.3.3). For example, mammals of note include the tree pangolin (*Manis tricuspis*), the otter shrew (*Potamogale velox*) and a new species of horseshoe bat (*Rhinolophus* sp. nov.) (F. Cotterill, pers. comm.). Although not under particular threat of habitat destruction, it was noted in 1990 that a substantial amount of riparian gallery forest along the Jimbe river had been destroyed (F. Cotterill, pers. comm.), and conservation sites should be identified as a matter of priority.

The Lukanga and Busango swamps on the upper reaches of the Kafue river are major wetlands that have received little attention. A biological and environmental study is being undertaken through the Environmental Council of Zambia to support designation of the Lukango swamps as a Ramsar site. This study may reveal sites of particular interest or concern.

The Lower Kafue floodplains are perhaps the best studied wetlands in the region. Apart from the large Kafue Flats National Park above and surrounding the Itezhi-Tezhi dam, there are two small National Parks on the main floodplain ! Lochinvar and Blue Lagoon (410 and 450 km² respectively); both are Ramsar sites. Although the hydrological regime and some of the biodiversity has been modified, these two areas are of great importance for conservation and contain significant numbers of lechwe, wetland birds and floodplain plant species.

Mid-Zambezi
Mana Pools is the only remaining significant floodplain in the Middle Zambezi since the formation of Lakes Kariba and Cabora Bassa, although it is not extensive and has been much modified by man and elephant. Floodplains in the Gwembe valley were all flooded by the formation of Kariba, and the new lakes do not support true wetlands. The floodplain of Mana Pools lies in a National Park, which is also a World Heritage Site. However, major damage to biodiversity continues to be done by elephants and impala, which are destroying the associated woodlands by excessive browsing of saplings.

Lower Zambezi
Apart from the comments above in the section on the Zambezi Delta, no other sites have been suggested. The sandy banks and backwaters of the Zambezi have been fairly intensively cultivated for centuries. In the middle years of this century the creation of sugar plantations resulted clearance of hundreds of square kilometres. From the air various lakes have been noted not far from the river, possibly filled in part by flooding. These may be good sites for conservation.

At the Shire/Zambezi confluence, and going upstream along the Shire, the extensive clay-rich floodplains have been heavily cultivated. Any remaining areas of relatively undisturbed swamp vegetation or riparian/swamp forest should be conserved, as similar areas in Malawi have been nearly all destroyed.

4.3 SPECIES OF INTEREST OR CONCERN

Probably as a reflection of the limited knowledge on biodiversity throughout the basin, the main species of conservation interest noted have been birds and large mammals. For other biological groups species of interest are suggested, but these may not be necessarily agreed upon or recognised as such by specialists in the field. Red Data books are not available for the Zambezi Basin area, or for many groups. The various biological groups are discussed separately.

4.3.1 **Plants and vegetation**
Plant species are not well known across the basin, apart from certain areas, e.g. Okavango, Lower Shire. No endemic swamp species have been noted with certainty, but this probably reflects our lack of regional knowledge. As many swamp and aquatic plants are water-dispersed, it is most probable that they are fairly widespread in distribution downstream, and local endemicity is unlikely. There are likely to be more endemic floodplain species.

M. Bingham (pers. comm.) reports a recent discovery on the Bulozi floodplain near Lealui of a large, bulbous, showy plant now named *Gloriosa sessiliflora* (Colchicaceae). Such a find indicates that there may well be other ‹specials', especially as the Barotseland wetlands have been comparatively stable ecologically. Even a preliminary list of plant species endemic to the wetlands and dambos of the proto-Upper Zambezi is not yet available.

The grasslands of Barotseland on Kalahari sand are a centre of diversity of a number of ‹underground trees' or suffrutices (White 1976), plants belonging to various unrelated tree genera that have adopted a dwarf habit with the main woody stem underground. Above-ground shoots, frequently destroyed by fire or frost, are minimised, and the ‹trees' often spread by means of rhizomes. It is thought the underground habit is an adaptation to high water table and anaerobic soil conditions on seasonally-flooded plains. Some of these suffrutex species are confined to the edaphic grasslands of Barotseland.

Riparian woodland, the species-rich assemblage of woody plants and herbs flanking larger water courses, is under threat both from settlement and clearing and from elephant (the latter most notably along the Chobe and Zambezi in Zimbabwe). Various plant species are confined to this habitat, and are in danger of being lost if woodland destruction continues. Strong efforts should be made to conserve from elephant damage any good remaining examples of this vegetation. Ironically, the situation is worse in the National Parks (Chobe National Park in Botswana, Zambezi and Mana Pools National Parks in Zimbabwe).

Mangrove swamps are found at the mouth of the Zambezi. These are quite extensive, particularly to the north of the river mouth, and concern is often expressed on their over-utilization. Certain areas may well require conservation attention.

4.3.2 **Mammals**

Only the large mammal fauna is sufficiently well known to enable wetland species of particular interest to be identified. The wetlands of the proto-Upper Zambezi are a centre of diversity of semi-aquatic antelopes of the genus *Kobus* (waterbuck, puku, lechwe). While waterbuck (*Kobus ellipsiprymnus*) is fairly widely distributed in southern and eastern African, puku (*Kobus vardoni*) are restricted to wetlands (including the Chobe and Barotse floodplains). The three subspecies of lechwe (*Kobus leche*) are restricted to the proto-Upper Zambezi. The threatened black lechwe (ssp. *smithemani*) is confined to the Bangweulu Swamps and the Kafue lechwe (ssp. *kafuensis*) to the Kafue Flats. The red lechwe (ssp. *leche*), the most widespread subspecies, is found on the Barotse floodplains, along the Kwando river in Angola, in the Kwando/Linyanti/Chobe area, in the Lukanga Swamps and near Lake Mweru. All subspecies are of conservation concern. There is good (although now perhaps dated) information on numbers and breeding of *K. l. kafuensis* and *K. l. smithemani*.

On the Kwando floodplains of Botswana/Namibia the oribi (*Ourebia ourebi*) is found in small numbers, as is Sharpe's grysbok (*Raphicerus sharpei)* on the basalt strip flanking the Chobe river near Kasane. Locally, both species are considered threatened.

As mentioned in Section 4.2.5, various species of mammal not seen elsewhere in the Zambezi Basin are found in the Mwinilunga area (F. Cotterill, pers. comm.) such as the tree pangolin (*Manis tricuspis*), otter shrew (*Potamogale velox*), another shrew (*Crocidura anselli*) and a new species of horseshoe bat (*Rhinolophus* sp.).

4.3.3 **Birds**

Birds are probably the best known of all the groups in terms of distribution and abundance. The recent initiatives in various countries to undertake bird atlassing projects mean that data on distribution are also more rigorously recorded.

The "flagship species" of the Zambezi wetlands is probably the Wattled Crane (*Bugeranus carunculatus*), found in the Bangweulu, Liuwa Plains, Okavango, Makgadikgadi, Kafue and Zambezi Delta. The world population is about 13-15,000 birds of which 95% is confined to the Zambezi Basin, Okavango and Lower Zaire (Beilfuss & Allan 1996). Other species of particular conservation concern (Red Data Book species) are White-winged Flufftail, Slaty Egret and Corncrake. A list of these and other threatened species is given in Table 4.1. The Slaty Egret has a very narrow range in the west of the Zambezi Basin and in the Okavango, and much of the breeding population of the Rock Pratincole, African Skimmer and Carmine Bee-eater are found along the Zambezi. The Kafue Flats are a major habitat for ducks and geese, including Palaearctic migrants (see Table 3.4).

Table 4.1. Bird species of conservation concern or with substantial populations within the Zambezi Basin (ZB) wetlands.

Species	Where found	Conservation category[1]	Pop[n.] status
White-winged Flufftail	Zambia, Zimbabwe	Endangered	V
Slaty Egret	Botswana, Namibia, Zambia	Vulnerable	RB
Wattled Crane	most wetlands; not Lower Shire	Vulnerable	RB
Corncrake	Zambia, Malawi, Zimbabwe	Vulnerable	PM
Madagascar Squacco Heron	Malawi, Moz(?), Zimbabwe	Near-threatened	V(IM)
Shoebill	within ZB, only Bangweulu	Near-threatened	RB
Lesser Flamingo	all areas in ZB	Near-threatened	N
Great Snipe	anywhere	Near-threatened	PM(V)
Black-winged Pratincole	western parts of ZB	Near-threatened	PM
Rock Pratincole	Namibia, Zambia, Zimbabwe	major population	IMB
African Skimmer	throughout ZB	major population	IMB
Carmine Bee-eater	mid-Zambezi & Shire	major population	IMB

Source: P. Mundy (pers. comm.).

[1.] From Collar *et al*. (1994)

RB = resident breeder, IMB = intra-African migrant breeder, PM = palaearctic migrant, N = nomad, V = vagrant.

4.3.4 **Reptiles and amphibians**

A preliminary checklist of the reptiles and amphibians of the various, broadly-defined wetland areas is given in Table 3.5. This is based on specimens collected, and there is no information on abundance or conservation threat. Species of particular interest owing to their restricted geographical occurrence are listed in Table 4.2. The major threats to them would appear to be land use change, drainage or flooding, and pollution.

Table 4.2. Herpetofauna of the Zambezi wetlands – species of particular interest.

Chelonii (tortoises, terrapins, turtles)		
Pelusios bechuanicus	Okavango Hinged Terrapin	Endemic to the Upper Zambezi system sensu lato.
Cycloderma frenatum	Zambezi Flap-shelled Turtle	Endemic to the Lower Zambezi system sensu lato.
Serpentes (snakes)		
Leptotyphlops pungwensis	Pungwe Worm-Snake	Probably endemic to floodplains of the Lower Zambezi system.
Proatheris superciliaris	Eyebrow Viper	Endemic to the floodplains of the Lower Zambezi system sensu lato.
Lycodonomorphus obscuriventris	Floodplain Water-Snake	Near-endemic to the floodplains of the Lower Zambezi system.
Limnophis bangweolicus	Bangweulu Water-Snake	Endemic to the Upper Zambezi system sensu lato.
Crotaphopeltis barotseensis	Barotse Water-Snake	Endemic to the papyrus swamps of the Upper Zambezi system.
Amphibia (frogs, toads)		
Bufo lemairii	Bangweulu Swamp Toad	Near-endemic to the Upper Zambezi system.
Ptychadena mapacha	Mapacha Ridged-Frog	At present only known from the East Caprivi wetlands.
Hyperolius marmoratus subsp. *aposematicus*	Aposematic Reed-Frog	Subspecies endemic to the Zambezi above Victoria Falls and the Eastern Caprivi.
Hyperolius marmoratus subsp. *pyrrhodictyon*	Kafue Reed-Frog	Sub-species endemic to the Kafue Flats.

Source: D. Broadley (pers. comm.)

4.3.5 **Fish**

The fish fauna of the waters of the Zambezi is fairly well documented in terms of species composition, but there is little published on the status of the various species or conservation requirements. The exception here is Lake Malawi, which supports a very diverse and unique cichlid fauna and has been the focus of much conservation attention. The fish fauna of Lake Malawi is probably 99% endemic, and over 500 endemic cichlid species have been described (B. Marshall, pers. comm.). Some information has accumulated on the status of fisheries in Lake Chilwa and the Elephant Marsh, but this is likely to be very out of date given high fishing pressures.

Both the widespread lungfish (*Protopterus annectens*) and spotted killifish (*Nothobranchius orthonotus*) are restricted to seasonal pools which are more susceptible to land use change and drainage. There are said to be two rare and one endemic (*Nothobranchius* sp.) fish species in the East Caprivi wetlands (Bethune & Roberts 1991); two of these are classified as Red Data book species. Table 4.4 gives a brief list of species of concern owing to restricted distribution or threat of habitat loss.

The fish fauna over much of the Middle Zambezi has been greatly modified by the construction of the Kariba and Cabora Bassa dams, as well as a large number of smaller dams on Zambezi tributaries, especially in Zimbabwe. Species adapted to the slower-flowing waters of the Upper Zambezi have been found in the placid waters of Lakes Kariba and Cabora Bassa where they would not have survived in the previously fast-flowing waters before the dams were built.

Table 4.3. Fish species of conservation interest from the Zambezi Basin.

species	rivers	notes
Paramormyrops jacksoni	U. Zambezi (Longa R.)	only known from 1 specimen
Barbus choloensis	Lower Shire	only in tributaries
Varicorhinus nasutus	M. Zambezi	fast-flowing streams. Main population in Batoka Gorge
Nothobranchius kuhntae	Pungwe	floodplains near Beira
Nothobranchius kafuensis	Kafue	endemic to pans on Kafue Flats
Nothobranchius sp.	Caprivi	endemic to pans in E.Caprivi

Source: B. Marshall, pers. comm.

4.3.6 **Invertebrates**

Only the butterflies (Lepidoptera) and dragonflies (Odonata) are sufficiently known to give an indication of species of interest. One species is *Archaeophlebia victoriae*, a primitive dragonfly only recorded from the Victoria Falls area, with its nearest relations in Madagascar (Pinhey 1963). Table 4.4 gives a list of butterflies confined to the Zambezi River and Okavango Delta, some of which are only known to occur along a particular part of it (M. Fitzpatrick, pers. comm.). There is no indication if these species are under any threat.

A genus and species of spider (*Paroecobius wilmotae*) is known only from the Okavango (Lamoral 1981), but could well be more widespread.

Table 4.4. Butterflies only recorded from the Zambezi River Basin.

Family	Species	Locality
Satyridae	*Ypthima granulosa*	Lower Zambezi, Mozambique
	Ypthima cataractae	Victoria Falls to Chirundu, Zimbabwe/Zambia
	Ypthimomorpha itonica	Okavango to Lower Zambezi
Acraidae	*Acraea dammii*	Lower Zambezi, Mozambique
	Acraea acerata	Okavango, Chobe
	Acraea atergatis	Okavango, Victoria Falls
	Acraea atolmis	Okavango, Victoria Falls
	Acraea buettnei	Okavango
Charaxidae	*Charaxes brainei*	Angola, Caprivi, Okavango
	Charaxes fulgurata	Chobe, Victoria Falls, Zambezi Valley (mid?)
Nymphalidae	*Euphaedra orientalis*	Lower Zambezi, Mozambique
	Neptis jordani	Okavango
Lycaenidae	*Spalgis lemolea*	Victoria Falls, Kariba
	Zeritis sorhagenii	Kazungula, Matetsi
Pieridae	*Mylothris bernice attenuata*	Okavango, Victoria Falls
Hesperiidae	*Teniorhinus herilus*	Lower Zambezi, Mozambique

Source: M. Fitzpatrick (from Pennington 1978).

4.4 SUMMARY

As became very apparent in the course of this study, there is insufficient information available, with the exceptions of birds and large mammals, on species presence and abundance at a regional level to be able to confidently identify species of conservation concern. The situation is particularly acute for invertebrates (with the possible exception of butterflies and dragonflies) ! virtually nothing is known on what species occur where or on their conservation status. The exception is solely due to the great interest and published papers on this group by one man – Elliot Pinhey – between 20 and 40 years ago.

Although the presence of a species in a particular area may have been noted, sometimes many years ago, in only a few cases is there any indication on whether that species still occurs there or what its conservation status might be. With birds and large mammals many people have been involved, formally or informally, amateur or professional, in bird atlas projects, game counts and similar exercises which provide a reasonably realistic picture not just of species occurrence across a country, but also of numbers and status. To a lesser extent this has occurred with tree species and some of the charismatic plants (e.g. succulents, orchids). A linking factor in these groups, of course, is their generally readily-identifiable nature and the

availability of good field guides. The best-known species are also, obviously, those most readily visible and active during daylight hours.

Historically, much of the biological expertise has been focussed at a national level (or just one part of a country), and has not had a regional perspective, a situation exacerbated these days by poor communications and bureaucratic constraints. Between the 1950s and 1970s the Natural History Museum in Bulawayo and the National Herbarium in Harare developed a regional view on some groups of organisms, at least for the Flora Zambesiaca countries (Botswana, Caprivi, Zambia, Zimbabwe, Malawi and Mozambique). But this expertise has now died, retired or moved out of the region. There are very few people that are still active who have a regional overview for their particular group. The situation is not helped by many of the published accounts being national in nature, or following political boundaries, notably the Zambezi River (e.g. Coates-Palgrave 1988, Smithers 1983).

As mentioned in Section 4.1, conservation attention has to become more focussed if it is to be effective. It is easier to raise awareness, and manage, a relatively small area for a particular set of objectives than a larger area for a multiplicity of objectives. However, the identification of particular sites of conservation interest requires something of a national perspective, not just knowledge of a district or similar sized area. A site of specific interest, by definition, implies that there are no better areas available with those characteristics and species (Timberlake 1996). Surprisingly few such sites were identified in the course of the study. In part this may have been due to difficulties in grasping the concept given a prevailing conservation paradigm which focusses on large state-controlled areas. But perhaps more importantly, this problem reflects both a lack of detailed field knowledge and the lack of a national or regional overview.

One finding from the study is that the sites most in need of conservation are often the remnants of previously more widespread vegetation types such as riparian woodlands and swamp forests. Locally, springs, pans or small lakes that support unique assemblages of organisms may also be under threat. Conservation of such vegetation patches in many cases will carry conservation of smaller species.

The conservation pressures on the vast wetlands of the Zambezi Basin are, by and large, broad in their effect – pressures such as flooding and flood control, over-fishing and pollution – although loss of habitat to agriculture is a major concern in some areas. The value of small conservation sites comes into its own in fragmented, heavily utilized environments, environments which are not common in the wetland areas. The main exception within the basin is possibly the Lower Shire valley.

With regard to species-based conservation, the various semi-aquatic antelopes (sitatunga, puku, lechwe) can be considered major focal points. If they maintain healthy populations in the various wetlands of the proto-Upper Zambezi then it is likely that these wetlands are still relatively healthy and able to provide both the various required ecosystem services and to support other components of biodiversity that are insufficiently known at present. Other focal points are bird species in both Upper and Lower Zambezi wetlands, such as the Wattled Crane – a readily visible species for which reasonable biological knowledge exists. Its continued presence may also indicate that many wetland functions and productivity levels are still in place.

5. HISTORICAL CHANGE AND HUMAN IMPACTS 85

5.1 INTRODUCTION

One of the major concerns of the IUCN Wetlands Project, and of other conservation bodies, is to determine what effects human activities have had, and continue to have, on biodiversity ! both on species composition and on ecological processes. We need to be able to determine what the effects of different activities might be, which are the most influential activities, and what the ecosystem or species tolerance limits are. We also need to discern which changes are caused purely by human intervention, and which form part of natural environmental processes – there is often an assumption that change is not ‹natural' and thus not ‹good'. As has been pointed out earlier, many wetlands are inherently ecologically unstable and the landscape within which they are situated is also evolving, for example through tectonic movement and natural erosion. Wetland ecology, and hence species composition, is in a state of flux as channels move, backwaters become main channels, and areas dry up owing to a series of droughts. As Smith (P.A. Smith, pers. comm.), writing about the Okavango, has said “We should guard against the ‹glasshouse' syndrome, of protecting nature in a static situation. Wetlands are dynamic .....they change quite drastically with river blockages and tectonic movements, independent of Man. Thus we should allow them to change, not rigidly fix them. The Okavango is not pristine – Man has lived there for centuries.... The swamps are dynamic, evolving and changing year by year as a result of natural as well as man-manipulated pressures. Channels move through siltation and vegetative growth; we just need to look at satellite imagery to see the past complexity of channel formation”.

Compared to many other river basins in Africa, the Zambezi for much of its length is relatively little affected by human activities. The major changes in land use affecting biodiversity over the last 100 years have obviously been the construction of the two major dams at Kariba in 1958 to form the 5361 km² Lake Kariba (Balon 1978; Balon & Coche 1974; Kenmuir 1978; Magadza 1993, 1995; Moreau 1997), and Cabora Bassa in 1974 to form the 2665 km² Lake Cabora Bassa (Davies 1975; Tinley 1975). Lesser dams that have still had major effects on biodiversity are at Kafue Gorge and Itezhi-Tezhi, both on the Kafue river in Zambia. Other dams are much smaller and situated on the upper reaches of tributaries. Two further dams are planned for the Zambezi ! at Batoka Gorge below Victoria Falls, and at Mepanda Uncua below Cabora Bassa.

The construction of these dams has resulted in regulation of the previously-vast annual Zambezi floods below Victoria Falls. This, in turn, has caused radical changes in the fish fauna of the Middle and Lower Zambezi, modification of riparian and wetland vegetation by encouraging woody growth at the expense of grassland and, obviously, the large-scale development of lacustrine environments and a benthic fauna. These, in turn, have led to modifications of bird populations and, to a lesser degree, of mammals and reptiles. Unfortunately, owing to the lack of a good series of pre-impoundment data on biodiversity and ecology, it is difficult to reliably determine the magnitude and exact cause of these changes.

Other important changes in land use and human activity related to wetland biodiversity are (a) agricultural expansion, (b) deforestation in the catchment area, (c) excessive hunting of large mammals, (d) increase in grazing pressure, (e) over-fishing in certain areas, and (f) pollution from pesticides, in particular from those used to control tsetse fly but also from agricultural runoff. Some of the landscape ecological and evolutionary concerns are addressed in Chapter 8.

This chapter provides an overview of the impacts of water resources development on the Zambezi Basin as a whole (Section 5.2, by C. Magadza), followed by an account of historical changes to the four project sites (Section 5.3).

5.2 OVERVIEW OF IMPACTS OF WATER DEVELOPMENTS

In discussing the ecological impacts of dam construction on the Zambezi River it is instructive to note that very few direct studies on the ecological impact of these dams have been undertaken. What we do know of the impacts consists of short term studies with limited fieldwork. Furthermore, it is difficult to make pre- and post-project comparisons as the Zambezi Valley was little known, at least from an ecological viewpoint, prior to their commencement.

The most dramatic impact of the hydroelectric development projects in the Zambezi Basin is the obliteration of the riparian wetlands of the Gwembe Valley and the of area above Songo. These annually flooded wetlands have now been replaced by lacustrine ecosystems. The biodiversity in these man-made ecosystems has been manipulated either through intended introduction of species from neighbouring ecosystems, or by accidental releases, as in the case of the fish *Oreochromis nilotica* in Lake Kariba.

Lake Kariba now produces in excess of 30,000 tonnes of fish per year, largely from introduced species; it is a popular tourist destination and the crocodile industry originally associated with the lake has been an important strategy in the conservation of this species in the rest of southern Africa. The number of fish species in the lake is nearly double what was recorded in the river prior to impoundment, while the diversity of phytoplankton exceeds the rather limited species of flowing waters. The shoreline of Lake Kariba also provides important pastures for a variety of ungulates and elephants. Thus the conservation issue becomes a philoophical question of whether humans can choose to replace one ecosystem with another.

5.2.1 **Impact of dams on selected wetlands**

No major developments have taken place on the Upper Zambezi floodplain. The currently perceived threat to these wetlands is human population encroachment due to population growth and land hunger. In this region of Zambia these are not severe threats. However, there is concern on the future of the Chobe/Caprivi wetland system, including that of the Okavango. These concerns arise from the population density along the Kavango and Kwando Rivers in Namibia and various proposed water resources development projects in Botswana (Scudder *et al.* 1993) and Namibia.

The impact of the Kafue scheme derives not so much from the reservoir project itself, but rather from the inadequately-planned Kafue Industrial Estate which has caused eutrophication of the Kafue Gorge dam. This has resulted in the export of aquatic weeds such as *Salvinia molesta* and *Eichhornia crassipes* into the Zambezi River. On the Upper Kafue catchment there could be emerging problems from peasant farmer land use in the upper catchment of the basin. But this are would be a result of population pressure rather than development as such.

In spite of nearly 40 years of operating Lake Kariba our knowledge of the downstream impacts of the lake is still very sketchy. Although Kenmuir (1976) noted that opening of the Kariba flood gates triggered spawning behaviour in the riverine fish species of the Mana Pools area, we have little information on what more than ten years of lack of pulse flooding has had in the Middle Zambezi. Presumably fish populations

in this sector must now be responding to local floods of small streams such as the Rukomechi, Sapi and Chewore.

Mana Pools is the other remaining wetland in the Middle Zambezi. Du Toit (1984) compared the large mammal biomass of the Mana Pool floodplain to that of Matusadona National Park & except for buffalo, Mana Pools had a much larger herbivore population. Jarman (1972) found similar comparisons between Mana Pools and Sinamwenda (on the southwest Lake Kariba shoreline) from data collected between 1964 and 1966. Though Attwell (1970) predicted an invasion of the floodplain ecosystem by dry woodland species, data from Du Toit (1984) do not indicate a significant change in species composition of the Mana Pools floodplain. Thus one can conclude that so far no significant changes in the ecology of the Mana Pools area have been detected, but this statement can only be made in respect of what is observable now and what was observable soon after Kariba was built. G. Tatham (pers. comm.) recalls periods before that when the floodplain was inundated to a depth of 2 m.

The frequency of pre-impoundment flooding and its ecological significance is also a matter of debate. It is popularly held that the Zambezi River periodically supplied silt material to the floodplain during innundation. However, oral history can only account for three flood episodes this century. Such a flooding frequency (with each flood cycle lasting less than two weeks) can not account for the amount of alluvium on the floodplain, leaving a possibility that it is perhaps a record of an earlier, wetter era (see Section 2.2.2). Alternatively, silt supply to the floodplain is predominantly derived from flooding of local streams. In either case, the present vegetation of the floodplain has established itself over a long period under xeric conditions, and is therefore unlikely to change as drastically as Attwell (1970) has suggested.

Below Cabora Bassa we have the brief observations of Davies (1975) and Jackson & Rogers (1976) which record the ecological processes following closure of the dam. Observations downstream in the sector between Cabora Bassa and the delta show at least 40 fish species, a much higher number than found in the Gwembe Valley prior to innundation. And we have information on the negative impacts of the Zambezi Basin dams on the shrimp industry of Mozambique at the Zambezi Delta (Gammelsrod 1992). Neither Lakes Kariba nor Cabora Bassa, nor the planned Batoka Gorge dam, have incorporated fish ladders in their design. There has been speculation on the impact of this segmentation of the Zambezi on migratory fishes such as the eels. As no definitive studies have been carried out on them, all that can be said of the impacts of the dams on these species is that they are still present in the Zambezi River. However, neither the Kafue Gorge Dam, nor the Liwonde Barrage on the Shire River, should pose any difficulties for migratory eels.

Perhaps the most affected wetlands in the Zambezi Basin are in the Lower Shire, in particular the Elephant Marsh. The major factors are (a) population pressure, which has resulted in encroachment of human settlements onto the wetlands particularly in dry years, and (b) agricultural and urban developments in the catchment of the Shire River.

Agricultural runoff, and possibly Blantyre sewage, has resulted in the eutrophication of the Lower Shire swamps leading to proliferation of *Salvinia molesta*, *Eichhornia crassipes* and *Pistia stratiotes*. These wetlands have a production of 6874 tonnes fish/year, a mean yield of 100 kg/ha, and such weed infestations have possibly resulted in decline of fish production as well as loss of biodiversity. It is also probable that pesticide runoff from the sugar estates upstream has affected these fish populations. The total production

from these wetlands alone exceeds the total gillnet production of Lake Kariba of some 900-1000 tonnes/year.

Given their elevation, the Lower Shire wetlands form a transitional zone between coastal fauna elements and the typical inland fauna. The White Pelican, within Malawi, is only found on Elephant Marsh and Lake Chilwa, while Newman *et al.* (1992) list some 64 bird species which utilize Elephant Marsh alone. After Lake Malawi the Lower Shire wetlands have the largest number (12) of exploitable fish species in the Malawi fishing industry, in comparison to five species in Lake Malombe and only three species in Lake Chilwa. All the commercially utilized species use the shallow floodplain for breeding, thus a reduction in wetland area constitutes both a commercial and conservation threat.

The impacts of the reservoirs on the remaining floodplains of the Zambezi are not well documented. It is known that the delta area of the Zambezi used to flood extensively, and that on occasions that flooding crossed over into the Pungwe Basin through Gorongosa National Park (Tinley 1977). With cessation of flooding, productivity of the alluvial floodplain is now determined primarily by rainfall, and there are reports of subsurface salt-water intrusion and of an invasion of the grasslands by woodland elements. Another significant impact of the dams on Marromeu is that cessation of flooding has increased accessibility of the wetlands to hunters, thus facilitating poaching of wild animals. Consequently most of the large mammals in the delta area have now been shot out.

One other unstudied factor concerning the cessation of silt transport to the Mozambican coast is the dynamics between coastal erosion and silt and sand deposition on the coastal delta. It is feared that exploitation of the mangrove resources, which form a thin barrier between the ocean and the coastal wetlands, could lead to accelerated erosion and salinisation of the hinterland wetlands. Observers also note that river flow in the delta area is confined to steep-sided channels, suggesting a lowering of the hydrostatic pressure of freshwater.

5.2.2 **Impact of dams on humans**

The most conspicuous impact of the Zambezi Basin hydroelectric development programmes has been on the human species itself. The scenario of human impacts is possibly more complex than the ecological impacts in that the human impacts appear to have escalation factors & one can talk about primary, secondary and tertiary impacts.

The primary impacts are those related to the forced migration of communities in the project areas. These have been amply documented by various scholars, particularly Scudder and Colson.

The secondary impacts arise from the facilitation of human migrations into the wetlands environs or their vicinity. The provision of infrastructure has enabled the penetration and settlement of once remote areas at an unprecedented rate, and without due regard to the ecological consequences of such human transmigrations. Magadza has noted that in the Omay Communal Lands on the shores of Lake Kariba in northern Zimbabwe, the population growth rate was 114%, largely due to migrants. Inappropriate land use has led to soil erosion such that any streams that used to store dry season water in pools no longer do so because of siltation, e.g. the Nyaodza River.

Furthermore, the need to protect humans and livestock from vector-borne pathogens, such as malaria, has resulted in the introduction of pesticides which have found their way into the wetland ecosystems through

runoff (e.g. Berg & Kautsky 1994; Douthwaite & Tingle 1994; Douthwaite *et al*. 1992). Although it is sometimes claimed that more than 20 years of DDT application has had no significant impact, various authors have produced evidence of deleterious impacts of DDT on a number of organisms associated with the Zambezi wetlands (see Magadza 1995b).

Tertiary impacts emanate from the other forms of land degradation in the Zambezi Valley. Persistent annual fires in the Charara Safari Area on the Zambezi escarpment have degraded woodland vegetation to an extent that the hydrology of the area has also altered. Runoff from rain episodes is immediate and rapid and the waters are silt laden. Animal populations in these areas have apparently declined from both habitat destruction and poaching.

5.2.3 **Summary**

From this brief overview it is evident that, considering Lake Kariba was the first of the big dams, more effort should have gone into studying its impacts outside its immediate area. Similarly, it is regrettable that 17 years of experience from Kariba did not influence the design of Cabora Bassa. The scientific community have missed unique opportunities for studying the impacts of large reservoirs. Social scientists, however, appear to have gathered a great deal more than the life scientists. But in spite of that knowledge the Cabora Bassa scheme still caused considerable social trauma to the people who were moved out of the project area.

With this background it is possible to construct an impacts scenario from various observations on water resources development made over the years in the Zambezi Basin. The emerging picture is that the Zambezi Delta wetlands are probably the most severely directly-affected ecosystem; impacts on other wetlands arise from population pressure, which would have developed in time anyway. Ecosystem impacts due to pollutants arise from ancillary activities such as tsetse fly control programmes, which are not necessarily the direct outcome of dam developments, and the construction of Lake Kariba did not make it inevitable that livestock should be introduced into the valley. With hindsight we now know that management of wildlife resources of the area would perhaps have been a more sustainable land use option, as it still is in some areas.

In the Okavango, Chobe and Caprivi wetlands there are no major developments, but plans for the utilization of these waters to satisfy growing water supply demands for urban as well as agricultural use are likely to impinge on them much more severely than dam construction has done on the Middle and Lower Zambezi wetlands. Any utilization of these areas should take cognisance of their very delicate hydrological balance, particularly in light of the projected climatic changes for the southern African region.

Lastly, the management of the Zambezi Basin wetlands needs to keep close surveillance on the trends in industrial development in the basin as a whole. Recent data now point to emerging problems of industrial pollutants, such as heavy metals as well as municipal wastes, which appear to have altered the nutrient levels of the Zambezi. The aquaculture industry needs to be carefully planned and monitored for both effluent management and introduction of alien species.

5.3 HISTORICAL CHANGE AT PROJECT SITES

5.3.1 **Introduction**

It was originally envisaged that one of the project activities would be a comparison of historical satellite imagery to detect differences in land use and vegetative cover for the four wetland project sites. This has not been done as it was not possible to obtain two sets of imagery from each area owing to (a) the unavailability of imagery, particularly in a format that copies could be made from, in most countries, (b) the unforseen high costs of Landsat TM imagery, and (c) the present unavailability in South Africa of historical Landsat MSS data, although this should be rectified in a few months. In addition, questions have been raised as to how much useful information can be obtained given the limitations of interpretation of 1:250,000 scale images with sufficient differentiation within the wetland areas. This particularly applies to the semi-linear wetlands of the Lower Shire. For meaningful comparison, imagery would have to be from the same time of year, for years of similar rainfall or flooding regimes, and for perhaps three separate years in order to separate trend from possibly isolated events. Wetlands of comparatively limited extent, e.g. the Chobe/Caprivi and the Lower Shire, are better studied using aerial photographs.

An exercise of analysis of land use change, similar to that envisaged here, has already been carried out for parts of the Caprivi area by the Department of Environmental Affairs of the Government of Namibia under their Environmental Profiles programme (Mendelsohn & Roberts 1997).

The rest of this chapter provides a brief summary, gained both from the literature and field visits, of historical changes in land use and human activities from a biodiversity perspective for the four project areas. What has happened over the last 100 years or more, what are the main factors, and what impact have they had on biodiversity?

5.3.2 **Barotse floodplains**

The floodplains of Barotseland are of some antiquity and relatively stable. Some of the plant species show evolutionary adaptation to periodic innundation, and vegetation patterns do not appear dynamic. In effect, the Barotse floodplains are a palaeo-landscape. The area has been settled for a long time and land use pressures, although intensifying, do not seem to have changed greatly in nature. The main historical factors affecting biodiversity are thought to be (a) variability in rainfall in the upper catchment, particularly prolonged droughts, (b) increased clearance for agriculture, particularly for rice, (c) deforestation in the flanking woodlands and of floodplain trees, (d) increased grazing pressures by domestic livestock, (e) increased incidence and extent of fire, and (f) hunting of wildlife, particularly hippo.

There are reports of smaller annual floods in recent years owing to poor rains in the upper catchment, particularly eastern Angola. Although sometimes speculated upon, there is no evidence to suggest agricultural or other human activities upstream have contributed significantly to smaller floods. Owing to reduced river flows over the last six or so years it is likely that regional water-tables are low and need several above-average rainfall years to recharge.

Large areas are reported to be cleared for agriculture now owing to increased human populations, higher levels of technology available, increased government and donor inputs, and better control of trypanosomiasis (a cattle disease carried by tsetse fly). Control of tsetse allows cattle populations, required for ploughing and improved household economic security, to increase (E. Chileshe, pers. comm.). However, only a small proportion of cultivation is actually on the seasonal floodplains or wetlands, mainly as these areas are under water for 2-4 months every year. The growth in small-scale commercial rice production is obviously focussed on wetland areas which retain adequate moisture for some months. Little

rice appears to be grown on the main floodplains, but is more common in some of the wetlands of large tributaries such as the Lui which do not receive annual floods from the main river.

Partly as a result of increased wealth and government/aid inputs, and partly a result of trypanosomiasis control (either through prophylactic drugs or control of the tsetse fly vector), cattle populations in the area have reportedly increased. Much of the grazing, except for the few months of flooding, takes place on the Zambezi floodplains. High grazing pressures, apparent in some areas, are known to slowly destroy some herbaceous components of the vegetation and can result in a more homogeneous environment, often lower in biodiversity.

There is much concern in government and conservation circles in Barotseland over the effects of fire (E. Chileshe & A. Kamuhuza, pers. comm.), and campaigns are in place to reduce its incidence. Fire has always played a role in the ecology of grasslands and woodlands, but was probably never as frequent as it is now. Regular burning may greatly reduce the incidence of fire-sensitive plant and animal species, and can also result in overutilization of recovering areas.

Deforestation in the woodlands flanking the floodplains, both miombo and *Baikiaea*-dominated, has been marked over the last 40 years, resulting in an opening of the tree canopy and accompanying increase in fire risk and hazard. Soil erosion and loss of valuable nutrients from the generally dystrophic soils has possibly also occurred. It has been said that there is no good *Baikiaea* forest with its unique assemblage of species now left in the area (M. Bingham, pers. comm.) owing to commercial logging in the past, charcoal manufacture and increased incidence of fire.

The main populations of large mammals in Barotseland are now found in the Liuwa National Park in the northern part of the Barotse floodplains, and to a lesser extent on the Luena Flats. Little wildlife is left on the other floodplains. Larger birds, especially ducks and geese, are widely shot for meat. Hunting and poaching pressures have been particularly high since independence when traditional Lozi authority was marginalised. Likewise, fishing in lagoons was previously carefully controlled by traditional authority, which in this respect has since broken down leading to over-fishing (A. Kamuhuza, pers. comm.). Much of the Zambezi appears suitable habitat for hippo but there are reportedly now very few, although they have apparently increased in number in recent years (E. Chileshe, pers. comm.). It is not clear if this reduction in hippo numbers has led to channel blockage, reduced flows or marked changes in floodplain ecology, but this is unlikely.

5.3.3 **Chobe/Caprivi**

The wetlands of the Kwando/Linyanti are ecologically somewhat separate from the floodplains of the Zambezi/Lower Chobe, although intimately connected to them, and there are some differences in the historical changes that have affected them. There have been wetlands in this area for hundreds of thousands of years (see Chapter 2 and discussion on palaeo-Lake Caprivi in Shaw & Thomas 1988). The Chobe/Caprivi wetlands are at the cross-roads of the Upper Zambezi system where the Kwando, Okavango/Makgadikgadi, Zambezi and proto-Kafue joined, and are also not far from the site of river capture by the proto-Lower Zambezi. Historically, both hydrologically and ecologically, it is an unstable area. Historical changes must be viewed in this light, and some of the more important are not a result of human activity.

The main historical factors affecting biodiversity are thought to be (a) hydrological changes, often associated with tectonic movements, (b) rainfall variability in the upper catchments, in particular a number of years of below-average rainfall,(c) clearance for agriculture, (d) heavy grazing by cattle, (e) increased incidence of fire, (f) over-hunting of larger mammals, and (g) over-fishing.

The existence of palaeo-Lakes Makgadikgadi and Caprivi, as well as a larger Okavango Swamp, is now well documented (Shaw 1984, 1985, 1988; Shaw & Thomas 1988; Thomas & Shaw 1988, 1991). The flow of the present Upper Zambezi passed through the East Caprivi and Chobe to the Okavango and palaeo-Lake Makgadikgadi, then via the present-day Shashe and Limpopo Rivers to the ocean. The landforms in East Caprivi-N.E. Botswana are very low and slight changes in elevation due to either minor tectonic movements or blockages/deposition in channels can lead to radical changes in hydrology and direction of flow. In addition, years of exceptional inflow can remove impediments, either vegetation or particulate deposits. This has been going on for millennia as can be seen from satellite imagery on which fossil channels and backwaters are clearly visible. Some of the mechanisms for these changes in hydrology are outlined by Ellery *et al.* (1989), McCarthy (1992) and McCarthy *et al.* (1988).

In the 1980s there was considerable concern over Lake Liambezi, which is fed by both the Linyanti River from the southwest and the Chobe River from the northeast (Seaman *et al.* 1978). Lake Liambezi, about 100 km² in extent, was an important fishing area (Van der Waal 1980) producing in excess of 360 tonnes of fish a year. After a series of dry years when the Chobe did not back up to fill it, Lake Liambezi dried up completely in 1985 (Grobler & Ferreira 1990). It is now an extensive area of grassland with scattered *Phragmites* and only seasonal wet patches. Burning occurs annually, and the peat that formed its bed has burnt completely leaving just a fine powdery ash. The only evidence of a lake are the scattered shells of freshwater molluscs buried in the ash. Apparently, the lake comes and goes. Selous in 1879 reports a large lake, but it was reportedly only 10 ha in extent in 1942. Curson in his 1949 study does not refer to it. The rapid drying up of the lake is not attributable to human activity, but to climate.

Settlement in the East Caprivi, although not in adjacent areas of Botswana (except the small Chobe Enclave), is heavy and apparently unregulated. In part this reflects the politics of the 1980s when the area was under South African military control. The rapid upsurge in settlement and influx of cattle this decade has probably led to significant changes in the ecology and biodiversity of the wetlands, although there have been no comparative studies nor are there much in the way of data for comparison. Floodplains previously only seasonally grazed, particularly the Zambezi and eastern Chobe floodplains, are now permanently settled and parts are cultivated. There has been interest in commercial sugar production in plantations south of Katima Mulilo, but nothing has yet materialised. Allied to the increase in settlement is an increased frequency and extent of wildfires. This is so marked on some satellite images that it is difficult to discern natural vegetation patterns.

During the period of South African occupation, and to a lesser extent since, there was extensive hunting of larger mammals in the Caprivi, often from the air. Wildlife populations, in particular antelope on the floodplains, were decimated and have not had a chance to recover. On the Botswana side, however, much of the area is protected and cattle-free. The damage to river front vegetation caused by elephant along the Chobe is something of an ecological disaster, and has had serious consequences for biodiversity conservation. On the Botswana side of the Kwando/Linyanti wildlife populations are in good health, and recolonisation of adjacent areas of Namibia occurs readily.

Owing to the high human population levels and aspirations in the Caprivi there is reportedly much over-fishing of both rivers and seasonal lagoons, resulting in changes in both aquatic ecology and species composition.

5.3.4 **Lower Shire**

This is the most intensively utilized of the four project areas, and major changes in species composition and ecology have been reported over the last 100 years, in particular since the 1950s when settlement intensified along wetland boundaries. The major historical factors affecting biodiversity are thought to be (a) changes in the water level of Lake Malawi, (b) rainfall amount and distribution, (c) hydroelectric dams and controls on river flow, (d) hunting (particularly in the early part of the century), (e) clearance for agriculture, both subsistence and commercial (sugar), and (f) over-fishing. Much of the following account is taken from C. Dudley (pers. comm.).

The Shire Valley forms part of the Great Rift Valley stretching down from Africa from the Red Sea. Although its own catchment is not insignificant, much of the water flowing through comes from Lake Malawi. These waters are now somewhat regulated by the Liwonde Barrage, Nkula Falls and Tedzani Falls hydroelectric schemes upstream of the marshes, although these are run-of-river schemes with little storage capacity.

The marshes were probably created, at least in their present-day form, by the backing-up of waters from the Shire River after the river capture of the Upper Zambezi by the proto-Lower Zambezi. Deposits of sand and silt at the present-day Shire-Zambezi confluence inhibit rapid flow of the Shire waters into the Zambezi. Therefore, biologically, the marshes of the Lower Shire are maybe comparatively young, perhaps only 150,000 years old (but see Section 2.2.2).

The water levels in Lake Malawi vary and are reportedly declining at present. In part this may be due to drought, but tectonic movements and possible underground seepages are also thought to be important factors. To a casual observer, the Lower Shire wetlands appear to be an ancient stable environment. On closer inspection it is clear that over and above the annual cycle, there have been considerable fluctuations of water levels, and in extent of marsh and human cultivation during the last 150 years. Richards (1954), Maxwell (1954) and Pike (1968) discuss the great influence that the levels of Lake Malawi and the size of the outflow channel of the Shire River have had on the water levels in the Shire Valley.

During a series of years of below-average rainfall in the river and lake catchments, the Elephant Marsh becomes very dry, allowing extensive cultivation of the area. Maxwell (1954) claims that in 1907 he “never found a trace of water or any indication of a marsh” north of Chiromo, the river being only 18 inches (45 cm) deep at this point. Richards (1954) describes much of the Elephant Marsh as under intensive cultivation of maize, cotton and rice during 1915-1937. SVDP (1975) report that during the period of their project the Elephant Marsh was heavily cultivated with cotton, maize, sorghum, fruits and vegetables, and that both it and the Ndindi Marsh had intensive dimba cultivation of the alluvial fans and levees.

At times of high annual precipitation in the river and lake catchments, the Elephant Marsh is subject to very damaging floods (i.e. the years 1948, 1952, 1956, 1967, 1971 (cited in Latham 1957 and SVDP 1975) and 1997). Due to excessive runoff upstream, the Shire backs up the Mwanza River just north of the Elephant Marsh, and at its junction with the Ruo River at Chiromo. Hence, flood waters spread widely throughout the area. The Elephant Marsh may act as a reservoir to absorb some of this flood damage

(Latham 1957). The flood of 1997 was unusual in that it was due principally to high rainfall in the Shire River catchment, most of the Lake Malawi catchment experiencing poor rainfall. Thus although flooding was widespread, the water levels of the marsh have now dropped to levels lower than the historic average. Flooding in the Ndindi Marsh area is subject to the regime of the Zambezi River ! high flow of the latter forcing the Shire River upstream and into the Ndindi Marsh. During the extraordinary wet years of 1976-1983, when lake levels reached historic highs (1980), the Lower Shire wetlands were extensive and cultivation within the marsh was very restricted.

The conservation importance of the Elephant Marsh may have been recognised early when it was established in 1897 as one of Nyasaland's (now Malawi) first two Game Reserves (Hayes 1978). However, from the reports of Faulkner (1868) and Young (1868, 1877) there may have already been significant declines in the populations of large mammalian fauna from Livingstone's early passage in 1859 (cited in Hayes 1978) even before the establishment of the Reserve. Game regulations were little enforced and Elephant Marsh was degazetted in 1922. Today, as Ansell & Dowsett (1988) note, Elephant Marsh contains little but hippos and crocodiles. Nevertheless, elephant and buffalo still occasionally pass through the marsh (e.g. in 1996/97) causing great excitement. Because of the development of the sugar estates and the density of the surrounding cultivation, the animals have to be driven out or sometime killed by government hunters.

Deforestation on the surrounding slopes, very clearly seen on satellite imagery, has obviously increased the rapidity of runoff and probably also increased nutrient and particulate matter loads in the Lower Shire. Whether this will result in increased siltation of the marshes, and whether the great increase in aquatic weeds partly arises from this, is not clear.

5.3.5 **Zambezi Delta**

In biological terms it is likely the Zambezi Delta is quite young and unstable, being formed after the proto-Middle Zambezi captured the much larger Upper Zambezi and forged a new, more direct route to the sea rather than flowing down the Urema Trough to join the Pungwe River and reach the sea at present-day Beira.

The major historical factors affecting biodiversity are thought to be (a) impoundment of flood waters by upstream dams, (b) extensive commercial cultivation of sugar, (c) excessive hunting of wildlife for many years, exacerbated over the last decade, and, possibly, (d) aquatic weeds.

The ecology and dynamics of the swamps and wetlands of the broad delta region was driven to a substantial, but unknown, extent by the occasional large floods from the Zambezi upstream (Tinley 1994). These floods have been greatly reduced in frequency and extent by impoundment at Kariba and Cabora Bassa. At present it is only the exceptional floodwaters from the Shire River (which were very marked in 1997) that are uncontrolled.

The effects of impoundment by firstly Kariba (1958) then Cabora Bassa (1974) have caused much concern (e.g. Anon. 1975; Beilfuss & Allan 1996; Davies 1975; Tinley 1975). But, although undoubtedly marked, the effects after the first year have not been documented owing to political changes at the time Cabora Bassa was closed and the long civil war. Likewise, the effects of flooding prior to this have not been documented. The large sugar estates downstream of Caia constructed an extensive system of bunds (earthen barriers) near the river to reduce flood risk. These, constructed before Kariba, have probably had

an important effect on vegetation flanking the main river channel. Clearance for sugar plantations, which were mostly under flood irrigation and covered hundreds of square kilometres, must also have had a major effect on both vegetation and wildlife. At present all the plantations are abandoned and have generally been so since the mid-1980s (Schmidt 1997). Fallow vegetation is taking over, consisting of scattered trees (*Acacia polyacantha*, *A. sieberiana*, *Lannea schweinfurthii*, *Piliostigma thonningii* and *Ficus sycomorus*, I. Mapaure, pers. comm.) in a tall grassland (principally *Pennisetum* cf. *polystachion*).

Subsistence and small-scale cultivation has been practised on suitable soils associated with the main river channels for centuries (Schmidt 1997). The Zambezi River has been a main trading route for the last 400-500 years, and the system of fiefdoms or prazos was established by 1600. It is possible that settlement densities are actually lower now than at any time in the last few hundred years.

Historical records (Schmidt 1997; G. Liesegang, pers. comm.) suggest that there has been much hunting of larger animals, both for meat and trade (ivory, skins, etc.) along the Lower Zambezi for hundreds of years (see also Kirk 1864; Maughan 1914; Maydon 1951; Tabler 1963; Vaughan-Kirby 1899). Wildlife numbers have probably been moderate to low for centuries. The Marromeu area is known for its large buffalo herds and wetland bird populations, and these high populations may in part, have been due to difficulties of hunting access into the extensively flooded short-grass plains. There are concerns now that the grasslands are slowly drying out, partly due to poor rainfall over the last decade, but also to reduced flooding since the closure of dams upstream. It is believed that wildlife populations will become more vulnerable to poaching and the land more suited to subsistence agriculture.

During the civil war there was great destruction of wildlife by the military on both sides, aided by aircraft and automatic weapons. This continued in 1992 after hostilities ceased. Hippo were particularly badly hit, numbers in Marromeu declining from 2820 in 1977 to 260 in 1990 (Anderson *et al.* 1990), while buffalo and waterbuck numbers over the same period declined by around 90%. One consequence of reduced hippo numbers is said to be the clogging of water channels by vegetative growth, particularly *Eichhornia* (R. Beilfuss, pers. comm.) resulting in reduced extent of flooding.

Many of the lagoons and channels of the wetlands north of the Zambezi River appear to be covered in aquatic weeds such as *Eichhornia*, *Pistia*, *Salvinia* and *Azolla* (R. Beilfuss, pers. comm.), perhaps as a result of reduced flushing of the wetlands by occasional floods. When large water bodies are invaded by such weeds there is known to be an effect on biodiversity, such as reduced fish diversity, but perhaps also an increase in benthic fauna.

6. WETLANDS EXPERTISE 97

6.1 EXPERTISE DATABASE

There are, and have been, many people working in the Zambezi Basin in the broadly-defined area of "biodiversity". What is not always clear is what their particular speciality is, and who else may also be involved in that area. Hence, a database of regional expertise in biodiversity was compiled. As with the bibliography, there was need to carefully define both the terms biodiversity and wetlands. The definitions used here were essentially the same as in Chapter 3.

Expertise was taken to cover both professional and amateur, and only include organismal biodiversity. In practice, it was defined as people who, within the Zambezi Basin, have been working on or with wetlands and groups of predominantly wetland organisms, and who have sufficient experience and ability in their given group of animals or plants as to be able to reliably carry out a biological survey or compile a checklist for that group in a given area. This assessment is based partly on track record, publications and peer recognition, and there could well be many others who should be included. Emphasis was placed on those people resident and working in the region (i.e. Southern Africa, excluding South Africa) and who have had experience of the Zambezi Basin. The list also includes persons less biologically based who have been associated with studies on wetland biodiversity *sensu stricto* within the region. Persons from South Africa or overseas who have been associated with aspects of Zambezi wetland biodiversity are also included, particularly those with an uncommon speciality or particular experience.

Fields in the database include name, position, institution, physical address, postal address, country, telephone, fax and email, and geographical and subject areas of expertise. The keywords used for fields of expertise are given in Appendix III along with the full list of persons. The list is also available electronically as a Read-Only file in the program Idealist on the accompanying disk. The disk version is accessed and operated in the same way as the bibliographic database (Section 3.1.3); instructions are in a README file on the disk and also printed out here as Appendix IV.

6.2 REVIEW OF EXPERTISE

A total of 135 persons based in 13 different countries were identified. A breakdown by geographical areas of expertise and biological group is given in Table 6.1 and by broader discipline in Table 6.2. Note that the total number of people is not obtained by direct addition as various people's expertise covers two or more groups, subjects or countries. The database is recognised to be very incomplete and uneven in its coverage ! some disciplines such as invertebrates are over-represented owing to less stringent criteria being used in definition of wetland groups, and some countries (e.g. Mozambique, Zimbabwe) are also over-represented owing to more readily-available information. Many persons whose expertise was not considered to be of direct relevance to wetland biodiversity were excluded. Another problem is the incomplete categorisation (i.e. incorrect or inappropriate use of keywords) of expertise cited. An additional factor to be considered in selecting expertise is what task it is required for. As much as was possible, given that it was not possible to interview all regional specialists, the criteria stated in Section 6.1 were adhered to.

As can be seen from the table, expertise in plant identification is widespread, but it is generally restricted to certain groups or areas. Few botanists are able to readily identify all flowering plants even in their own areas as there are so many species compared to the total number of species of birds, herps, fish or mammals. Botanical expertise is principally associated with herbaria, some of them university-based, but there are a significant number of people based at environmental NGOs or working as consultants.

Table 6.1. Expertise in organismal biodiversity of the Zambezi Basin.

group	country/area of expertise								Regional total for group [1]
	Ang	Bot	Mal	Moz	Nam	SAfr	Zam	Zim	
Plants	-	5	5	10	3	4	4	10	30
Mammals	-	1	3	1	1	1	1	1	9
Birds	-	4	4	7	5	2	4	4	25
Herps	-	-	-	1	2	5	2	4	10
Fish	-	-	2	1	2	2	1	8	15
Inverts.	-	-	5	6	5	8	3	7	33

Source: Expertise database on disk

[1.] This figure is not a summation of entries in each row, but is independently determined from the database. Some persons have two or more countries of expertise, and some two or more groups of expertise.

Note: This is just a tabulation of entries to date in the database, and reflects the known distribution of taxonomic expertise in wetland biological groups. It is by no means comprehensive - southern Africa (SAfr), in particular, is grossly under-recorded, whilst Zimbabwe and Mozambique are comparatively over-recorded.

Expertise in identification and ecology of larger mammals is, as would be expected, reasonable. Those persons listed here, including those cited under “wildlife”, are mostly associated with National Parks and Wildlife departments, while expertise on small mammals is mostly based at museums. Expertise in bird identification is good and widespread. Many of these people are good amateurs ! amateur ornithological societies and clubs are very strong in some countries.

Despite the numerous people listed, it is felt that the weakest area is invertebrates, both aquatic and terrestrial. This is principally due to the great diversity of groups, vast numbers of species, and the degree of specialisation required to get to grips with any one of these. Some of the expertise in Lepidoptera (principally butterflies) is amateur, but is often of a high and experienced standard. Entomological expertise is principally associated with museums and universities, with each person generally specialising in a particular group. Namibian institutes appear particularly strong in this regard.

Expertise in very specialised groups, e.g. phytoplankton or particular invertebrate groups, or world authorities on groups of organisms, are mostly based in South Africa, Europe or the USA. However, such people, many based at museums or universities, are often willing to assist in identification of specimens, and they also have better access to the important reference works and reference collections. In many cases such resources are sadly lacking in the region and, in addition, some collections are poorly curated or have difficulties with access. This results in practical difficulties in developing experience in identification, and takes away much of the incentive to build up national collections.

In terms of general wetland ecology and long-term experience of working in wetlands of the Zambezi Basin, expertise is not well developed. Many of the people who have been involved in large ecological studies of wetlands (e.g. Okavango, Kafue, Bangweulu, Marromeu) are no longer in the region, or are now fully occupied in administrative jobs and thus not active in the field.

Table 6.2. Expertise by country of interest and in various aspects of wetland biology for the Zambezi Basin.

subject/area of expertise	no. of persons
Angola	1
Botswana	14
Malawi	24
Mozambique	31
Namibia	20
Southern Africa	23
Zambia	17
Zimbabwe	33
wildlife	10
conservation	20
ecology (+wet-ecol)	20
aquatic weeds	4
Total number of persons listed	135 [1]

Source: Expertise database on disk

[1] This figure is not cumulative from the entries above. Some persons have expertise in two or more countries or subjects.

From a country perspective, South Africa, although not specifically covered in this study, would appear to be well-endowed with biodiversity expertise for most groups. There is, perhaps, an important role here for regional cooperation. Namibia, considering its small size, has a very good cross-section of expertise, but training of the next generation has only recently got underway. Botswana appears to have limited expertise in biodiversity, much of it expatriate.

In Zambia there was a lot of biological collecting in the past, but some of these collections are not very accessible or well curated at present. Considering how much work has been done in the country on fish, plants, mammals, reptiles, birds and general wetland ecology over the last 50 years, this situation represents a big loss of information. In Malawi most of the expertise is concentrated in the National Museum and National Herbarium, although the former is severely under-funded and under-staffed.

Mozambique lost nearly all of the expertise it had in biodiversity issues at Independence in 1975, and the civil war and poverty has greatly restricted any development since. The Natural History Museum (now under Eduardo Mondlane University) and the National Herbarium under Agricultural Research, had the major biological collections, while mammal and ecological expertise was in the Wildlife Department (then under Veterinary Services). The Department of Biology at the University has been making strides in recent years to redevelop some capacity in biodiversity evaluation. However, the focus for this has principally been marine and coastal rather than terrestrial, but has relevance to studies in the Zambezi Delta.

Historically, Zimbabwe has always had good collections at the Natural History Museum and National Herbarium, in part dating from the days of the Federation. But these institutions are now not as well-funded and active as they were. The Department of National Parks and the University have been very involved, both in the past and more recently, in fisheries, limnological and wildlife research. The first two topics were stimulated by the formation of Lake Kariba and the eutrophication of Lake Chivero, Harare's main water supply. Although much of this expertise has now retired or left the institutions, many of the individuals are still in the country but working in the private and NGO sectors.

6.3 IDENTIFICATION OF GAPS IN EXPERTISE

A major factor in determining where there are gaps in expertise is the size and complexity of the species group and the availability of good identification manuals or books. A group with only a few hundred species, such as birds, reptiles or mammals, clearly separable in an illustrated guide, is easier to handle than some of the invertebrate groups which number thousands of species separated by microscopic characters and for which the only key is a 50 year old paper written in German.

Museums and herbaria, many of which are university-based, are nearly always the main repository of collections of biological specimens and of the literature required for accurate identification. They have also been the main employer of expertise. The main exceptions to this have been large mammals (wildlife departments), fish (fisheries departments) and birds (amateur bird societies). Expertise in large mammals has managed to hold its own in the face of severe cuts in funding for wildlife departments through individuals moving in to NGOs, particularly those involved in community-based resource management or other forms of economic utilization of mammals, or into the tourism industry. Fisheries departments, because of the economic importance of fishing to rural populations and the value of commercial fisheries on large inland lakes, have avoided the worst of funding cuts. Good regional identification manuals and papers are also

available for fish so that it is possible to identify, carry out surveys and build up experience. Ornithological organisations have kept going as the individuals are generally employed elsewhere. Increase in knowledge has continued apace with many trips to unusual areas, continued recording in areas close to towns or farms, a good series of journals or newsletters to publish records in, and good and easily-available identification books. Recent attempts at compiling bird atlases have improved knowledge and helped identify gaps.

The main gaps in regional biodiversity expertise appear to be (a) invertebrates (all groups except butterflies), (b) flowering plants (herbs and grasses), (c) zooplankton (technically a sub-set of invertebrates), and (d) phytoplankton. These are serious gaps as invertebrates comprise the vast majority of species and possibly animal biomass found in wetlands. Plant communities generally define the habitat within which most of these organisms live and feed; in wetlands the woody flora is generally of less significance than the herbaceous.

Much of what expertise there is in these fields is also fast ageing and numbers are declining as people retire or move away. Many of the institutional bases for it are undergoing severe problems in funding, motivation and direction. Given the potential importance of monitoring of water quality through biological indicators, principally aquatic invertebrates, the lack of expertise in this area is a cause for serious regional concern.

7. ECOLOGICAL STRATIFICATION 103

7.1 INTRODUCTION

It was originally envisaged that a preliminary interpretation of satellite imagery of the four wetland project sites would be undertaken in Phase 1. This would provide a first hypothesis for the identification of apparently ecologically homogeneous units in these areas. Field checking of the resulting draft maps was only envisaged for Phase 2.

A preliminary ecological stratification would:

a) provide a clearer categorisation of the diversity of habitat within each project site,
b) allow for a better and less-subjective comparison between project sites,
c) assist in better focussing subsequent biological inventory work,
d) assist in identifying potential sites of conservation interest and priority sites for future studies,
e) provide a framework for a better assessment of species' status.

In addition to the ecological stratification there was to be a preliminary identification of gross changes in land cover in the four IUCN Wetland Project sites over the last 20 years, also using satellite imagery or air photos (see Section 5.3.1).

However, contrary to expectation, satellite imagery for the four project areas was not freely-available in some countries, necessitating purchase from the Satellite Applications Centre (SAC) in South Africa at a substantially higher cost than available in the project budget. IUCN-ROSA made additional funds available in June 1997 for purchase of imagery for the three outstanding areas, but owing to problems at SAC beyond the control of contractor and project, the imagery was only made available in November 1997. Rather than hold up the remainder of Phase 1 it was decided, in conjunction with the IUCN Project Manager, to incorporate these activities into Phase 2.

7.2 ECOLOGICAL MAPPING TO DATE

Below is a brief discussion on ecological/vegetation mapping of the four IUCN Wetland Project sites carried out to date using satellite imagery of one form or another.

Barotse floodplains
The vegetation map of Jeanes & Baars (1991) was based on 1:250,000 satellite imagery, and is excellent in its scope and detail. However, it focusses on the woodland and grassland areas rather than on the Zambezi floodplain and wetlands, much of which is mapped as one unit. Its usefulness from a wetland ecology viewpoint is therefore limited.

Chobe/Caprivi
A vegetation map based on recent satellite imagery for the Namibian portion of the Chobe/East Caprivi wetlands has recently become available (Hines 1997). This is based on detailed interpretation and fieldwork and shows 14 floodplain/swamp vegetation types, each described in terms of structure and species composition. This map will be good enough for survey and ecological activities in Phase 2 after minor changes and/or amalgamations, but will need to be extended to cover the (substantially smaller) Botswana portion of the wetlands. The present satellite images, however, do not cover these sections well.

Lower Shire wetlands

A series of land cover maps of Malawi have been produced (Satellitbild 1993) using visual interpretation of 1:150,000 Landsat TM imagery, but published at a scale of 1:250,000. These maps show the density and broad type of woody cover. The wetlands of the Lower Shire are all mapped as "Marshy Area or Swamp", surrounded by "Agriculture in Mainly Grass Area". Again, there is insufficient detail for use in stratifying biological survey work or in allowing comparisons with other project sites.

Zambezi Delta

There are no similar maps available for the Zambezi Delta other than the (unseen) Forest Inventory of Mozambique (Saket *et al.* 1995), carried out at a scale of 1:250,000 using Landsat TM imagery. It is unlikely that these maps will assist in ecologically stratifying the wetland areas.

8. PRELIMINARY ASSESSMENT 105

8.1 INTRODUCTION

An assessment of the role and importance of the Zambezi Basin wetlands for biodiversity conservation is difficult at this stage owing to the fragmented and incomplete information available, both on biodiversity and ecology. For some important groups, such as insects, it is so fragmentary as to provide little in the way of insight. Such questions as the role biodiversity – organismal and ecological – of the Zambezi Basin wetlands plays in biodiversity conservation of the whole basin, and how important the wetlands are to conservation in a broader perspective, are still unanswered. Put another way: if one or more of the wetlands were radically modified or destroyed, would what is lost be unacceptable biologically, resulting in loss of species and ecological services? As yet we do not really know.

Given this situation, we can only make extrapolations from existing knowledge, particularly of the better-known groups, coupled with theory and insights developed from particular wetlands within the Zambezi Basin and elsewhere in Africa. Hypotheses can be constructed as to what the major ecological determining factors are and what might happen if certain components are removed or modifications made, such as control of seasonal flooding or an increase in nutrient inflow. These hypotheses need to be rejected, confirmed or modified in light of future work. Meanwhile we should take heed of the precautionary principle – if one doesn't know, tread carefully.

The assessment below is based primarily on what has been gleaned from a survey of the biodiversity literature pertaining to the Zambezi wetlands. The theoretical background is given in Section 1.3. Literature from other parts of the world, which might throw much light on processes operating here, has not been looked at. Likewise, the importance to conservation worldwide is not well covered as it would have required a more exhaustive search of a wider literature. The role of the wetlands in providing goods and services to human populations is explicitly not covered.

8.2 ASSESSMENT OF THE IMPORTANCE OF WETLAND BIODIVERSITY

8.2.1 **Role and characterisation of wetlands**

Wetlands are an integral part of most landscapes – they are the places where surplus water builds up before being drained away, primarily in river flow or (rarely) by seepage or evaporation. Within a landscape, including the Zambezi Basin as a whole, they fulfil a regulatory function like a sponge, curbing the effects of flooding downstream yet ensuring some flow during drier periods. This regulatory function comes and goes depending on the lie of the land and climatic cycles. In flat landscapes, “sinks” form where moisture inflows exceed the capacity of the land to shed such moisture, while in incised landscapes wetlands can hardly develop owing to the good drainage network.

The Zambezi Basin landscape is continually changing through tectonic movement (which can be quite rapid and marked), natural erosion, river capture and, more recently, the hand of man. Therefore wetland type and extent will also be changing. It is important to realise that wetlands are not cast in stone, they are part of an evolving landscape at whatever scale it is viewed – whether as the whole basin or as a single swamp area such as the Linyanti. Thus it is not necessarily important, from a landscape perspective, to retain each and every wetland in its “natural” state. But it is important to retain the ability for wetlands to develop and to expand or contract.

Wetlands, more specifically swamps, are therefore inherently unstable over much of the Zambezi Basin, expanding and contracting not only over a year but over the decades following rainfall cycles. Plant communities and habitats are modified over wet and dry periods, and they also move around the landscape mosaic. For example, the extent of swamp vegetation with a requirement for perennial water at least 50 cm deep may contract during a dry period, or start to develop in a nearby site that was previously a flowing channel 2 m deep. Because of this instability the organisms living there are often pioneers, moving into suitable environments rapidly when conditions permit. The story of Lake Liambezi in East Caprivi, which has come and gone in historical times, is testament to this.

Wetlands are of two types, and the distinction in terms of biodiversity attributes is very important. These two types are: (a) swamps or marshes, where water sits virtually year-round and the plants are distinctly hydrophytic, and (b) floodplains, which are areas flooded, usually on an annual basis, for a few weeks or months (see Figure 1.1). Swamps and marshes are generally unstable, and the plant species found there, which determine the available food and habitat for animals, generally reflect this. Such species tend to be widely distributed throughout a river basin and more catholic in their ecology. Floodplains and pans, however, are much more stable over time, even if they are subjected to marked annual changes of moisture. Plant species present are adapted to seasonal fluctuations and trees are absent except in better-drained sites. Floodplains, dambos and seasonal pans are poorly interconnected biologically, thus species found there are more dependent on the specific characteristics of the substrate and are more restricted in their individual ranges.

8.2.2 **Biodiversity of wetlands**

There are some general aspects of the biodiversity of wetlands which should be briefly discussed before attempting an assessment of their importance. Some of these were discussed in the previous section – their instability and mobility. The other aspects are (a) biogeography, (b) differences between wetland types, (c) patterns of endemicity or distribution across the basin, and (d) similarities to wetlands outside the Zambezi Basin.

As mentioned previously, there are three distinct biogeographical areas covered by the Zambezi Basin reflecting the three different geographical origins of many of the species and genera. The Upper Zambezi element centres on the extensive area of floodplain, grasslands and dambos, and slow-moving waterways of the proto-Upper Zambezi (including Bangweulu, Kafue, E. Angola and the Okavango). Here, owing to the age and stability of the gently undulating landscape, speciation has taken place into the available niches. Classic examples are the lechwe antelope (*Kobus leche*) which has evolved into four sub-species, one now extinct (see Section 3.2.3), and the "underground trees" or suffrutices, woody plants adapted to the poorly-drained dambos and floodplains. The Lower Zambezi element (often termed the Mid/Lower Zambezi) is less clearly focussed geographically, but very distinct from the Upper Zambezi element, the disjunctions being at Victoria Falls and at the Kafue gorge. In part the differences are ecological, reflecting the quite different habitats present in the two sections. A third element is the Guineo-Congolian element, found at the headwaters of the Zambezi (Mwinilunga District in NW Zambia) but not extending far downstream. This suite of species requires moister conditions than are normally present in the remainder of the, essentially semi-arid, Zambezi Basin. Their affinities are to the forests of West Africa and the Congo Basin where rainfall is much less seasonal and the climate moister. Species diversity is high here, perhaps a reflection of being less affected by the Pleistocene dry periods (see Section 2.1.2). However, although there are many grasslands, and some swamp forests, there is little in the way of true wetland (i.e. floodplains or swamps).

Wetlands are of different types depending on depth and period of innundation and on substrate, and comparisons should compare like with like. Swamps, as mentioned earlier, are generally not particularly species-rich and tend to be similar between areas, possibly owing to the limited number of species that can tolerate flooded conditions and the easy dispersal of species between wetland sites through the medium of water currents. For example, the papyrus swamps of the Okavango do not appear to be dissimilar to the papyrus swamps of the Zambezi Delta, nor indeed from those on Lake Naivasha, Kenya. Floodplains are very different in this respect as the soil type and period of innundation result in a series of different habitats, each capable of supporting different plant species, and hence animal species. They are open grasslands with many shallow-rooted and bulbous herbs as woody plants can not survive the high water-table and flooding, except in better-drained sites. Dambos are linear features found along ill-defined drainage lines, usually in gently undulating landscapes on the main plateau away from large watercourses. They are rarely flooded, but are areas of poor sub-surface drainage due to an impervious layer in the soil. Again, grasses, sedges and herbs dominate, with very few woody plants except in better-drained sites such as gullies and termitaria. Pans are smaller, usually ovoid, and hold water for only a short period of the year. They are localised features, sometimes resulting from small topographical differences or from specific underlying geology such as calcrete deposits. As they hold water they can be of great significance for waterfowl and mammals. Plants found in them normally have rapid life-cycles and can survive long dry periods as dormant rootstocks or as seed, and many invertebrates are similarly adapted.

Plants

Unlike swamps, which show similarities in vegetation across the basin, floodplains and dambos can hold a greater diversity of plant life (including some unusual woody plants on the ecotones or closer to the woodland margins). Some of these species are geographically restricted to certain areas, and have perhaps evolved *in situ*. Pans, likewise, support some very unusual small herbaceous species (R. Drummond, pers. comm.). It is not clear how restricted in distribution a lot of these species are, primarily as so little collecting has been done. One conclusion, therefore, is that on present evidence it is the floodplains and dambos that are more diverse in terms of plant species, and possibly also of dependent animal species, than swamps.

Mammals

This finding also holds for mammals, for example the Reduncine antelope. Only the sitatunga appears to be adapted to swamp conditions. The grazing potential of floodplains is much higher than that of swamps, and in addition swamp plants show silica-enrichment or tough stems as defence against herbivores.

Patterns of distribution of wetland mammals across the basin do not show any marked differences, except those related to habitat availability. The lack of grazers and preponderance of browsers in the stretch of the Zambezi between Kariba and Cabora Bassa (M. Irwin, pers. comm.) is probably a reflection of this. The one major exception, again, are the Reduncine antelope, particularly lechwe and puku. Both these species are restricted to the floodplains of the proto-Upper Zambezi. However, there are no similar floodplains on the Lower Zambezi – those at Marromeu and Gorongosa are much more nutrient-rich than those of the old weathered landscapes of the Central African Plateau.

Birds

Patterns of distribution of birds depend on the group. There are a large number of wetland birds (Table 3.3) but an assessment of which are found on swamps, floodplains, dambos and pans has yet to be done. The palaearctic migrants, mostly waterfowl, are dependent on swamp habitat, but are not apparently restricted to particular ones – individuals can readily move between them. Cranes, on the other hand, although frequently moving between wetlands, need certain conditions for breeding, and these conditions can be interfered with by human activities such as hunting and river impoundment. For example, the breeding success of the Wattled Crane is possibly dependent on short grass conditions found after herbivore grazing. The Zambezi wetlands also hold significant populations of 12 species of birds under threat (Table 4.1), most of them from the western part of the basin.

Herpetofauna

There are marked differences in species composition of reptiles and amphibians between the Upper and Lower Zambezi (Table 3.5). Also, amphibians as a group have a greater dependence on wetlands than reptiles owing to breeding requirements. It is not clear how many of these species are endemic to the basin as a whole, but quite a few species of both reptile and amphibians are only recorded from specific wetlands or areas (D. Broadley, pers. comm.).Table 4.2 gives a list of species of particular interest owing to restricted distribution. The conservation status of these is not known.

Fish

Fish tend to be restricted to the riverine system in which they evolved, and rarely do species cross watersheds. They are therefore more susceptible to marked changes in habitat or water quality than most other aquatic organisms and those that have a non-aquatic adult phase (e.g. many insects). Fish species of shallow slow-water habitats are, almost by definition, restricted to what is here termed wetlands. Therefore destruction or major modifications to wetlands will have major repercussions on their status, possibly resulting in extinction. The fish fauna of the Middle Zambezi has been dramatically altered by the construction of dams at Kariba and Cabora Bassa, and also by the myriad of dams in the upper reaches of its tributaries in Zimbabwe. The introduction of alien fish species such as *Oreochromis nilotica* may also have a major impact on other species of tilapia through hybridisation (B. Marshall, pers. comm.).

Out of the 140 fish species recorded for the Zambezi Basin (Table 3.7) it is not clear how many are totally dependent on wetlands, but it is likely to be the majority. Table 4.3 shows the seven species threatened with extinction by habitat change and/or their limited distribution.

Invertebrates

Dragonflies are restricted to aquatic habitats owing to their breeding requirements, as are various other lesser-known insect groups. Again, it is not clear how many species are totally dependent on the continued existence and health of the wetlands of the basin or, more specifically, on the wetlands of the four project sites.

Butterflies restricted to certain sections of the Zambezi are listed in Table 4.4, but most are probably restricted by occurrence of their larval food plants rather than wetlands as such.

Mussels are the other better-known invertebrate group restricted to aquatic environments. It is not yet clear how widespread the various species are, or how important the wetlands of the basin are to their conservation, but it is likely to be significant.

8.2.3 **Importance of wetlands by area**

As was seen in Chapter 4, few sites of particular interest which could act as ‹focal points' were identified. In part this is due to our lack of knowledge on species distributions, but in part it probably reflects a lack of such sites. Wetlands within the basin are mostly linked by watercourses and swamps are generally young and ecologically unstable. Therefore there has been little opportunity for the development of habitats of restricted occurrence – any restriction is likely to be due to clearance by man.

Within the Zambezi Basin as a whole, it is thought that the geologically-old and relatively stable grasslands and floodplains of the Upper Zambezi have been the scene of speciation for various groups over evolutionary time. For example, the “underground trees”, Reduncine antelope and amphibians. This speciation is not restricted to wetlands as such, or to specific sites, but to the whole upper catchment area. It is a moot point whether such processes continue, or can continue, today given the fragmentation of habitat by cultivation, drainage, heavy grazing, elimination of large mammals from many areas, and the movement of organisms (indigenous and exotic) between sites or habitats aided by the hand of man. Perhaps species radiation is a thing of the past, with the main evolutionary activity now being adaptation to changed environments.

Upper Zambezi

From the perspective of the Zambezi Basin, the headwaters of the Zambezi around Mwinilunga and in E. Angola contain many species and habitats not found elsewhere. As mentioned previously, however, there are few real wetlands here but mostly swamp and riparian forests and edaphic grasslands.

The Barotse floodplains are vast and encompass a range of habitats and wetland vegetation types, mostly grasslands rather than swamps. Owing to the paucity of information on them for most groups it is speculative to discuss their importance for biodiversity conservation. There are known to be a number of plants endemic to the broad area, although a listing is not yet available, and it is an important area for wetland birds. The herpetofauna is thought (but not yet known) to be very rich and interesting (D. Broadley, pers. comm.) as the floodplains and grasslands of the Upper Zambezi are believed to be a centre of diversity owing to their age and stability. This is also seen, on a broader canvas, to be the case with Reduncine antelope, particularly the four subspecies of lechwe which are restricted to the floodplains of the proto-Upper Zambezi – the Bangweulu Swamps (*Kobus leche smithemani*), Kafue Flats (*K. l. kafuensis*) and the upper Barotse floodplain (*K. l. robertsi* ! now extinct) ! while *K. l. leche* is more widespread across this area. Various reptiles and amphibians are endemic to this area (Table 4.2).

The Kafue Flats are well-known as being of great importance to biodiversity by virtue of supporting the endemic Kafue lechwe and large numbers of waterfowl, including migrants, and Wattled Crane. Although the ecology of the floodplain has been much altered these populations remain, but it is not clear if any subtle ecological changes will allow large populations to maintain themselves in the long-term.

The Chobe/Caprivi is a comparatively recent and unstable wetland ecosystem, and one which has been, at least locally, fairly heavily affected by man and elephant. One endemic frog and one endemic fish are recorded from the area, but generally the species and habitats found are also seen in other wetlands of the basin, including the Okavango. The Slaty Egret, although not endemic to the Chobe, has its major population there.

The dambos of the Central African Plateau, covering both much of the catchment of the Upper and Middle Zambezi, are a widespread but biodiverse habitat with many species not found elsewhere. These habitats

are threatened with drainage, pollution and overgrazing, and many species typical of them have probably now disappeared from parts of their range. The importance of these dambos and vleis to biodiversity conservation has often been grossly underestimated.

Middle Zambezi

The Middle Zambezi, including most of its tributaries (with the exception of the Luangwa), has been heavily modified by dams – large and small. Flows are now more seasonal, and flooding reduced. Indeed, it has been stated that there are no real wetlands in this part of the basin, and this is certainly true regarding swamp and extensive floodplain habitats.

This stretch of the Zambezi Valley does not appear to be a centre of diversity for any group, nor does it appear to hold any endemic wetland species. Its importance to biodiversity conservation is principally because so much of it is now conserved as National Park or controlled hunting area, rather than because of any unique wetland habitat or species. It is now essentially a man-managed environment with little human settlement. The macro-ecological processes have been tamed and modified despite the veneer of ‹wilderness'. However, it is much at risk from urban and agricultural pollution.

Lower Zambezi

This is a very heterogeneous section of the Zambezi Basin, especially if the Middle Shire and Lake Malawi are included. Lake Malawi is a site of major international biodiversity significance owing primarily to the explosive radiation of cichlid fish resulting in around 500 endemic species. The lake is deep with an extensive pelagic (open water) environment, an environment which, before the advent of man-made dams, was not found in the southern African region. It is ecologically isolated and unique, and, within the context of the Zambezi Basin, of paramount conservation interest.

The Lower Shire is comparatively young geologically, probably post-dating the formation of Lake Malawi. The swamps associated with it are therefore younger still, and also very unstable. There have been drastic changes in land use in and around the Lower Shire over the last 50 or so years, and a (presumed) substantial reduction in biodiversity and modification of ecological processes. The remaining wetlands are not in a good state of conservation, particularly those situated inside Malawi, and are not known to contain any species or habitats not found elsewhere in the basin. The riparian and wetland habitats in adjacent parts of Mozambique have been less heavily affected, and probably have a higher biodiversity.

The Lower Zambezi, above the Zambezi Delta, is also young and unstable owing to regular and catastrophic flooding. It, too, has been much modified by cultivation but for much longer than the Lower Shire, although with possibly less intensity. It is poorly-known biologically, and its importance for biodiversity is probably in providing a fairly extensive area of riparian and sandy floodplain habitat and acting as a biological link between the Shire and the Zambezi Delta.

The Zambezi Delta is a very extensive and diverse wetland area covering a wide range of habitats from palm savanna, floodplains and swamp to mangrove, riparian and coastal forest. It is this habitat diversity that makes it perhaps the most important wetland biodiversity and conservation area in the Zambezi Basin. Each habitat is sufficiently well represented that viable populations of species dependent on them probably remain, and habitats are sufficiently interconnected that environmental changes causing fluctuation in extent may be compensated for elsewhere. Conservation at a landscape scale is possible here as nowhere else in the basin. Its conservation value is greatly enhanced if it is seen as part of a complex stretching from Gorongosa Mountain across the savannas of the Urema Trough (Gorongosa National Park) and the

miombo woodlands and dry forests of the Cheringoma Plateau, to the grasslands of Marromeu and the coast. There are attempts to gazette these wetlands as a conservation area under the Ramsar convention.

Species diversity of the whole complex is unknown, but is probably much higher than other wetland areas owing to high habitat diversity. The grasslands of Marromeu contained large populations of buffalo (numbers are now building up again after massive reductions over the last 20 years), and still support high numbers of wetland birds such as Wattled Crane. It is likely that viable populations of most of the wetland species of the Lower Zambezi can be found within the delta, as well as estuarine species not seen elsewhere in the basin.

8.3 SUMMARY

A preliminary assessment of the characteristics and importance of biodiversity within the Zambezi Basin wetlands shows that:

1. Any comparison of biodiversity across the basin must take into account the different types of wetland habitat and biogeographical regions.

2. Floodplains and dambos have, in general, a higher biodiversity than swamps, and contain more species of restricted distributions.

3. The Upper Zambezi has a range of habitats not found in the Middle and Lower Zambezi, and correspondingly there are some habitats in the Lower Zambezi not represented in the Upper.

4. The Upper Zambezi wetlands are geomorphologically-older environments and have been an important focus of evolution and speciation over the last few million years. Thus their biota is correspondingly older and richer.

5. The Middle and Lower Zambezi wetlands have a much younger biota which shows no exceptional diversification, other than in Lake Malawi.

6. Although it is not yet even partially quantified, a multitude of reptile, amphibian, fish, invertebrate and plant species occur in the Zambezi wetlands and nowhere else.

7. The floodplains of the proto-Upper Zambezi hold the world population of lechwe antelope, in three separate subspecies.

8. The wetlands hold significant populations of some globally-threatened bird species. Indeed, the destruction or excessive modification of many wetlands in the basin would result in the partial extinction of such species as the Wattled Crane and Slaty Egret.

9. Wetlands are important for palaearctic migrant birds as ‹wintering sites'.

10. The Wattled Crane and the lechwe (*sensu lato*) are probably the best “flagship” species for the wetlands of the Zambezi Basin, covering much of the diversity and many of the major conservation issues.

11. The Zambezi Delta, with the inclusion of the adjacent dryland and forest habitats, is a major conservation priority for the Zambezi Basin. It is probably the single most diverse wetland area and provides an excellent opportunity for holistic, landscape-based biodiversity conservation.

9. CONCLUSIONS AND RECOMMENDATIONS 113

This section attempts to summarise the major findings from the study, give recommendations where appropriate, and briefly describe its limitations. Outputs are evaluated against the original Terms of Reference.

It has proved difficult to make many categorical statements on the biodiversity of the Zambezi Basin wetlands owing to the very incomplete and fragmented knowledge base. The wetlands, ranging from floodplain to swamp, from the Central African Plateau to the coast, are sufficiently varied as to make most generalisations dangerous. The study principally focussed on collecting, collating and reviewing published information rather than on identifying specific conservation actions.

Recommendations are divided into two groups – those which are general in nature and apply to the basin (or large portions of it) as a whole, and those which are more specific and apply to the four IUCN sub-project sites. It is the latter which could be implemented under ZWCRUP. Recommendations for basin-wide research, enabling conservation to be regionally rather than nationally focussed, are also given. It should be borne in mind that conservation requirements are, in most cases, dependent on human activities rather than on intrinsic biology. Detailed fieldwork, as suggested for Phase 2, should yield clearly focussed recommendations for conservation activities. Recommended activities take cognisance of other on-going activities such as the Economic Valuation of Wetlands Goods and Services component and activities being carried out in the Zambezi Delta through the International Crane Foundation.

9.1 BIOGEOGRAPHY

The clear division of the Zambezi Basin into three physical and biogeographical sections ! Upper, Middle and Lower ! has been known for some time, particularly for fish. This study has documented that further and shown that the biogeographical distinctions (primarily between the Upper and Middle/Lower Zambezi) also hold for other groups of organisms (e.g. amphibians, reptiles, plants).

This biological distinction arises from the geologically-recent river capture of the proto-Upper Zambezi system (which included the Bangweulu Swamps, Kafue and Okavango) by the much smaller Middle Zambezi, which in turn was a tributary of the Shire River. The Shire drained Lake Malawi, ran through what is now Gorongosa National Park, and exited at the sea near Beira after joining the Pungwe. The present Zambezi Delta is therefore comparatively young, perhaps only 0.5 million years, a result of a ‹short circuit' to the sea after capture of the Upper Zambezi.

The landscapes of the Middle and Lower Zambezi are young in geological terms, therefore so are its wetlands. The floodplains of the Upper Zambezi, however, including the dambos and vleis of the central watersheds, are much older and have persisted relatively unchanged for perhaps millions of years. They have also been the site of evolutionary radiation of various groups of both plants and animals. The biodiversity of these areas is thus significantly richer, and they contain more endemics or species of restricted distribution than similar environments downstream. It is not clear if such evolutionary processes can still occur today owing to human activity and ecological homogenisation.

9.2 KNOWLEDGE OF BIODIVERSITY

Almost 1000 references on wetland organismal and ecological biodiversity from the Zambezi Basin were identified, from both the informal and formal literature. There is great disparity in coverage, both between biological groups and between wetland areas. For example, over 40% of references pertain to the Upper Zambezi (*sensu lato*), and only 16% to the Lower Zambezi *(sensu lato*). And of the references on the Middle Zambezi, 54% pertain to Lake Kariba. Overall, the areas best covered are the Kafue floodplains, the Chobe/Caprivi area, Lake Kariba and the Lower Shire, whilst, given their extent and importance, the Barotse floodplains and Zambezi Delta are particularly poorly covered. A subjective assessment or summary of the extent of available knowledge is shown in Table 9.1.

The best covered biological groups are plants/vegetation, large mammals, birds and fish. All invertebrate groups (except Odonata) are very poorly covered. For all groups coverage is uneven geographically. For example, 28% of fish references pertain to Lakes Kariba and Cabora Bassa, while no references were found from the Lower Zambezi (*sensu stricto*) and the Zambezi Delta.

Given the progression in biological knowledge through the stages of basic taxonomy (what is what?), geographical and ecological distribution of species (what is where, and why?), to ecological role (what does it do and what happens if it is removed?), nearly all the literature for all groups is still at the first two stages. The taxonomy of flowering plants, mammals, birds, reptiles, amphibians, fish and a few invertebrate groups (e.g. dragonflies, butterflies, mussels) is adequate to good for the region, and identification manuals are available. For the great majority of invertebrate groups, however, and for phytoplankton and microscopic groups, taxonomic knowledge is grossly inadequate ! a major impediment to survey and inventory work.

Knowledge on distribution varies from patchy to good. Adequate checklists exist for plants, large mammals, birds, reptiles, amphibians, fish and dragonflies for many wetland areas, but for almost every group there are significant gaps which preclude a detailed comparison of biodiversity between wetlands or across the basin. Comprehensive coverage on status and relative abundance, however, is missing in most cases – birds and mammals being the occasional exceptions. Most invertebrate groups are so little known that we do not even have a clear insight into patterns of species richness.

Coming to the ecological role of the various components of wetland biodiversity, the literature is scant indeed. The nearest we have to an ecological perspective is for the Kafue floodplain, the site of many intensive studies in the 1970s, and for lakes Kariba, Chivero, Chilwa and Malawi. Some of these studies attempted to identify key ecological processes in order to gain a predictive understanding; less than a handful of papers have attempted to tackle wetland productivity. The best known wetland animal species are probably the various subspecies of lechwe antelope, the Wattled Crane, some waterfowl and a few fish species. In terms of plants, only *Salvinia molesta* (water fern) has been looked at in detail, both in terms of its distribution and spread and in its effect on other aquatic organisms.

Although there are a number of species endemic to the wetlands of the Zambezi Basin, particularly to the floodplains of the Upper Zambezi, detailed listings are not yet available except for reptiles, amphibians and fish. Little is known on the conservation status of these endemics. The species that are known, with some degree of reliability, to be threatened, are all birds and mammals.

Table 9.1. Overall assessment of the state of knowledge on organismal biodiversity within the wetlands of the Zambezi Basin.

	vegetation/ plants	mammals	birds	herps	fish	invertebrates	OVERALL
Barotse floodplains	3	2	2	3	3	1	2
Kafue floodplains	4	4	4	3	4	2	4
Chobe/Caprivi floodplains	4	3	4	4	4	2	4
Okavango swamps	4	3	4	4	4	2	4
Lake Kariba	4	3	4	4	4	3	4
Mid-Zambezi floodplains	3	4	4	4	4	2	4
Cabora Bassa	2	2	1	2	3	1	2
Lake Malawi	3	3	4	3	4	2	3
Lower Shire wetlands	3	4	4	3	4	2	3
Zambezi Delta	1	2	2	1	1	1	1
OVERALL	2	3	4	2	3	1	

Source: Subjective assessment based on quantity and content of available literature.

1 - insignificant/poor
2 - basic
3 - moderate
4 - good

In many respects the lechwe antelope (*Kobus leche*) and the Wattled Crane (*Bugeranus carunculatus*) can be said to be the "flagship" species of the Zambezi Basin wetlands. The various subspecies of lechwe are endemic to the proto-Upper Zambezi wetlands, while the wetlands of the whole basin contain perhaps 90% of the world population of Wattled Crane. The conservation of these two species encompasses the major concerns and issues of wetland conservation in the basin.

Across all groups, with very few exceptions, our understanding of the role of species in wetland ecology and function is so scanty that it is difficult to make reliable predictions as to what might happen if species are removed, or if there were major modifications to wetland habitats. There is also less original survey data being published now than has been the case over the last 30 years. Our understanding of the wetlands of the Zambezi Basin is not expanding commensurate with the pressures being applied to them.

9.3 WETLAND AREAS AND CONSERVATION SITES

A sound comparison of biodiversity composition and importance between the wetlands of the basin is not yet possible, at least for all but a couple of groups, owing to paucity of information. However, with minimal additional field collecting, checklists could be compiled for a range of groups which would allow such a comparison. An additional difficulty in comparison is the enormous disparity in size between wetland areas, including the four IUCN wetland sub-project sites, which range from the extensive Barotse floodplains to the narrow marshes of the Lower Shire valley.

In geological terms, the Barotse floodplains are comparatively old and stable, and have been the location of recent speciation. Knowledge on biodiversity for most groups is very limited ! birds being the best-covered group. There is a good vegetation survey of much of the area, but little detail for the floodplains themselves ! perhaps a reflection of their ecological homogeneity. Details on fish are available, and on many of the plants of interest to livestock. There is no specific information on invertebrates. Of the literature surveyed, 63 publications (6.7%) refer specifically to the Barotse floodplains.

The floodplains and swamps of the Chobe/Caprivi area, covering, in effect, Botswana and Zambia as well as Namibia, are much younger and ecologically unstable. It is the best documented of the four project sites with 109 references (11.6% of total), and much of this knowledge has been synthesised. Well covered groups are vegetation, mammals, birds, reptiles, amphibians, fish and dragonflies. Some invertebrate groups have been briefly covered. Owing to its historical instability, and being a meeting place of various drainage systems, there are very few endemics, although some birds of restricted distribution are found here.

The wetlands of the Lower Shire are also young and unstable, naturally fluctuating in extent. In recent years very heavy land use pressures and over-exploitation of biological resources have led to a marked diminution of biodiversity. It is possible that parts of this ecosystem will not be able to recover their former ecological function or composition. There is a moderate knowledge of biodiversity with 90 references (9.6% of total), particularly strong on birds, herps and fish, but with major gaps for the invertebrates. No species of particular interest have been noted.

The Zambezi Delta incorporates a wide range of habitats, perhaps greater than for any other wetland of the basin. Because of its extent and habitat diversity it probably contains viable populations of most wetland species of the Lower Zambezi. Published knowledge on the area is scant, with only 37 references (3.9%

of total), mostly concerning large mammals and vegetation. There are no comprehensive checklists available for any biological group. The only invertebrates specifically covered are marine shrimps.

Very few sites of particular interest or concern for conservation were identified from the Zambezi Basin as a whole or from the four sub-project sites. Swamp forest and remnant fringing riparian forest have been extensively destroyed both by man and elephant, and conservation activity should include these as a priority.

9.4 HISTORICAL CHANGE AND HUMAN IMPACT

The ecology of wetlands, particularly swamps, is based on instability and fluctuation. Wetlands are the result of impeded landscape drainage and thus change in extent and type over the years depending on natural erosion and climatic cycles. Within a swamp, channels also move owing to vegetation build-up and other biological, as well as physical processes. Any change in extent and composition, therefore, can be natural as well as the result of human impact. There is some documented evidence of natural hydrological changes for Lake Liambezi in the Chobe area, for the Okavango swamps, and for the Lower Shire. The floodplains of the Upper Zambezi and dambos on the watersheds of the Central African Plateau, on the other hand, appear to be of much greater antiquity and to have been geomorphologically stable for hundreds of thousands, or perhaps millions, of years.

Changes to wetland extent over the last hundred years have been primarily caused by changes in rainfall, with droughts resulting in the drying up of some swamps. However, major changes in the biodiversity of wetlands have been primarily caused by human activities ! in particular the construction of dams, impoundments and flood regulation. The major dams are those at Kariba, Cabora Bassa and Itezhi-Tezhi, but the many small dams on tributaries of the Zambezi in Zimbabwe have undoubtedly also had a major effect. The Middle Zambezi has had its ecological character substantially changed over the last 40 years with the loss of many habitats, but with the creation of new ones. The effect of river impoundment on biodiversity much further downstream (e.g. in the Zambezi Delta) is not clear. An evaluation of all changes in biodiversity has been bedevilled by the lack of pre-impoundment data and, in some cases, a lack of monitoring since.

Other changes to wetland areas have been caused by excessive hunting and over-fishing, expansion of agricultural activity (crops and livestock grazing), fire and pollution. Large mammal populations in Barotseland, Caprivi, the Lower Shire and the Zambezi Delta have been greatly reduced by hunting, either in the last century or more recently, while agricultural expansion has severely affected biodiversity in the East Caprivi and Lower Shire. Pollution has resulted from the wide-scale application of pesticides used in controlling the tsetse fly and from nutrient overload from sewage associated with large urban areas. Industrial pollution does not yet appear to have affected wetland biodiversity and ecology, except close to Harare and Lusaka.

9.5 BIODIVERSITY EXPERTISE

Expertise in organismal biodiversity is scattered through the region. Most of it was based at national institutions such as universities, herbaria and museums, but over the last 20 years a significant proportion has moved into local or regional NGOs, or has been lost through retirement or emigration. A total of 135 persons are listed, both professional and amateur, although this list is by no means exhaustive. The main biological groups covered are plants and birds, and most of the expertise is based in Zimbabwe and South Africa. All these findings should be treated with caution as they may reflect other biases rather than the

actual situation. It is clear, however, that taxonomic expertise in groups such as zooplankton and phytoplankton, and many of the invertebrates, is dangerously limited, which reflects the global situation.

World authorities on most wetland groups are based in, or affiliated to, institutions in Western Europe, North America and South Africa. A prerequisite for such expertise to be functional is access to comprehensive literature and reference collections ! something becoming less available in the Zambezian region owing to funding restrictions and low government priorities for such activities.

The important role of amateur naturalists, particularly for birds, large mammals and butterflies, needs to be more fully recognised. Overall, there is also an important role for better regional collaboration and access to collections and literature.

9.6 LIMITATIONS AND EVALUATION

9.6.1 **Limitations of study**

The study has various limitations, some of which resulted from its focus on reviewing existing information from a comparative basin-wide perspective rather than focussing exclusively on specific sites. A further factor is the broadly-defined nature of the project sites – should the literature analysis and assessment principally look at the true wetland zones, or should they also address adjacent areas and factors which directly impinge on them? In practice a broader approach was adopted. As mentioned earlier, only a superficial familiarity with the four field sub-project sites has been obtained to date, thus detailed and specific conclusions would be inappropriate.

A further problem, which only became apparent later in the study and thus was not fully resolved, was the question of definitions. Although the Zambezi Basin has been broadly defined in the report, much of the effort of literature acquisition was focussed on specific wetlands. Some areas within the basin, such as the Bangweulu and Okavango swamps and the Malawian lakes, have not been well covered. Comparisons may thus be misleading. Similarly, expertise in wetlands biodiversity proved difficult to define clearly for comparative purposes.

A more important problem with definitions has arisen over the word “wetland”. As has become apparent, the more specialised and localised biodiversity, hence that of greater conservation interest, is often associated with dambos and old floodplains rather than with the swamps that are normally the focus of wetland-related activities. Although these drier wetlands do not perhaps come under the present mandate of ZWCRUP, nonetheless they are important from a biodiversity conservation viewpoint.

9.6.2 **Evaluation of output**

The outputs as presented in the report generally accord well with the original Terms of Reference. More literature was found than was originally envisaged, although the gaps in knowledge were sometimes of greater magnitude than initially thought. The review of information has been comprehensive but owing to its wide-ranging nature, and the need for what transpired to be mutually-incompatible focal points (biological groups, geographic areas and ecological processes), it is lacking in clarity at times. The electronic database has worked very well.

The database on expertise is by no means complete or balanced, and should only be regarded as preliminary.

Owing to the unavailability of satellite imagery during the period the study was underway, the expected outputs on determination of land use change and ecological stratification could not be carried out. In addition, it has been determined that historical satellite imagery is not a useful tool to detect change, particularly at the smaller sites.

Surprisingly, the identification of sites of conservation interest using regional specialists proved difficult. This may be a result of the nature of many wetlands in that they fluctuate in extent and composition and are similar across large areas. More success was obtained in the identification of species of interest, particularly for well known groups such as birds. Insufficient knowledge on the distribution and abundance of many organisms means that much more survey work is required for these groups in order to determine status.

Only an overview has been presented on historical changes in the four sub-project sites. Detailed work within each area, much of it in the archives, is required to obtain a full picture of how such changes have affected biodiversity.

An overall assessment of the importance of wetland biodiversity for conservation was produced, but owing to the fragmented knowledge base it has not been as prescriptive as was hoped. A similar overview on the effects of human activities on biodiversity was presented, but a more focussed evaluation is needed in the future to give clearer guidelines to management.

The detailed proposal for Phase 2 addresses many of the specific recommendations in Section 9.7, and activities carried out under it should yield much clearer answers to questions on the conservation importance of wetland biodiversity. Given that ZWCRUP is attempting to implement conservation in four wetland sites, it is important to be able to provide biological focal points for those activities to the maximum benefit of both biodiversity and the people who live there.

9.7 RECOMMENDATIONS

General – Basin wide

1. A landscape or catchment perspective to wetlands of the basin should be adopted so that individual areas are seen in context.

2. Compile a common vegetation legend for all wetland areas. This will enable a clearer comparison of habitat type and extent across the Zambezi Basin.

3. More attention should be paid to old floodplains and dambos within the basin, particularly in the Upper Zambezi, as these have been comparatively under-recorded yet contain important biodiversity.

4. Prepare detailed reviews of various groups of wetland organisms with common objectives in order to bring together presently disparate information and to obtain a basin-wide perspective.

5. Carry out surveys of wetland areas to identify particular sites of conservation interest or concern. Although carried out at a district (or equivalent) level, this exercise should retain a regional perspective.

6. Identify those species, in various taxonomic groups, which are possibly in need of active conservation measures owing to rarity, susceptibility to disturbance or habitat loss, or to pollution.

7. Carry out regular censuses of major wetland species (antelope, cranes, etc.) in specified areas (e.g. Kafue, Zambezi Delta) in order to monitor aspects of wetland productivity and function.

8. Set up a series of monitoring sites in wetlands across the Zambezi Basin in order to obtain baseline information on biodiversity and ecological function against which changes due to human activity or natural phenomena can be compared.

9. Carry out basic training in field taxonomy and biological collecting for the various groups in basin states.

10. Rewrite and package information coming out of reviews to make it more readily available to a broader group of people including, in particular, those who influence policy and planning.

General – Research

11. Investigate further the mechanisms and extent of natural "background" change to hydrology and wetland biodiversity in swamp areas. Good sites for this would be the Chobe/Linyanti or Okavango areas.

12. Investigate what the minimum biodiversity requirements are for the sustainable functioning of a wetland as an independent ecosystem. A good site for this would be the wetlands of the Lower Shire.

13. Investigate what the effects of upstream impoundment and flood regulation have been on the wetlands of the Zambezi Delta, and how any deleterious effects could be ameliorated.

14. Investigate further the potential for use of aquatic organisms (fish and invertebrates) as surrogates in determining changes in wetland habitat and function.

15. Investigate further the belief that hippo maintain open channels in swamps, and thus facilitate water flow.

Specific

16. Revise and update the annotated bibliography, and produce a more concise review of available Zambezi Basin wetland literature suitable for wider dissemination.

17. Carry out biodiversity inventory of selected better-known groups (e.g. flowering plants, birds, herps, fish, dragonflies) at the four sub-project wetland sites in order to compile wetland-specific checklists, also incorporating existing information. This would enable a comparison of biodiversity between the four wetlands, and also go some way towards obtaining a clearer basin-wide perspective on diversity and importance. Individual activities are listed below under sites.

18. Produce vegetation maps with a common legend of the four sub-project sites based on satellite imagery and/or air photos. Existing maps can be used as a basis for Barotseland and the Chobe/Caprivi, but extensive fieldwork will be required for the Lower Shire and Zambezi Delta. Individual activities are listed below under sites.

19. Use satellite imagery and/or air photos, and regional or local specialists, to identify potential sites of conservation interest within all four sub-project areas. This should be followed up by fieldwork and the chosen sites briefly described.

20. Carry out an assessment of land use change over the last 20 years, using satellite imagery and/or air photos, for the Barotse floodplains, the Lower Shire and the Zambezi Delta. This would help in determining possible causation of recorded change in biodiversity.

Site–specific

21. Barotse floodplains:
    - Compile a checklist of birds based on fieldwork and existing records
    - Compile a checklist of reptiles and amphibians based primarily on fieldwork.
    - Compile a checklist of small mammals based on fieldwork and existing records.
    - Compile a checklist of dragonflies and butterflies based on fieldwork and existing records.
    - Compile a checklist of wetland plants with particular emphasis on the floodplains based on fieldwork and existing records.
    - Compile a vegetation map using a common legend from the existing rangeland map.

22. Chobe/Caprivi
    - Compile a checklist of small mammals based on fieldwork and existing records.
    - Compile a checklist of wetland plants with particular emphasis on the swamps based on fieldwork and existing records.
    - Compile a vegetation map using a common legend from the existing vegetation map.

23. Lower Shire
    - Compile a checklist of birds based solely on existing records.
    - Compile a checklist of freshwater molluscs based on fieldwork and existing records.
    - Compile a checklist of wetland plants from existing records
    - Produce a vegetation map of wetland areas, including adjacent parts of Mozambique, based on fieldwork.

24. Zambezi Delta
    - Compile a checklist of birds based on fieldwork and existing records
    - Compile a checklist of small mammals based on fieldwork.
    - Compile a checklist of freshwater fish based on fieldwork.
    - Compile a checklist of reptiles and amphibians based on fieldwork and existing records.
    - Compile a checklist of dragonflies and butterflies based on fieldwork and existing records.
    - Compile a checklist of wetland plants based on fieldwork and existing collections.
    - Carry out a reconnaissance survey on distribution of aquatic weeds.
    - Produce a vegetation map of the delta area based on fieldwork.
    - Carry out an aerial census of large waterbirds, with particular reference to the Wattled Crane. [This activity is being undertaken by the Maputo Natural History Museum through the International Crane Foundation].
    - Carry out an analysis of land cover change based on air photos to detect changes due to flood control. [This activity is being carried out by the International Crane Foundation, but there is scope for cooperation under Phase 2.]

- Identify potential sites for long-term monitoring of environmental change, and establishing an appropriate methodology.

10. PROPOSAL FOR PHASE 2 123

10.1 INTRODUCTION

The rationale for the biodiversity evaluation being implemented by The Zambezi Society (ZamSoc) and the Biodiversity Foundation for Africa (BFA) was stated in the original proposal for Phase 1, as follows:

Wetlands contain important biodiversity both 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 improve water quality through their filtration and biological processing capacities;
- They provide biological goods and services of great importance to the local economy.
- Although 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.

Biodiversity considerations at a landscape or regional scale have 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 IUCN wetland sub-project sites (Barotse floodplains, Chobe/Caprivi swamps, Lower Shire marshes and the Zambezi Delta) are only loosely defined.

IUCN requires an assessment of the biodiversity importance of these four wetlands within the context of the Zambezi Basin as a whole; it also wishes to determine the major biological features of these wetlands, and to determine whether biodiversity will be detrimentally affected or modified by land use changes.

Activities will continue to be undertaken in recognition of, and in co-operation with, other elements of the Zambezi Basin Wetlands Conservation and Resource Utilisation Project (ZBWCRUP) work plans, in particular the Economic Valuation of Wetlands Goods and Services component.

10.2 PHASE 1

The activities required for the biodiversity evaluation were divided into two phases. Phase 1 gathered and evaluated existing information, made preliminary assessments of importance and threats, and generally set the scene for detailed fieldwork and analysis in Phase 2. It has also produced documentation and conclusions which can be used directly and immediately by the IUCN project, and others in the region, for planning and as a basis for future studies.

10.3 PHASE 2

10.3.1 **Observations and scope**

The original proposal to ZBWCRUP suggested that the major thrust of the second and larger phase of the biodiversity evaluation was likely to be detailed fieldwork within the four sub-project sites to accomplish a range of objectives. These included field checking of ecological and land use maps; biodiversity inventories of selected groups; the establishment of at least one comparative plot for studying the impact of land use changes; and detailed evaluations of the socio-economic and biodiversity importance of

Zambezi basin wetlands. The overall thrust ! that of intensive field work ! is still valid in the view of ZamSoc/BFA. However, experience gained during Phase I has led to some restructuring of the proposed Phase 2 activities.

The information acquired during Phase 1 indicates that Zambezi basin wetlands may not be as important to biodiversity conservation as had been thought. Information acquired during this phase also indicates that as much as 80% of the wetland biodiversity may be encompassed by the Upper Barotseland floodplains and the Zambezi Delta areas. The loss of the Lower Shire and Chobe/Caprivi wetlands would appear, *prima facie*, to be of comparatively lesser consequence to biodiversity conservation. The greatest single human influence on biodiversity identified during Phase 1 is the modification of ecosystems caused by the impoundment of water in large dams.

There is considerably increased funding available for Phase 2. Equally, however, it is apparent that a full evaluation of biodiversity within the sub-project areas is an open-ended task, depending on the degree of refinement considered appropriate. The philosophy underlying the selection of activities for Phase 2 is that it is better to meet the objectives of ZBWCRUP through a limited range of activities that can be well done within the available funding, than to spread funds thinly over a wider range of tasks. It is therefore recommended that activities be weighted, to an acceptable extent, towards the two major areas – the Barotse floodplains and the Zambezi Delta – that are still relatively intact and can be treated at landscape scale.

The information acquired during Phase I shows that a range of biological groups are fairly well covered but often with significant gaps. There is, however, little or no information existing at present for certain other groups and taxa, and the cost and time involved in the acquisition of useful information for these groups is far beyond the capacity of the present project. It is therefore proposed, as core activities, to focus on filling gaps in knowledge for better-known groups and taxa, and undertaking inventories and full reviews of these groups, to enable comparisons to be drawn between sites and across the Basin from a biogeographical and conservation perspective. Specific wetlands and taxa can then be prioritised and targeted for conservation action.

In view of ZamSoc/BFA's relative inexperience in socio-economic issues, and the currently-running Economic Valuation of Wetland Goods and Services component being executed by the Directorate of Environmental Affairs of the Government of Namibia, as well as the need to devote funding to intensive technical biodiversity work, socio-economic aspects have been omitted from the ZamSoc/BFA Phase 2 proposal.

10.3.2 **Objectives**

The objectives for both project phases were stated in the original overall project proposal (see Appendix I). These have been slightly amended in the light of experience. In particular, the evaluation of economic and social importance has been deleted. Proposed Phase 2 objectives are now as follows:

(a) To collect, assess and make available information on the ecology and biodiversity of the Zambezi Basin wetlands, with particular reference to the four IUCN sub-project wetland sites;

(b) To carry out ecological surveys and inventories of selected biological groups within the four sub-project sites;

(c) To identify and describe the major biodiversity features of the selected wetlands, and identify and prioritise biological communities and species of concern;

(d) To determine the regional importance of Zambezi Basin wetlands, particularly the four sub-project sites, for the conservation of biodiversity;

(e) To assess the threats to biodiversity arising from human activity, changes in land use or development projects.

10.4 PROPOSED PHASE 2 ACTIVITIES

10.4.1 **Core activities**

Activities 1 to 6 represent core activities designed to complete, as comprehensively as possible, the evaluation of the importance of Zambezi Basin wetlands to biodiversity on the basis of desk and field research, and to provide a sound technical basis for wetland conservation and prioritisation on biodiversity criteria.

Activity 1: Carry out biodiversity inventory of selected groups at the four sub-project wetland sites, incorporating use of local expertise.

Justification: Some biological groups have been comparatively well collected within the project areas, and for others the taxonomy is relatively good. However, there are large geographical gaps in knowledge which, if filled, would allow comparisons of species composition and diversity between the four project sites and across the Zambezi Basin. The major groups concerned are: wetland plants, birds, reptiles, fish, freshwater molluscs (mainly mussels), Odonata (dragonflies) and Lepidoptera (principally butterflies).

Museum and herbarium technicians and local expertise will be used where appropriate and available, but design, collation, identification and reporting would be done by recognised specialists.

Activity 2: Compile checklists of better-known groups for the four sub-project wetland sites.

Justification: The inventory required under Activity 1 will contribute towards the compilation of checklists for these better-collected biological groups for each project site and for the Zambezi Basin as a whole. The inventories will be 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.

Activity 3: Produce detailed reviews of knowledge on selected wetland biological groups from a basinwide perspective, incorporating checklists of available data. Groups and species proposed are: wetland plants, Reduncine antelopes, wetland birds, reptiles, fish, freshwater molluscs, Odonata,

Lepidoptera and aquatic invertebrates. Reviews will incorporate assessments of biodiversity importance, conservation trends and threats, and identification of species of particular concern.

Justification: A more detailed assessment of the distribution, biogeography, ecology, importance, conservation interest and status of selected groups is possible given existing information and expertise. This was not possible during Phase I owing to budgetary constraints. Detailed reviews of groups of ecological importance will include detailed comparative checklists (see Activity 2), details of localities thus enabling GIS distribution mapping to be carried out, and an assessment of the ecological and conservation importance of each group thus enabling conservation efforts to be more focussed. A biogeographical analysis of differences in composition across the Basin will also be carried out.

Activity 4: Obtain a clearer indication of sites and species of particular interest or concern.

Justification: Phase 1 identified a number of species of conservation concern. This preliminary identification will be developed further in Phase 2, with more detailed documentation and justification. Information for this activity will mostly come out of Activity 3, and will provide a better focus for future conservation actions.

Activity 5: Undertake further evaluation of human impacts on the biodiversity of Zambezi Basin wetlands, with particular emphasis on the four sub-project sites.

Justification: This component builds on work already undertaken during Phase 1, and is intended to provide a clearer picture of existing and likely human impacts on biodiversity resulting from a range of activities, both in the sub-project sites and throughout the Zambezi Basin.

10.4.2 **Vegetation & land use mapping**

A preliminary ecological stratification forms part of Phase 1, although this has not been completed at the time of writing due to delays in obtaining appropriate satellite imagery. It is assumed that imagery will become available in the first half of 1998 and an ecological stratification will be carried out as part of Phase 2. The other activities described in this section are designed to build on this stratification and to reinforce the evaluation of human impact.

Activity 6: Produce ecological maps of the four sub-project sites based on remote sensing and the development of a common legend.

Justification: Wetlands are not uniform and any survey work, evaluation of threat or land use change, or assessment of socio-economic importance, requires some form of ecological stratification to place the findings in context. Fairly detailed fieldwork is required for a proper ecological map but this is not envisaged here, except for the Lower Shire and Zambezi Delta (Activity 7). Recent satellite imagery, in the process of being acquired, will be used for stratification using visual interpretation techniques. Relatively homogeneous units will be delineated from an landscape ecological perspective. A strong effort will be made to develop a unified legend that covers all Zambezi wetland areas, yet is compatible with previously-published descriptions.

Activity 7: Produce vegetation maps based on remote sensing of the broad Lower Shire and Zambezi Delta areas.

Justification: Good vegetation maps exist for Barotseland and Caprivi, although both need slight modification to be inter-compatible. Such maps do not, however, exist for the Lower Shire and Zambezi Delta. The Lower Shire map will be based on airphotos with fieldwork, and will include the Mozambican section of Ndinde Marsh. The Zambezi Delta map will be less detailed and based on satellite imagery and, of necessity, more generalised fieldwork. All maps will use a similar legend and allow comparisons to be drawn between wetlands.

Activity 8: Compile semi-detailed land use change maps of the Barotse floodplains, Lower Shire 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.

Justification: Changes in land use (specifically, land cover) in recent years are thought to be responsible for changes in biodiversity, but little quantitative data is available to support this conclusion. Changes in land use patterns have been compiled for the Caprivi, but are lacking for the other three project sites. Description and quantification of changes in extent of land cover will be done for these sites using historical satellite imagery (Landsat MSS), but using airphotos (if available) for the Lower Shire. An assessment of these changes from the viewpoint of biodiversity conservation will be made.

10.4.3 **Synthesis and evaluation**

The findings of desk and fieldwork noted above will be synthesised in order to meet the overall project objectives. However, a further activity, which has always been envisaged as forming part of Phase 2, is included:

Activity 9: Publication of an annotated bibliography and review, based on a substantial revision of the Phase 1 report with additional data.

Justification: The draft annotated bibliography produced in Phase 1 is of general interest and needs to be published and made more widely available. However, it should first be revised to overcome some of its present shortcomings (keywords, detail in annotation, and the inclusion of further references). The review from Phase 1 will be greatly improved by the incorporation of information and checklists resulting from Phase 2 activities. It is suggested that these are compiled and put in a publishable form, perhaps by mid-1999.

10.4.4 **Information activities**

The ZamSoc/BFA have proposed that a modest information budget be incorporated into Phase 2. Activities under this budget would focus primarily on disseminating important biodiversity findings from both Phase 1 and Phase 2 via a range of media within the appropriate Zambezi Basin states. The use of printed and electronic media has been selected as the most cost-effective initial means of generating a favourable climate of opinion among a wide target audience. It is intended to precede and supplement any information activities that IUCN may propose to target at specific governmental or local target audiences.

The proposed *modus operandi* for this project component is to utilise Zambezi Society expertise in the selection, interpretation and treatment of content, but to facilitate its dissemination through field project officers and IUCN country offices as appropriate.

Activity 10: Generate a minimum of 100 good quality colour transparencies of areas, sites and species of high interest and/or concern from within the four wetland sub-project sites.

Justification: IUCN has expressed a perceived requirement for illustrative material of particular interest for publication in a variety of media, including reports and brochures. This is required in the form of 35mm colour slides. The photographs will be obtained during fieldwork within the four sub-project sites. Such photography will, in addition, strongly reinforce media and other information activities proposed by The Zambezi Society.

Activity 11: Compile, centralise and catalogue printed and electronic media lists for sub-project countries.

Justification: Information on appropriate media is an essential infrastructural component for any proposed media activity.

Activity 12: Prepare an initial interpretive media briefing document on the objectives, activities and findings to date of the biodiversity evaluation project component. Also to produce and distribute guidelines for media briefing for field project officers.

Justification: There is a need to interpret the overall biodiversity evaluation, its context within ZBWCRUP, and the findings to date, to a broad audience within project area countries. The briefing document will provide baseline information to relevant media, upon which further information releases can build.

Activity 13: Produce six quarterly updates on the biodiversity evaluation for field project officers; produce six parallel media updates, and consign to project field officers for local distribution.

Justification: The biodiversity evaluation will produce a steady flow of information, of interest to field project officers, that can also be modified for media distribution. This will maintain the profile of the evaluation, within the context of ZBWCRUP, with media and their audiences.

Activity 14: Produce a final summary of overall biodiversity findings suitable for media use, and distribute through field project officers.

Justification: The final report phase of the biodiversity evaluation is likely to produce information and recommendation of wide interest. These findings should be summarised and distributed to media and lay audiences.

10.5 FURTHER POTENTIAL ACTIVITIES

Though the funding for Phase 2 is considerably greater than for the preliminary phase, it is almost certainly insufficient to cover the entire range of activities that have suggested themselves as appropriate during the implementation of Phase 1. In the view of ZamSoc/BFA, it is much more useful to focus available funds

on meeting overall ZBWCRUP objectives through activities that can be fully and effectively undertaken. Nevertheless, the following two activities are suggested as desirable.

Activity 15: Set up a series of biodiversity monitoring sites in the Zambezi Delta, to assess change resulting from changes in land use upstream.

Justification: Many studies have considered changes in biodiversity following major environmental change (impoundment, droughts, etc), but there has rarely been good baseline data with which to make useful comparisons. The wetland perhaps most affected by dam construction, and with possible future dams to be built, is the Zambezi Delta. Concerns on unacceptable changes to its ecology have been expressed for over 20 years. It is proposed to put in a series of permanent biodiversity monitoring plots for selected groups in the Marromeu area and an accessible coastal area. The output will be detailed baseline data for the Zambezi Delta, so far not available, against which to measure future changes in biodiversity attributable to changes in flow regime, pollution, and other impacts can be measured. This will have broad applications when potential dam sites are under consideration within the Zambezi Basin. However, this component will involve much effort – technical as well as logistical – and will be expensive.

Activity 16: Initiate a biodiversity survey of freshwater invertebrates with the objective of using them as biological indicators of water quality.

Justification: Freshwater invertebrates have great potential as indicators of water quality, an important consideration in the face of rapidly-expanding industrial and agricultural development and pollution. However, the taxonomy and ecology of this group is very poorly known. A study will be initiated in an agreed area (ideally the Okavango/Caprivi region) to initiate inventory work on this group. An initial identification manual will be developed, along with an indication of the appropriateness of this form of monitoring under present conditions.

10.6 OUTPUTS

The provisional outputs from Phase 2 are as follows:

(a) Annotated bibliography and review, based on a substantial revision of the Phase 1 report with additional data.

(b) Biodiversity inventories and checklists for the wetland sub-project sites.

(c) Bibliographic database incorporating additions and modifications.

(d) Vegetation maps for the Barotseland and Delta project sites.

(e) Assessment and mapping of recent land use change in the Barotseland, Lower Shire and Zambezi Delta project sites.

(f) Detailed reviews of knowledge on selected wetland biological groups, focussing on the four sub-project sites but with a basin-wide perspective, incorporating checklists of available data. Reviews

will incorporate assessments of biodiversity importance, conservation trends and threats, and identification of species of particular concern.

(g) An attempt to identify indicator taxa.

(h) Identification of sites and species of concern.

(i) Evaluation of the impacts of human activity on wetland biodiversity.

(j) 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.

(k) Training for local scientists and museum/herbarium technicians.

(l) Collections of well-labelled herbarium and museum specimens with locality data.

(m) 100 35mm colour slides of important species and sites.

(n) Catalogued media lists for each sub-project site.

(o) A media briefing document on aspects of the IUCN wetlands project biodiversity component, and guidelines for project staff on media briefing.

(p) Six updates on wetland biodiversity evaluation for the media and field project officers.

(q) A final summary of the findings of the wetlands biodiversity project component suitable for media release.

10.7 GIS COMPONENT.

This is a separate project component, suggested for implementation by a Canadian group directly under contract to ZBWCRUP, and with separate funding arrangements. Below is a list of proposed activities that we consider necessary for, and complementary to, our proposal and activities.

- Digitise (or compile) maps of (a) the Zambezi Basin, (b) White's vegetation map, (c) physical features and drainage. Wetland areas should be clearly brought out for the whole basin.
- Digitise (or compile) detailed maps of the four project sites.
- Digitise project maps, produced during Phase 2, of vegetation and of land use change.
- Put biological records of distribution of selected groups onto GIS using information derived from Phase 2.
- Compile species and/or taxonomic group distribution maps on request.
- Provide readily-usable electronic data on the above with a manual on use, such that PC-based systems can add to or print out maps.

APPENDIX I. TERMS OF REFERENCE

Below is an abbreviated version (paragraphs 1 and 3 only) of the activities to be carried out, as specified in the project document of 16 December 1996 signed by IUCN-ROSA and the Zambezi Society.

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, as an initial step, project work plans call for an assessment of the role of Zambezi Basin wetlands in overall biodiversity preservation. Particular reference will be made to the 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

Although these 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.

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 require an assessment of the importance of 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 those wetlands to local populations. 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 is envisioned that a two-phase study is needed to satisfy these requirements. The first phase is the subject of this contract. The Zambezi Society, hereafter referred to as the Contractor, in collaboration with the Biodiversity Foundation for Africa, is in a position to perform the required assessment.

3. TASKS TO BE PERFORMED

3.1 *Activities*

The contractor will carry out the following activities:

3.1.1 Identification and contacting of regional experts in various aspects of wetland biodiversity,

3.1.2 Acquisition and compilation of existing ecological and biodiversity information, including maps,

3.1.3 Critical assessment of available information, identification of gaps and preparation of an annotated bibliography and review,

3.1.4 Establishment of a user-friendly electronic database listing these sources of information,

3.1.5 Analysis of selected historical satellite imagery to determine the type and extent of gross changes in land cover in the wetlands and adjacent watersheds,

3.1.6 Preliminary ecological stratification of the wetland areas using recent satellite imagery,

3.1.7 Preliminary identification of sites and species of regional interest or concern, based on existing knowledge and expertise,

3.1.8 Reconnaissance field visits to each wetland and a preliminary ecological assessment of major features, concerns, threats and trends,

3.1.9 Assessment of the actual impacts of human activities on Zambezi Basin wetland biodiversity and a synopsis of literature on the subject,

3.1.10 Overall assessment of the role and importance of the Zambezi Basin wetlands in biodiversity conservation,

3.1.11 Preparation of a detailed report covering activities and assessments, including conclusions and recommendations,

3.1.12 Development of a detailed proposal for Phase 2.

These activities are more particularly described in Chapter 2.1 of the Zambezi Society's Proposal for Biodiversity Assessment of Zambezi Basin Wetlands: Third Draft.

3.2 *Outputs*
The contractor will deliver the following outputs:

3.2.1 An annotated list of key people and institutions with scientific knowledge of wetlands biodiversity,

3.2.2 An annotated bibliography and review of existing information on the ecology and biodiversity of the selected wetlands,

3.2.3 An electronic database, for regional use, containing the information described in 3.2.1 and 3.2.2 above,

3.2.4 A preliminary ecological stratification of the four wetland areas,

3.2.5 A preliminary identification of sites and species of concern,

3.2.6 A description of historical changes in land use in each wetland area,

3.2.7 A provisional report on the importance of wetland biodiversity and possible threats resulting from human activities,

3.2.8 A detailed proposal for Phase 2 of the wetlands biodiversity study based on, but not necessarily limited to, the description of the second phase contained in the Zambezi Society's Proposal for Biodiversity Assessment of Zambezi Basin Wetlands: Third Draft.

APPENDIX II. PARTICIPANTS IN STUDY

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We also gratefully acknowledge the support and assistance of the following:

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APPENDIX III. LIST OF EXPERTISE ON WETLANDS BIODIVERSITY

Keywords for expertise database:
Keywords are used alone or with a qualifier (in round brackets)

Conservation
Ecology
Wet-ecol [wetland ecology]
Wildlife
Mammals (large)
(small)
Birds
Herps
Fish
Inverts (insects)
(lepidoptera)
(aquatic)
(marine)
(arachnids)
(molluscs)
Plants (aquatic)
(marine)
(mangroves)
Aquaticweed [aquatic weeds]

Angola
Botswana
Malawi
Mozambique
Zambia
Zimbabwe
SAfrica [southern Africa]

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APPENDIX IV. SEARCHING BIODIVERSITY DATABASES IN IDEALIST: AN INTRODUCTORY MANUAL

INTRODUCTION AND GENERAL COMMENTS

These biodiversity data were originally managed with ProCite and later in Idealist for Windows. The original bibliographic data are available as Windows text files (comma-delimited) and ProCite 2.2 for DOS and ProCite 3.0 for Windows files, in addition to the Idealist databases. These can be made available to interested individuals for importation into a database of their choice.

Due to conditions pertaining to the distribution of software, the working copy of the database has been distributed on a read-only version of Idealist for Windows. The following notes have been compiled to help you access the database, search it, print individual records and export hitlists resulting from searches.

Remember: In times of stress, when all available evidence suggests that the data are stubbornly inaccessible or Idealist refuses to do what you wish, consult the extensive on-line help facility in Idealist for Windows. Sections of help can be printed or copied and pasted into your word processor for further customization and printing.

Contacting the Software Vendor.....

Idealist for Windows was developed by Blackwell Scientific, Oxford, UK. Only Windows versions (16 bit and 32 bit) are available.

The software is supported and distributed by:

Bekon Software
2 North Place
Stockport
Cheshire SK1 1HH
UK

Phone: +44-161-4761300
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HARDWARE AND INSTALLATION

Idealist for Windows requires the minimum hardware configuration running Windows 3.1 or above. **It cannot be used under DOS**. An IBM compatible personal computer with at least a 286 processor with 1 Megabyte of RAM (system memory) is the extreme lower limit. An 386 or 486 with 4 Megabytes (MBytes) of RAM is preferable. A mouse (pointing device) is highly recommended to operate both Windows and Idealist.

It is assumed that you have a working knowledge of the Windows 3.1 or Windows ‹95 interface and are familiar with creating and switching between Folders (directories), creating and executing Windows program short cuts (represented by icons), using the Windows clipboard (copying and pasting between applications), and managing files.

If not already done, create a directory called "Idealist" on the C: partition of your hard drive. Then copy all files on the 1.4Mb disk to this directory "C:\Idealist". **You must operate this version from a directory called Idealist on the C drive**. Unzip the files in this directory, as follows:

move to the Idealist directory, and type:

pkunzip wetland

This will install all the database files, configuration files and all files needed to run Idealist for Windows. Only the 16 bit executable file (Iread16.exe) is present.

Create a Windows shortcut to this executable file Iread16.exe (see the Windows manual or your Windows on-line help).

RUNNING IDEALIST

Your can now launch Idealist by clicking on the file Iread16.exe directly or (preferably) double-clicking on the Idealist icon.

OPENING DATABASES

1. Click on "File" and select "Open" at the bottom of the pull-down menu

2. Click on database you want to use, either BIBLIO.TEX or EXPERTIS.TEX

3. Click on the "OK" button

4. Click on the maximise window icon (in the top right hand corner of the window) to force the database window to occupy all available screen space.

You can open both databases at once, and switch between them using the Windows pull down menu in Idealist.

It is often useful to structure, or order, the database according to an alphabetic format, usually using the field, "Authors" or "Name". To do so:

1. Click on "View" and select "Select" near the middle of the pull-down menu

2. Click on the field (either "Authors" or "Name", or alternatively click in this field of the current record before executing Step 1)

3. Tag the "Ascending" option on the Sort menu, but leave other options clear
4. Click on the "OK" button

To scroll between records, either click on the left two arrow buttons on the toolbar with your mouse or use the "-" and "+" keys on the numeric keypad.

You can also view the complete list of records in the currently selected database by clicking on the Overview button (next to the Save button, which is disabled in this read-only version):

1. Select a field (usually "authors" or "name") to view in the right-hand window of the overview menu

2. Use the scroll bars to scroll through the list of records in the left window. Single records can selected, and then

3. Click on "OK" to return to the record view, or "Print" to print the selected record

CONFIGURING THE IDEALIST INTERFACE

Four layouts for configuring Idealist are available for viewing and searching data. Different layouts have been created to allow you to more easily export information from the different databases:

"sample.lay" is the standard interface for viewing records and searching databases. This is the default layout (part of Idealist) and will be opened when you first launch Idealist and open either (or both) of the two databases.

When running Idealist with this layout, to aid scrolling between records, configure the record view as follows:

1. Click on "View" and select "Options" at the bottom of the pull-down menu

2. Click on "Hide Empty Fields"

3. Click on the "OK" button to return to the database

Either of the other two layouts "Abstract" and "Authors" can be opened as follows:

1. Click on "View" and select "Layout....Open" near the top of the pull-down menu

2. Click on either "Abstract.lay" or "Authors.lay" with the mouse to select the layout definition file

3. Click on the “OK” button to return to the database

4. If the window is not maximized, then do so by clicking on the Maximize Windows icon in the right hand corner of the database window

These two layouts allow you to scroll between bibliographic records with single mouse clicks on the buttons. Full search capabilities (see below) are available when viewing the database in either “Abstract” and “Authors” layouts.

NB. The above two layouts are only suitable for viewing and searching the bibliographic database “BIBLIO.TEX”.

The layout “expertis.lay” has been created to view and search the expertise database, and export selected records to a wordprocessing program (see below for details for exporting Expertise records).

Single records can be printed directly from Idealist by clicking on the “Print this Record” button

In the bibliographic database “BIBLIO.TEX” clicking the button “Export Hitlist to Clipboard” will automatically save the current hitlist (see following section “Searching Databases” and the on-line help for more information on hitlists) to the Windows clipboard (volatile memory) and thus effectively exported out of Idealist. The saved data are automatically formatted into separate paragraphs and can be pasted into your Windows wordprocessor.

NB. You further configure the Idealist for Windows environment by selecting View| Modify and then clicking on the Toolbar. The menu allows you to create buttons with embedded commands. See on-line help for further details.

SEARCHING DATABASES

Idealist allows you to search the currently open database.

Either press “F5" on the keyboard, or click “Search” and select “Find...”. Then choose your search criteria, and type in keywords to search the database. A search will collate a series of records in a subset called the “hitlist”. Further searching of a hitlist is possible, and it can be exported to the Windows clipboard for printing.

To return to the entire database, either press “Shift F5" on the keyboard, or click “Search” and select “Find All Records”. Alternatively, click on “Search” and then select “Widen...” and select the “Find All Records” option.

Many search operators are available in the search menu to refine your searches of a database.

In all cases, the Export menu provides different options of exporting different sets of records (All records, Hitlist, Current Record or Hitlist Range). These options are available when working on any Idealist database.

To export Expertise records, select the export format file "expertis.exp" and click on "Copy Hitlist to Clipboard" while viewing an Expertise record.

Remember: After the sorting described above.... If you want to view the entire dataset, press Shift F5 (Find All Records) after sifting records as described above.

Furthermore, things that may look wrong but aren't.....

The following is a list of comments and explanations on various aspects of the software, intended for the more seasoned user.

The records in the database appear out of order. Idealist is designed to relieve you of worrying about where a record is in a database or what its number might be; it is very seldom necessary for an Idealist database to be sorted into any particular order. The usual method of working is to create a hit list and then sort it into whatever order is required, prior to exporting or printing it.

Tip: If the records in your database are in a particular order, for example if you had imported a book into Idealist, then you might sometimes want to look at the next physical record from the one you are currently looking at. You can do this by widening the hit list to include all the records in the database (Search, Widen, All) and then looking at the next record (View, Next).

The list box in the index browser does not work properly. When browsing the index, remember that the controls that appear are not list boxes. Instead, they are specially designed so that the selected item stays in the centre of the control. Also, note that the thumb in the scroll bar of the index browser cannot always be positioned accurately. This is a harmless side-effect of the way the Idealist index works.

Some words I didn't search for are highlighted. The hit word highlighter is very 'liberal'; it will highlight any hit word involved in a search wherever it occurs. It could be that the highlighted words are defined as synonyms.

A record won't print on an area greater than the size of the paper of the current printer. The printing features of Idealist are designed for printing small reports and labels. If your record won't fit on the paper, you have to export it to a file, suck it into a word processor/DTP package and print it from there.

I can't find a number in a number field. Make the number look more like a number when you type it into the search dialogue. For example, Idealist thinks that 2143 is a piece of text, but has no doubt that 2143. or 2143.0 are numbers. Alternatively, you can use an index cast, for example (number)=2143. See the section on search command syntax for more details.

The record won't scroll horizontally and/or vertically. If you want the record to scroll vertically and/or horizontally, turn on the horizontal and/or vertical scroll bar in View, Options.

Records that haven't been deleted appear in the Record, Undelete dialog. If a record in the middle of the database grows in size as a result of you editing it, then Idealist copies the new version of the record to the end of the database and 'deletes' the older, smaller version of the record. This process creates phantom deleted records that appear in the Record, Undelete dialog.

A field containing embedded buttons can't be edited or deleted. Buttons can be embedded into a field and the commands ‹in' them edited only in Source mode. In Result mode, the field becomes read-only.

When pasting text from Microsoft Word for Windows, unexpected line breaks are inserted. The line breaks are inserted by Word for Windows, and not by Idealist. Looking at the text using the clipboard viewer and selecting View, Text should make this clear.

APPENDIX V. KEYWORDS FOR BIBLIOGRAPHIC DATABASE

Type of work
Bibliography
Survey [incorporating new data]
Checklist [incl. partial species lists]

Geographical scope
SAfrica [Southern Africa]
Zbasin [Zambezi Basin]
UZam [Upper Zambezi]
MZam [Middle Zambezi]
LZam [Lower Zambezi]
Angola
Zambia
Namibia
Botswana
Zimbabwe
Malawi
Mozambique
Headwater [i.e Mwinilunga]
Bangweulu
Barotse [Barotse floodplains]
Chobe [Chobe/Linyanti/E.Caprivi]
Okavango
Kafue [Kafue river & floodplains]
Kariba
Chivero [Lake Chivero]
Mana [Mana floodplain]
Luangwa [Luangwa valley]
Cabora
LMalawi [Lake Malawi]
LChilwa [Lake Chilwa]
MShire [Middle Shire]
LShire [Lower Shire]
Delta [Zambezi delta]

Subject
Palaeogeography
History [last 150 years]
Environmental assessment [incl. EIA]
Pollution [including toxicity]
Water quality
Hydrology
Human use/impact
Agriculture [including soils]
Range/livestock
Probspp [problem species]
Fisheries

Vegetation
Conservation
Biogeography
Ecology

Biological group
Lmammals [large mammals]
Smammals [small mammals]
Birds
Reptiles
Amphibians
Fish
Insects
Molluscs
Crustacea
Oinverts [other invertebrates]
Plants [flowering plants]
Phytoplankton [including algae]
Zooplankton

APPENDIX VI. ZAMBEZI BASIN WETLANDS BIBLIOGRAPHY

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Not seen.
UZam, survey, Botswana, Chobe, vegetation, environmental assessment, ecology, Lmammals, plants

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Not seen.
UZam, Zbasin, environmental assessment, hydrology, ecology

3. Allen, G.M. (1938). A checklist of African mammals. *Bulletin of Museum of Comparative Zoology, Harvard* **83**: 1-763.
First complete list of all described taxa of African mammals.
SAfrica, checklist, Lmammals, Smammals

4. Allen, L.D.C. (1963). The lechwe (*Kobus leche smithemani*) of the Bangweulu Swamps. *The Puku* **1**: 1-8.
General account of the biology and status of black lechwe. Notes that the subspecies is almost extinct from the upper Chambeshi in NE Zambia.
UZam, Zambia, Bangweulu, Lmammals

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Account of Salvinia infestation on Lake Kariba.
MZam, Zimbabwe, Kariba, probspp, plants

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Botanical study of the composition and structure of vegetation at the Sapi/Zambezi river confluence in N Zimbabwe. Five vegetation types are described, including grassland on sandbanks. Vetiveria grass is dominant, and Faidherbia albida woodland is found at a higher level, only occasionally flooded. The sequence of succession is described.
MZam, Mana, survey, Zimbabwe, vegetation, plants

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Consultants' report giving results of a survey of the Marromeu complex in September 1990 to determine numbers and distribution of the major wildlife species. There has been a drastic decline in numbers since 1978 - 91% reduction for buffalo, 90% for waterbuck and 83% for hippo; elephant numbers appear similar. Total number of buffalo counted was 3696. The conservation importance of the area is pointed out, along with the detrimental effects from reduced flooding and increased burning. Various recommendations are given, including registering the area as World Heritage and Ramsar sites.
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checklist, Zambia, UZam, Barotse, reptiles

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Descriptions in French of some reptiles and amphibians from Lealui in Zambia.
Zambia, Barotse, checklist, UZam, reptiles

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Useful general account of the fisheries and related ecology of the lower Shire, including the problems of water hyacinth and pollution.
Malawi, LShire, LZam, fisheries, probspp, ecology, water quality

11. Anon. (1975). What's happening to the Zambezi? *African Wildlife* **29**(2): 18-21.
Popular account of the environmental damage Cabora Bassa dam might do. The lack of biological knowledge of the area and of the lower Zambezi valley is emphasised.

LZam, Mozambique, Cabora, environmental assessment, ecology, conservation

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Popular article on the Zambezi Delta. 156 Wattled and 25 Crowned Cranes were seen in an aerial census in March 1995, along with pelicans, storks and Goliath Herons.
LZam, survey, Mozambique, Delta, birds

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Not seen.
UZam, Zambia, Kafue, conservation, Lmammals

14. Ansell, W.F.H. (1957a). The declining red lechwe. *Black Lechwe* **1**(2): 17-20.
Popular article on the decline of Kafue lechwe from 250,000 in 1930s to 26,000 in late 1950s.
UZam, Zambia, Kafue, conservation, Lmammals

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Additions to Lancaster's (1953) checklist of Zambian mammals. Lists 29 species, principally bats and murids.
Zbasin, checklist, Zambia, Lmammals, Smammals

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Guide to the mammals of Zambia, with keys. A few species are illustrated; notes are given on distribution, diet and breeding.
Zbasin, checklist, Zambia, Lmammals, Smammals

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Details on new specimens collected from Zambia covering 20 species.
Zbasin, Zambia, Lmammals, Smammals

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UZam, Zambia, Kafue, Lmammals

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Zbasin, Zambia, Lmammals, Smammals

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SAfrica, checklist, Lmammals, Smammals

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Detailed taxonomic account on 16 species of mammal in Malawi, including records from the lower Shire.
LZam, LShire, Malawi, Smammals

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Zbasin, checklist, Malawi, biogeography, Lmammals, Smammals

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LZam, Mozambique, Delta, agriculture, vegetation

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checklist, SAfrica, molluscs

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SAfrica, checklist, biogeography, molluscs

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Zambia, UZam, Barotse, birds

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Colour map at scale 1:215,000 of the South Luangwa, based on Astle et al. (1969). Some wetland types are shown.

MZam, Luangwa, survey, Zambia, vegetation, ecology

33. Astle, W.L., Phiri, P.S.M. and Prince, S.D. (1997). Checklist of the flowering plants and ferns of the South Luangwa National Park, Zambia. *Kirkia* **16**(2): 109-160.
Checklist of the plants of the South Luangwa National Park categorised by vegetation type, including wetland types.

MZam, Luangwa, checklist, survey, Zambia, plants

34. Astle, W.L., Webster, R. and Lawrance, C.J. (1969). Land classification for management planning in the Luangwa Valley of Zambia. *Journal of Applied Ecology* **6**: 143-169.
Account of land/vegetation classification of the S Luangwa valley, using topography, soils and vegetation. Very few wetland areas are present.
MZam, Luangwa, survey, Zambia, vegetation

35. Attwell, C.A.M. and Bhika, M. (1985). Feeding ecology of impala on Starvation Island, Lake Kariba. *South African Journal of Wildlife Research* **15**: 41-48.
Study of an isolated population of impala depending on Lake Kariba lakeshore grassland.
MZam, Zimbabwe, Kariba, ecology, Lmammals

36. Attwell, R.I.G. (1963). Surveying Luangwa hippo. *The Puku* **1**: 29-49.
Survey of Luangwa river hippo population over the 1950s. There is historical evidence that this population suffered heavy human depredations in the mid 19th century, when hippo meat was traded actively.
MZam, Luangwa, survey, Zambia, conservation, history, Lmammals

37. Attwell, R.I.G. (1970). Some effects of Lake Kariba on the ecology of a floodplain of the mid-Zambezi Valley of Rhodesia. *Biological Conservation* **2**(3): 189-196.
Account of the ecology and importance of the Mana Pools floodplains, and the effects of Kariba dam. Various large mammal species are having a major effect on the ecology of the floodplain woodlands owing to a change in the hydrological regime, and vegetation changes are occurring. The major difference is in the lack of seasonal flooding, resulting in a more homogenous regime. The lack of pre-impoundment studies is pointed out, along with the necessity for occasional releases of water to create flooding.

MZam, Mana, Zimbabwe, environmental assessment, vegetation, ecology, Lmammals

38. Auerbach, R.D. (1987). *The Amphibians and Reptiles of Botswana*. Mokwepa Consultants, Gaborone, Botswana. ISBN 99912-0-113-0. 295 pp.
Detailed accounts of all reptile and amphibian species in the country, with distribution maps.
Zbasin, checklist, Botswana, reptiles, amphibians

39. Azevedo, J.F.d., Medeiros, L.d.C.M.d., Faro, M.M.d.C., Xavier, M.d.L. and Gandara, A.F.E.M.T. (1961). Os moluscos de agua doce do ultramar Portugues, III - Moluscos de Mocambique. *Estudos, Ensaios e Documentos* **88**: 1-394.
Not seen.
LZam, Mozambique, molluscs

40. Baars, R.M.T. (1996). *Condition and management of the rangelands in the Western Province of Zambia*. PhD thesis, Wageningen Agricultural University. Wageningen, Netherlands. 152 pp. ISBN 90-5485-548-7.
Mainly covers land evaluation for extensive grazing and the determination of livestock potential carrying capacity for Western Province. Descriptions are given of 9 Land Regions, subdivided into 32 Land Systems, 124 Land Units and 415 Land Facets. A vegetation map is given (original at scale 1:500,000). There are said to be no signs of overgrazing.
survey, Zambia, UZam, Barotse, range/livestock, vegetation, plants

41. Balinsky, B.I. (1967). On some intrinsic and environmental factors controlling the distribution of dragonflies (Odonata), with redescription and a new name for a little known species. *Journal of the Entomological Society of Southern Africa* **29**: 1-22.
Contains a list of 27 species of dragonfly from the Okavango swamps, and 42 species from Kariba (before and after impoundment).
UZam, MZam, checklist, Botswana, Okavango, Zimbabwe, Kariba, insects

42. Balon, E.K. (1971a). Age and growth of tiger fish, *Hydrocynus vittatus* Castelnau, 1861, in Lake Kariba, Sinazongwe area. *Fisheries Research Bulletin, Zambia* **5**: 89-118.
Account of a biological study on tiger fish in part of Lake Kariba.
MZam, Zambia, Zimbabwe, Kariba, fish

43. Balon, E.K. (1971b). Replacement of *Alestes imbiri* Peters, 1852, by *A. lateralis* Boulenger, 1900, in Lake Kariba, with ecological notes. *Fisheries Research Bulletin, Zambia* **5**: 119-162.
The two Alestes (now Brycinus) species are described as ecologically separated in the upper Zambezi and Kafue River catchments and lower Zambezi respectively. Both occur sympatrically in the new lake owing to invasion of the middle Zambezi by A. lateralis.
Zambia, UZam, MZam, Kafue, Kariba, biogeography, ecology, fish

44. Balon, E.K. (1971c). The eels of Siengwazi Falls (Kalomo river, Zambia) and their significance. *Zambia Museums Journal* **2**: 65-82.
List of the fish species collected in the Kalomo river, with a discussion of the importance of Siengwazi Falls as a barrier to movement of eels from the middle to upper Zambezi.
MZam, checklist, Zambia, UZam, biogeography, fish

45. Balon, E.K. (1972). Possible fish stock size assessment and available production survey as developed on Lake Kariba. *African Journal of Tropical Hydrobiology and Fisheries* **2**(1): 45-73.
Description of a programme to estimate the abundance of inshore fish species in Lake Kariba. A list of species caught in one area is given.
MZam, survey, Zambia, Kariba, fisheries, fish

46. Balon, E.K. (1973). Results of fish population size estimates in Lake Kariba coves (Zambia), a decade after their creation. In: *Man-made Lakes: Their Problems and Environmental Effects* (edited by Ackermann, W.C., White, G.F. and Worthington, E.B.). Geophysical Monograph Series Vol. 17. American Geophysical Union, Washington DC, USA. pp.149-158.
Describes a programme to estimate the abundance of inshore fish species. Lists of fish caught are given.
survey, Zambia, MZam, Kariba, fisheries, fish

47. Balon, E.K. (1974a). *Fishes of Lake Kariba*. T.F.H. Publications, Neptune City, New Jersey, USA. 144 pp.
Illustrated descriptions of the fish of Lake Kariba, with notes on their size and biology.
MZam, checklist, Zimbabwe, Zambia, Kariba, fish

48. Balon, E.K. (1974b). Fishes from the edge of Victoria Falls, Africa: demise of a physical barrier for downstream invasions. *Copeia* **3**: 643-660.
Study of the fish faunas from above and below Victoria Falls. The faunas are shown to be comparatively distinct, and the Falls is considered a physical barrier to upstream migration. Fish biodiversity is substantially higher in the upper Zambezi. However, the Falls are not considered a downstream barrier as can now be seen from the invasion of Lake

Kariba by upper Zambezi species. The downstream barrier is considered to have been ecological, a lack of sufficient suitable habitats.
survey, Zimbabwe, Zambia, UZam, MZam, Kariba, biogeography, fish

49. Balon, E.K. (1975). The eels of Lake Kariba: distribution, taxonomic status, age, growth and density. *Journal of Fish Biology* **7**: 797-815.
Detailed account of the biology of eels in Lake Kariba. Although initially it was thought eels would die out as young would not be able to surmount Kariba dam, evidence is presented here that upstream migration is still possible.
MZam, Zambia, Zimbabwe, Kariba, environmental assessment, fish

50. Balon, E.K. (1978). Kariba: the dubious benefits of large dams. *Ambio* **7**(2): 40-48.
Good brief overview, from a conservation perspective, of the effects of the construction of Kariba on fish ecology.

MZam, Zambia, Zimbabwe, Kariba, conservation, environmental assessment, fish, fisheries

51. Balon, E.K. and Coche, A.G. [editors] (1974). *Lake Kariba: a Man-made Tropical Ecosystem in Central Africa.* W. Junk, The Hague, Netherlands. ISBN 90-6193-0766. 767 pp.
Multidisciplinary account of the formation and early limnology, biology and fisheries of Lake Kariba soon after its impoundment. The importance of Victoria Falls as a zoogeographic barrier is discussed. There are sections on the fishery productivity of the Kafue Flats and on the introduction of kapenta.
MZam, Zambia, Zimbabwe, Kariba, Kafue, fisheries, ecology, biogeography, fish

52. Balon, E.K. and et al. (1974). Fish production of a tropical ecosystem. In: *Lake Kariba: a Man-made Tropical Ecosystem in Central Africa* (edited by Balon, E.K. and Coche, A.G.). W. Junk, The Hague, Netherlands. ISBN 90-6193-0766. pp.249-575.
Summary of much of Balon's previous work. Detailed lists of species collected at various sites are given, with details on their growth.
MZam, Zambia, Zimbabwe, Kariba, fisheries, fish

53. Banda, H.M. (1996). Status of the Nyika Wattled Crane and management recommendations. In: *Proceedings of 1993 African Crane and Wetland Training Workshop* (edited by Beilfuss, R.D., Tarboton, W.R. and Gichuki, N.N.). International Crane Foundation, Baraboo, WI, USA. pp.295-303.
Account of the Wattled Crane in the Nyika NP. Includes a map of the wetlands of Malawi.
Malawi, conservation, birds

54. Banister, K.E. and Clarke, M.A. (1980). A revision of the large *Barbus* (Pisces, Cyprinidae) of Lake Malawi with a reconstruction of the history of the southern African Rift Valley lakes. *Journal of Natural History* **14**: 483-542.
Not seen.
Malawi, LMalawi, biogeography, fish

55. Barbosa, L.A.G. (1952). Esboço da Vegetaçâo da Zambézia. Documentário Moçambique No. 69. Junta de Exportaçâo do Algodâo, Maputo, Mozambique.
Vegetation survey of Zambezia Province, north of the Zambezi river. 18 vegetation types are described; the delta is mapped as hydrophilic grassland plus patches of "morrumbala" forest, with mangrove forest and salt flats flanking some of the larger tributaries close to the coast.
LZam, survey, Mozambique, Delta, vegetation, plants

56. Barbosa, L.A.G. (1968). Moçambique. In: *Conservation of Vegetation in Africa South of the Sahara. Proceedings of a symposium held at the 6th AETFAT Congress, Uppsala, September 12-16 1966* (edited by Hedberg, I. and Hedberg, O.). Acta Phytogeographica Suecia No. 54. Almqvist & Wiksells, Uppsala, Sweden. pp.224-232.
Brief account of the vegetation of Mozambique, including the grasslands of Marromeu on the Zambezi delta.
LZam, Mozambique, Delta, vegetation, conservation

57. Barbosa, L.A.G. (1970). *Carta Fitogeográfica de Angola.* Instituto de Investigaçâo Científica de Angola, Luanda, Angola. 323 pp. One map.
Report and colour map at 1:2.5 million scale of vegetation of Angola, compiled from existing surveys. There are 32 vegetation types described, grouped into 10 physiognomic types. The upper Zambezi grasslands are classified as grasslands of sandy plains with poor drainage, typified by Loudetia simplex (Type 31). Occasional trees of Parinari pumila, Syzygium sp. and Magnistipula eglandulosa are found. Corresponds to vegetation type 65 of Wild & Barbosa (1968).
survey, Angola, UZam, headwaters, vegetation, plants

58. Barnard, K.H. (1948). Report on a collection of fishes from the Okavango river, with notes on Zambezi fishes. *Annals of the South African Museum* **36**: 407-458.
Not seen.
Botswana, UZam, Okavango, fish

59. Barnes, J.E. and Turton, L.M. (1994). A list of the flowering plants of Botswana in the herbaria at the National Museum, Sebele and University of Botswana. Botswana Society/National Museum, Monuments & Art Gallery, Gaborone, Botswana. 66 pp.
A full listing of all plant species, arranged by family, found in the major herbaria in Botswana (excluding Maun). It can be considered a preliminary checklist of Botswana's flora, although the wetland flora is poorly covered.
Zbasin, checklist, Botswana, plants

60. Bartlett, M., Hickley, M., Lennard, D., Bartlett, R., Pasteur, A., Chiwona, E., Munthali, H., Chikuni, A., Salubeni, A. and Ngonda, J. (1996). The ecology and human geography of the Elephant Marsh - Lower Shire valley, Malawi. Report of the Cambridge expedition to Malawi, July-August 1991. Pembroke College, Cambridge University, Cambridge, UK. 135 pp.
Expedition report on the Elephant Marsh. Not much on biodiversity.
survey, LZam, Malawi, LShire, fishing, human use/impact, reptiles, amphibians, birds, Lmammals

61. Begg, G.W. (1970). Limnological observations on Lake Kariba during 1967 with emphasis on some special features. *Limnology and Oceanography* **25**: 776-788.
Not seen.
Zimbabwe, MZam, Kariba

62. Begg, G.W. (1973). The biological consequences of discharge above and below Kariba Dam. In: *Proceedings of the 11th Congrès des Grands Barrages*. Commission Internationale des Grands Barrages, Madrid, Spain. pp.421-430.
Account of the influences of lake level fluctuations (2m annual fluctuation is said to most suitable for fisheries), and on the downstream effects of discharge on both fish and wildlife.
MZam, Mana, Zimbabwe, Zambia, Kariba, environmental assessment, fish

63. Beilfuss. R. (1995). Wattled Cranes in the Great Zambezi Delta. *ICF Bugle* **21**(3): 3.
Popular account of the Marromeu area and aerial crane census, and conservation priorities. At least 58 pairs and several large flocks were seen.
LZam, Mozambique, Delta, survey, conservation, birds

64. Beilfuss, R.D. and Allan, D.G. (1996). Wattled crane and wetland surveys in the Great Zambezi Delta, Mozambique. In: *Proceedings of 1993 African Crane and Wetland Training Workshop* (edited by Beilfuss, R.D., Tarboton, W.R. and Gichuki, N.N.). International Crane Foundation, Baraboo, WI, USA. pp.345-353.
Of a total world population of 13-15,000 Wattled Cranes, more than 95% occur on the floodplains of the Zambezi, lower Zaire and Okavango. Breeding attempts are highly dependent on hydrological regime. An aerial survey of the Marromeu complex in March 1995 gave an estimate of 208 cranes and 77 breeding pairs, but at a time when most would have dispersed. Other species of crane, storks and egrets were counted. Important numbers of African Openbilled Storks, Saddlebilled Storks and Pelicans were seen. The buffalo count showed c.1000. Drastic reductions in numbers of waterbuck, zebra, hippo and elephant from previous censuses were noted. The level of agricultural development in the wetlands was low, but there is much settlement along the banks of the Zambezi. Numbers of birds seen are tabulated.
LZam, survey, Mozambique, Delta, conservation, environmental assessment, birds, Lmammals

65. Beilfuss, R.D., Tarboton, W.R. and Gichuki, N.N. [editors] (1996). *Proceedings of the 1993 African Crane and Wetland Training Workshop*. International Crane Foundation, Baraboo, Wisconsin, USA. 661 pp.
Contains many papers of interest on cranes and wetlands (function and policy) from all over Africa, 18 concerning parts of the Zambezi Basin. Also includes 'crane and wetland action plans' for Botswana, Malawi, Mozambique, Namibia and Zambia.
Zbasin, conservation, ecology, birds

66. Bekker, R.P. and de Wit, P.V. (1991). Contribution to the vegetation classification of Botswana. Field Document No. 34. FAO/UNDP, Gaborone, Botswana. 66 pp.
A compilation of vegetation data from the nationwide soil survey to draw up a vegetation map of Botswana. The Chobe/Linyanti floodplains are covered under Region 12. They consist of grasslands with fringing riverine woodland of Combretum imberbe, Acacia erioloba and Colophospermum mopane.
UZam, Chobe, Botswana, vegetation

67. Belcher, C.F. (1930). *The Birds of Nyasaland.* Technical Press, Kingston Hill, UK. 356 pp.
Not seen.
Zbasin, checklist, Malawi, birds

68. Bell, R.H.V., Grimsdell, J.J.R., Van Lavieren, L.P. and Sayer, J.A. (1973). Census of the Kafue lechwe by aerial stratified sampling. *East African Wildlife Journal* **11**: 55-74.
Four aerial surveys over 2 years, from 1970 onwards, are reported. Population trends and human threats are discussed.
UZam, survey, Zambia, Kafue, conservation, Lmammals

69. Bell, R.H.V. and Grimsdell, J.J.R. (1973). The persecuted black lechwe of Zambia. *Oryx* **12**(1): 77-92.

Not seen.
UZam, Zambia, Bangweulu, conservation, Lmammals

70. Bell-Cross, G. (1965). Movement of fish across the Congo-Zambezi watershed in the Mwinilunga District of Northern Rhodesia. In: *Proceedings of the Central African Scientific and Medical Congress, Lusaka, Northern Rhodesia, 26-30 August 1963* (edited by Snowball, G.J.). Pergamon Press, Oxford, UK. pp.415-424.
Account of movement of fish across the watershed from the Congo drainage system to the Zambezi via wetland areas during the rainy season. Of 16 fish species recorded, 6 crossed the watershed.
headwater, Zambia, UZam, biogeography, fish

71. Bell-Cross, G. (1965a). The distribution of fishes in Central Africa. *Fisheries Research Bulletin, Zambia* **4**: 3-20.
Account of the differences in fish fauna between the upper and mid/lower Zambezi river systems. This is ascribed to there being two distinct drainage basins in the past, which have now joined. A brief account is given of additional mechanisms causing separation. An extensive list of 184 fish species present in the various central African drainage systems is included.
checklist, Zbasin, biogeography, ecology, fish

72. Bell-Cross, G. (1965b). Preliminary observations on *Hydrocynus vittatus* in the Upper Zambezi river basin. *Fisheries Research Bulletin, Zambia* **4**: 21-27.
Not seen.
Zambia, UZam, Barotse, fish

73. Bell-Cross, G. (1965c). Physical barriers separating the fishes of the Kafue and middle Zambezi river systems. *Fisheries Research Bulletin, Zambia* **4**: 97-98.
Lists of species found above and below the Avumba Menda Falls on the Kafue river are given. The Falls are shown to be a zoogeographical barrier to fish from the mid Zambezi.
MZam, UZam, Zambia, Kafue, biogeography, fish

74. Bell-Cross, G. (1971). Weir fishing on the Barotse flood plain. *Fisheries Research Bulletin, Zambia* **5**: 331-340.
Account of traditional fishing in the upper Zambezi floodplains. The cropping of juveniles is not thought to be detrimental to populations.
Barotse, Zambia, UZam, fisheries, fish

75. Bell-Cross, G. (1972). The fish fauna of the Zambezi river system. *Arnoldia (Rhodesia)* **5**(29): 1-19.
Species lists of fish in the Zambezi basin and Lake Malawi, with a discussion on their biogeography. 361 species are listed, including 22 estuarine and 217 endemic to Lake Malawi.
checklist, Zbasin, biogeography, fish

76. Bell-Cross, G. (1974a). A fisheries survey of the Upper Zambezi river system. *Occasional Papers of the National Museums and Monuments of Rhodesia* **5**(5): 279-338.
Description of the fisheries of the upper Zambezi, including an annotated checklist of the fish species.
checklist, Zambia, UZam, Barotse, biogeography, fisheries, fish

77. Bell-Cross, G. (1974b). Observations on fish-eating birds in central Africa. *Honeyguide* **77**: 23-31.
Many species watched - by a fish biologist.
Zambia, UZam, Barotse, birds

78. Bell-Cross, G. (1976). *The Fishes of Rhodesia*. National Museums and Monuments of Rhodesia, Harare, Zimbabwe. ISBN 0-7974-0184-9. 262 pp.
Comprehensive account of the fish fauna of Zimbabwe, including the upper and mid Zambezi. Identification keys and descriptions for each species are given, with notes on distribution and biology.
UZam, MZam, checklist, Zimbabwe, fish

79. Bell-Cross, G. (1982). *The biogeography of the Zambezi river fish fauna*. MSc thesis, University of Natal. Pietermaritzburg, South Africa. 223 pp.
Not seen.
Zbasin, biogeography, fish

80. Bell-Cross, G. and Bell-Cross, B. (1971). Introduction of *Limnothrissa miodon* and *Limnocaridina tanganyikae* into Lake Kariba. *Fisheries Research Bulletin, Zambia* **5**: 207-214.
Account of the introduction of kapenta species into Lake Kariba.
MZam, Zambia, Zimbabwe, Kariba, fish

81. Bell-Cross, G. and Kaoma, J. (1971). Additions and amendments to the checklist of fishes of Zambia - No. 3. *Fisheries Research Bulletin, Zambia* **5**: 235-244.
Includes a checklist of fishes of Lake Tanganyika, recent additions to Lake Kariba, and a list of upper Zambezi fishes not recorded in the mid Zambezi prior to the formation of Lake Kariba.
Zbasin, checklist, Zambia, Zimbabwe, UZam, MZam, Kariba, fish

82. Bell-Cross, G. and Minshull, J.L. (1988). *The Fishes of Zimbabwe*. National Museums and Monuments of Zimbabwe, Harare, Zimbabwe. ISBN 0-7974-0830-4. 294 pp.
Comprehensive account of the fish fauna of Zimbabwe, including the Zambezi basin. Subjects covered include the history of ichthyology, zoogeography, ecology, fish morphology and colouration, nomenclature, angling, size records, commercial fishing, description of the river systems of Zimbabwe and fish distribution. This is followed by a key to families and genera, and detailed descriptions of all 132 fish species known to occur in the country, many illustrated in colour.
checklist, Zimbabwe, UZam, LZam, Kariba, fisheries, fish, biogeography, ecology

83. Benson, C.W. (1959). Bird protection in Northern Rhodesia. *Ostrich Supplement* **3**: 10-13.
Based on the Fauna Conservation Ordinance of 1955, which applied everywhere except Barotseland, ducks and snipe could be hunted under a game licence. Cranes, egrets, locust-eating birds (White Stork, Abdim's Stork, Red-winged Pratincole), Marabou and Saddle-billed Storks, owls, Shoebill and flamingoes are protected against hunting.
Zbasin, Zambia, conservation, birds

84. Benson, C.W. (1960). Recent records from north-western Northern Rhodesia. *Bulletin of the British Ornithological Club* **80**: 106-112, 114-119.
Not seen.
UZam, Barotse, birds

85. Benson, C.W. (1969). Large mammals of the Liuwa Plain and Sioma-Ngwezi Game Reserves, Barotse. *The Puku* **5**: 49-57.
Descriptive list of larger mammals of some protected areas in Barotseland in 1964, including results of counts. 18 species were noted from the Liuwa Plains.
survey, Zambia, UZam, Barotse, Lmammals

86. Benson, C.W. and Benson, F.M. (1948). Notes from southern Nyasaland, mainly from the lower Shiré valley at 200 ft. altitude. *Ostrich* **19**(1): 1-16.
Annotated list of 94 bird species seen in the lower Shire, including 15 species of waterbirds.
LZam, Malawi, LShire, checklist, birds

87. Benson, C.W. and Benson, F.M. (1975). Studies of some Malawi birds. *Arnoldia (Rhodesia)* **7**(32): 1-27.
Includes explanatory notes on 10 species of waterbirds.
Zbasin, Malawi, birds

88. Benson, C.W. and Benson, F.M. (1977). *The Birds of Malawi*. Montfort Press, Limbe, Malawi. 263 pp.
A guide to all birds found in Malawi; has a section on habitats.
Zbasin, checklist, Malawi, birds

89. Benson, C.W., Brooke, R.K., Dowsett, R.J. and Irwin, M.P.S. (1970). Notes on the birds of Zambia: part V. *Arnoldia (Rhodesia)* **4**(40): 1-59.
Includes notes on 50 species of waterbirds. Also rejects the sighting of White-winged Flufftail.
Zbasin, Zambia, birds

90. Benson, C.W., Brooke, R.K., Dowsett, R.J. and Irwin, M.P.S. (1971). *The Birds of Zambia*. Collins, London, UK. ISBN 0-00-211097-0. 414 pp.
Illustrated guide to all birds found in Zambia, including notes on distribution and breeding times.
Zbasin, checklist, Zambia, birds

91. Benson, C.W., Brooke, R.K. and Irwin, M.P.S. (1971). The Slatey Egret *Egretta vinaceigula* is a good species. *Bulletin of the British Ornithologist's Club* **91**: 131-133.
Brief history of its progress since first being named in 1895. Also some distribution and breeding records. Only the third specimen was collected in the E Caprivi in 1958.
UZam, Namibia, Chobe, birds

92. Benson, C.W. and Irwin, M.P.S. (1965a). Some birds from North-Western Province, Zambia. *Arnoldia (Rhodesia)* **1**: 29.
Not seen.
UZam, Barotse, birds

93. Benson, C.W. and Irwin, M.P.S. (1965b). Some intra-African migratory birds: II. *The Puku* **3**: 45-55.

Description of localities and times of occurrence for Rock Pratincoles in Zambia.
UZam, Zambia, birds

94. Benson, C.W. and Irwin, M.P.S. (1966). Some intra-African migratory birds: III. *The Puku* **4**: 49-56.
Description of localities and times of occurrence for African Rail Heron in southern Africa.
SAfrica, birds

95. Benson, C.W. and Irwin, M.P.S. (1967). A contribution to the ornithology of Zambia. *Zambia Museum Papers* **1**: 1-139.
Detailed notes of selected species particularly in Barotseland, including 42 waterbirds.
Zbasin, Zambia, UZam, Barotse, birds

96. Benson, C.W. and Pitman, C.R.S. (1964). Further breeding records from Northern Rhodesia (No. 4). *Bulletin of the British Ornithological Club* **84**: 54-60.
Of dozens of breeding attempts sighted of the Wattled Crane in the Zambezi basin wetlands, only two are of two chicks being reared.
UZam, Zambia, birds

97. Benson, C.W. and White, C.M.N. (1957). Check list of the birds of Northern Rhodesia. Government Printer, Lusaka, Zambia. 166 pp.
658 species are listed.
Zbasin, checklist, Zambia, birds

98. Berg, H. and Kautsky, N. (1994). Persistent pollutants in Lake Kariba ecosystem - a man-made lake. CIFA Report /94/Sem.A.8. FAO, Harare, Zimbabwe.
Report on a study of pesticides in Lake Kariba. Data indicate accumulations of high levels of heavy metals and pesticides, especially DDT derivatives.
Zimbabwe, MZam, Kariba, pollution, environmental assessment, water quality

99. Bernacsek, G.M. and Lopes, S. (1984a). Cahora Bassa. In: *Status of African Reservoir Fisheries* (edited by Kapetsky, J.M. and Petr, T.). CIFA Technical Paper No. 10. FAO, Rome, Italy. pp.21-42.
Account of the fisheries of Cabora Bassa. Fishery at present is grossly underutilised, and few data are available. Large fluctuations in water level and high clay loads reduce potential productivity. Data are given on hydrology and water quality. Conflict and inadequate attention to biological concerns during design are outlined. From an ecological viewpoint, Cabora Bassa could be "the least studied and least environmentally acceptable dam project in Africa".

MZam, Mozambique, Cabora, hydrology, water quality, fisheries

100. Bernacsek, G.M. and Lopes, S. (1984b). Investigations into the fisheries and limnology of Cahora Bassa reservoir seven years after dam closure. FAO/GCP/MOZ/006(SWE) Field Document No. 9. FAO, Rome, Italy. 145 pp.
Not seen.
LZam, Mozambique, Cabora, hydrology, water quality, fisheries

101. Bernacsek, G.M., Massinga, A. and Contreras, P. (1983). Exploratory gill-netting in Lake Niassa, Mozambique, including biological profiles of the main taxa caught. FAO/GCP/MOZ/006(SWE) Field Document No. 5. FAO, Rome, Italy.
Not seen.
Mozambique, LMalawi, fisheries, fish

102. Berry, P.S.M. (1973). A hippo count on the upper Luangwa river. *The Puku* **7**: 193-195.
Brief report on hippo numbers along the Luangwa river in 1967. Total was estimated at 324.
MZam, Luangwa, survey, Zambia, Lmammals

103. Bethune, S. (1991). Kavango river wetlands. *Madoqua* **17**(2): 77-112.
Account of the wetlands associated with the Kavango river in N Namibia, including sections on hydrology, water chemistry, ecology, vegetation and biodiversity. The wetlands are shown to be important for local economic utilisation, provision of environmental services and for conservation. Lists of 889 species of plants (including 20 algae) and 73 species of fish are given.
UZam, Okavango, survey, checklist, Namibia, vegetation, conservation, environmental assessment, human use/impact, waterqual, hydrology, plants, phytoplankton, fish, birds, Lmammals, Smammals

104. Bethune, S. (1996). Biological control of *Salvinia molesta* in the Eastern Caprivi; progress report, 1980-1995. Report No. RR/96/1. Department of Water Affairs, Windhoek, Namibia. 51 pp.
Detailed technical report on the problem of Salvinia molesta infestation in the E Caprivi, and on the biological control methods used and their success.
UZam, Namibia, Chobe, probspp, plants, insects

105. Bethune, S. and Roberts, K. (1991). Checklist of the fishes of Namibia for each wetland region. *Madoqua* **17**(2): 193-199.

List of fish species found in Namibia. 72 species are recorded from the E Caprivi, of which one is endemic and two rare.
UZam, checklist, Namibia, Chobe, biogeography, fish

106. Bhima, R. (1996). Census of hippopotamus (*Hippopotamus amphibius* (L)) in the Upper Shire River, Malawi. *African Journal of Ecology* **34**: 83-85.
Brief account of a census of hippo along the upper parts of the Shire river. Estimated number is 1029.
LZam, MShire, survey, Malawi, Lmammals

107. Biggs, R.C. (1976). The effects of the seasonal flood regime on the ecology of Chief's Island and the adjacent floodplain systems. In: *The Okavango Delta and its Future Utilisation* (edited by Botswana Society). Botswana Society, Gaborone, Botswana. pp.113-120.
Account of the vegetation types of a large island in the Okavango delta. 5 main types, subdivided into 21 types, are described based on seasonal water availability and species composition.
UZam, Botswana, Okavango, vegetation, ecology, plants

108. Biggs, R.C. (1979). *The ecology of Chief's Island and the adjacent floodplains of the Okavango delta*. MSc thesis, University of Pretoria. Pretoria, South Africa.
Not seen.
UZam, survey, Botswana, Okavango, vegetation, ecology, Lmammals

109. Bingham, M.G. (1990). An ethno-botanical survey of Senanga West. RDP Livestock Services/Department of Agriculture, Senanga, Lusaka, Zambia. 62 pp.
Includes a comprehensive list of 304 species of flowering plants with vernacular names (principally Lozi), arranged in alphabetical order by genus/species. The different types of plant usage are described and discussed.
UZam, Barotse, survey, checklist, Zambia, human use/impact, plants

110. Bingham, M.G. (1994). Zambezi source area: Zambia. In: *Centres of Plant Diversity: A guide and strategy for their conservation. 1 - Europe, Africa, South West Asia and the Middle East* (edited by Davis, S.D., Heywood, V.H. and Hamilton, A.C.). WWF/IUCN, Cambridge, UK. ISBN 2-8317-0197-X. pp.192-193.
Data sheet on Zambezian Regional Centre of Endemism (CPD Site Af39) in the Mwinilunga area of NW Zambia. This area of 1700 km² at the headwaters of the Zambezi river contains edaphic grasslands/wetlands owing to impervious drainage, with affinities to the Zambezian and Guineo-Congolian phytochoria. The seepage dambos are permanently wet peat areas rich in orchids and other herbs.
headwater, survey, Zambia, UZam, vegetation, conservation, biogeography, plants

111. Bingham, M.G. (1996). Western Province plant species list. Unpublished report, Lusaka, Zambia.
An updated and expanded version of Bingham's ethno-botanical survey of Senanga West (1990). The alphabetically-arranged list gives a brief description, vernacular names, habitat and uses.
checklist, Zambia, UZam, Barotse, human use/impact, plants

112. Birkhead, M.E. (1978). Some aspects of the feeding ecology of the Reed Cormorant and Darter on Lake Kariba, Rhodesia. *Ostrich* **49**(1): 1-7.
Study of gut contents and habitat preferences of 2 water birds. Cichlids constituted over 90% of the fish eaten; both species fed in the littoral zone.
MZam, Zimbabwe, Kariba, ecology, birds

113. Blackmore, S., Dudley, C.O. and Osborne, P.L. (1988). An annotated check-list of the aquatic macrophytes of the Shire River, Malawi, with reference to potential aquatic weeds. *Kirkia* **13**(1): 125-142.
Survey of the non-microscopic aquatic plants of the Shire river in Malawi during 1979/80. The 71 species recorded are classified by life-form and position with respect to the water surface. An annotated checklist covers 93 species. The major habitat and plant communities are described. The threat posed by the aquatic weed Eichhornia is pointed out. The lower Shire (from Kapichira Falls to its confluence with the Zambezi) has a very shallow gradient. The two main marshes which have a well-developed aquatic flora are Elephant Marsh (500 km²) and Ndinde Marsh (150 km²). Both support important fisheries industries.
LZam, survey, checklist, Malawi, MShire, LShire, vegetation, probspp, plants

114. Blair Rains, A. and McKay, A.D. (1968). The Northern State Lands, Botswana. Land Resource Study 5. Land Resources Division, Surrey, UK. 124 pp.
Investigation into the land resources of the Northern State Lands of NE Botswana with a view to developing the cattle industry but conserving wildlife. The area covers c.65,000 km² and includes the Chobe waterfront as far west as the Goha hills (24E E), thus excluding the major wetland areas. A vegetation map (scale 1:500,000) is given, and shows a narrow fringe of floodplain grassland along the Linyanti river. Seasonally flooded grasslands along the Chobe river are dominated by Chloris gayana and Setaria sphacelata. Beds of Cyperus papyrus, Phragmites mauritianus and Vetiveria nigritana occur in permanently wet areas.
UZam, Botswana, Chobe, vegetation, range/livestock, plants

115. Bond, W.J., Coe, N., Jackson, P.B.N. and Rogers, K.H. (1978). The limnology of Lake Cabora Bassa, Moçambique, during its first year. *Freshwater Biology* **8**(5): 433-447.
Not seen.

MZam, Mozambique, Cabora, ecology

116. Bond, W.J. and Roberts, M.G. (1978). The colonization of Cabora Bassa, Moçambique, a new man-made lake, by floating African macrophytes. *Hydrobiologia* **60**(3): 243-259.
Account of the spread of Salvinia and Eichhornia on Cabora Bassa. Problems are likely to be less than with Lake Kariba.
MZam, Mozambique, Cabora, probspp, plants

117. Boon, P.J. (1984). A re-examination of the submerged tree fauna in Lake Kariba (South Central Africa), 24 years after innundation. *Archive für Hydrobiologie* **101**(4): 569-576.
Account of the invertebrates found on submerged trees in Lake Kariba, and changes in their composition and abundance since the 1960s. A species of mayfly comprised 90% of total biomass.
MZam, Zimbabwe, Kariba, ecology, Oinverts

118. Bootsma, H.A. and Hecky, R.E. (1993). Conservation of the African great lakes: a limnological perspective. *Conservation Biology* **7**(3): 644-656.
Limnology of the three Great Lakes is described by examining how their physical, chemical and biological properties will determine the response to human activities. Pollution could be a problem as flushing rates are low, climatic change could cause large changes in levels, and eutrophication would cause changes in fish composition. The importance of international cooperation in their conservation is emphasised.
Malawi, LMalawi, conservation, ecology, water quality, fish

119. Botswana Society [editor] (1976). *The Okavango Delta and its Future Utilisation.* Botswana Society, Gaborone, Botswana. 350 pp.
Proceedings of a conference on the Okavango. There are 32 papers covering geology, geography, hydrology, history, ecology, utilisation and potential developments of the area.
UZam, Botswana, Okavango, environmental assessment, hydrology, ecology, conservation, fisheries, vegetation, fish, reptiles, Lmammals, plants

120. Boughey, A.S. (1963). The explosive development of a floating weed vegetation on Lake Kariba. *Adansonia* **3**: 49-61.
Account of floating weed mats on Lake Kariba, particularly Salvinia. Colonisation by other plants is described.
MZam, Zimbabwe, Kariba, ecology, probspp, plants

121. Bourn, D.M. (1972). *The feeding, diet and ecological relations of three species of fish of economic importance in southern Malawi*. MSc thesis, University of Edinburgh. Edinburgh, UK. 99 pp.
Not seen.
Malawi, LChilwa, ecology, fish

122. Bowmaker, A.P. (???). In: *Man-Made Lakes: Their Problems and Environmental Effects* (edited by Ackermann, W.C., White, G.F. and Worthington, E.B.). Geophysical Monographs Vol. 17. American Geophysical Union, Washington DC, USA.
Not seen.
SAfrica, Zimbabwe, Kariba

123. Bowmaker, A.P. (1960a). A report on the Kariba Lake area and Zambezi River prior to innundation and the initial effects of innundation with particular reference to the fisheries. FAO-ETAP Report 1299(2). FAO, Rome, Italy. 100-127 pp.
Report giving early estimates of the fishery potential of Kariba, limnological and taxonomic work preceding impoundment is discussed, and recommendations for improving fisheries are given.
MZam, Zimbabwe, Zambia, Kariba, environmental assessment, fisheries, fish

124. Bowmaker, A.P. (1960b). Seasonal hydrological changes affecting the ecology of Luaka Lagoon, Lake Bangweulu: some preliminary observations. In: *Proceedings of the Third Symposium on Hydrobiology and Inland Fisheries: Major Lakes. Lusaka, Zambia.* CCTA/CSA Technical and Scientific Publication No.63. Conseil Scientifique pour l'Afrique au Sud du Sahara, 22 pp.
Not seen.
UZam, Zambia, Bangweulu, hydrology, ecology

125. Bowmaker, A.P. (1968). Preliminary observations on some aspects of the biology of the Sinamwenda estuary, Lake Kariba. *Proceedings and Transactions of the Rhodesia Scientific Association* **53**(3): 5-7.
Not seen.
MZam, Zimbabwe, Kariba, vegetation, ecology, plants

126. Bowmaker, A.P. (1973a). *An hydrobiological study of the Mwenda river and its mouth, Lake Kariba*. PhD thesis, University of Witwatersrand. Johannesburg, South Africa.
Not seen.
MZam, Zimbabwe, Kariba, vegetation, ecology, plants

127. Bowmaker, A.P. (1973b). Hydrophyte dynamics in Mwenda Bay, Lake Kariba. *Kariba Studies* **3**: 42-59.
Account of water plants on a flooded valley on Lake Kariba. A reduction in Salvinia is described. The shoreline was sterile in 1967 and by 1972 had been stabilised by Panicum repens. A succession of submerged hydrophytes has occurred, and this is enhanced by stable water levels, variation of which should not exceed 2 m.
MZam, Zimbabwe, Kariba, vegetation, ecology, probspp, plants

128. Bowmaker, A.P., Jackson, P.B.N. and Jubb, R.A. (1978). Freshwater fishes. In: *Biogeography and Ecology of Southern Africa* (edited by Werger, M.J.A.). W. Junk, The Hague, Netherlands. ISBN 90-6193-083-9. pp.1181-1230.
Review of knowledge of the freshwater fish of southern Africa. The origins of the fish fauna and its current distribution and probable dispersal routes are examined. The two major fish faunas are of standing and running waters. The considerable and rapid changes in water availability during the Pleistocene are pointed out. The effects of man on fish distribution and composition are discussed, with particular reference to Lakes Kariba and Cabora Bassa. Checklists of river fishes and fishes of Malawi are given.
SAfrica, checklist, Zbasin, Kariba, Cabora, environmental assessment, biogeography, ecology, fish

129. Boye-Chisholm, M. and Robarts, R.D. (1982). An SEM study of bacteria and zooplankton food sources in Lake McIlwaine. In: *Lake McIlwaine: the eutrophication and recovery of a tropical African lake* (edited by Thornton, J.A.). W. Junk, The Hague, Netherlands. ISBN 90-6193-102-9. pp.101-106.
Brief account of bacteria and phytoplankton found in Lake Chivero. Their importance as food for zooplankton is pointed out.
MZam, Chivero, Zimbabwe, phytoplankton, zooplankton

130. Braga, J.M. (1952). Materias para o estudo da fauna malacologica de Moçambique. *An. Junta de Investigaçoes de Ultramar* **7**: 65-127.
Not seen.
LZam, Mozambique, molluscs

131. Branch, W.R., Haagner, G.V. and Channing, A. (1994). Geographical distribution: Amphibia, Anura, Bufonidae: *Bufo lemarii*. *African Herp News* **21**: 23.
Note on distribution of a species of toad in the Caprivi.
UZam, Namibia, Chobe, amphibians

132. Branfield, A. (1989). A birding experience in the eastern Caprivi. *Bokmakierie* **41**(2): 38-40.
Popular account of the birds of the E Caprivi; 330 species were recorded in 1988.
UZam, Namibia, Chobe, conservation, birds

133. Branfield, A. (1990). New bird records for the East Caprivi, Namibia. *Lanioturdus* **25**: 4-21.
Added 8 species of waterbird during 1988.
UZam, Namibia, Chobe, birds

134. Brass, L.J. (1953). Vegetation of Nyasaland. Report on the Vernay Nyasaland Expedition of 1946. *Memoirs of the New York Botanic Garden* **8**(3): 161-190.
Account of the vegetation of various collecting sites in Malawi, particularly mountains. Nothing on wetlands.
Zbasin, survey, Malawi, vegetation, plants

135. Breen, C.M. (1991). Are intermittently flooded wetlands of arid environments important conservation sites? *Madoqua* **17**(2): 61-65.
Very good overview of wetland definition, functions and values, with particular reference to Namibia but with direct relevance to the Zambezi Basin. The paper suggests a classification of wetlands based on the US Fish and Wildlife Service definition, which makes much biological sense. This definition incorporates system (marine, estuarine, riverine, lacustrine and palustrine), regularity of flooding and substrate type.
SAfrica, Zbasin, Namibia, vegetation, ecology, hydrology

136. Breen, C.M. and Begg, G.W. (1989). Conservation status of southern African wetlands. In: *Biotic Diversity in Southern Africa: concepts and conservation* (edited by Huntley, B.J.). Oxford University Press, Cape Town, South Africa. ISBN 0-19-570549-1. pp.254-263.
Definition of wetlands and outline of ecological importance and threats. Although focussed on South Africa (with some mention of dambos in Zimbabwe), this paper has wider applications.
SAfrica, conservation

137. Brelsford, V. (1961). The story of a swamp: Lake Bangueulu in Northern Rhodesia. *Horizon* **3**(7)
Not seen.
UZam, Zambia, Bangweulu

138. Britton, P.L. (1970). Birds of the Balovale District of Zambia. *Ostrich* **41**: 145-190.
Not seen.
UZam, Barotse, birds

139. Broadley, D.G. (1963). An expedition to Tete and south Nyasaland. *Journal of Herpetological Association of Rhodesia* (20): 18-26.
Account of an expedition with notes on species collected, including some from Tete (but not from the lower Shire).

MZam, Mozambique, Malawi, reptiles

140. Broadley, D.G. (1967). A review of the genus *Lycodonomorphus* Fitzinger (Serpentes: Colubridae) in southeastern Africa, with a key to the genus. *Arnoldia (Rhodesia)* **3**(16): 1-9.
Description of a group of water snakes, including a species from the lower Zambezi.
SAfrica, LZam, Malawi, LShire, Mozambique, reptiles

141. Broadley, D.G. (1971). The reptiles and amphibians of Zambia. *The Puku* **6**: 1-143.
Comprehensive and annotated list, with keys, of all reptiles and amphibians in the country. Distribution maps are given.
Zbasin, checklist, Zambia, reptiles, amphibians

142. Broadley, D.G. (1977). A revision of the African snakes of the genus *Psammophylax* Fitzinger (Colubridae). *Occasional Papers of the National Museums of Rhodesia* **6**(1): 1-44.
Taxonomic revision of a group of snakes, with a description of a species found in Barotseland and Caprivi.
SAfrica, UZam, Barotse, Chobe, reptiles

143. Broadley, D.G. (1981). A review of the genus *Pelusios* Wagler in southern Africa (Pleurodira: Pelomedusidae). *Occasional Papers of the National Museums and Monuments* **6**(9): 633-686.
Monograph on a group of terrapins found in the region.
SAfrica, reptiles

144. Broadley, D.G. (1983). *Fitzsimons' Snakes*. Delta Books, Johannesburg, South Africa. ISBN 0-908387-04-0. pp.
Book providing detailed accounts and distribution maps for snakes of the region south of the Zambezi.
SAfrica, checklist, biogeography, reptiles

145. Broadley, D.G. (1990). The Zambezi flapshelled turtle or Nkhasi (*Cyloderma frenatum*). *Zimbabwe Science News* **24**(10/12): 100-101.
Brief account of the biology of a freshwater turtle, which in the Zambezi basin is confined to the lower Zambezi below Cabora Bassa, the Shire valley and Lake Malawi.
LZam, Malawi, LMalawi, LShire, Mozambique, reptiles

146. Broadley, D.G. (1991). The herpetofauna of northern Mwinilunga District, northwestern Zambia. *Arnoldia (Zimbabwe)* **9**(37): 519-538.
Annotated checklist of 57 species of reptile and 35 species of amphibian collected in the Mwinilunga area in 1990.

headwater, checklist, Zambia, UZam, reptiles, amphibians

147. Broadley, D.G. (1995). A small collection of reptiles and amphibians from central and southern Malawi. *African Herp News* **24**: 16-18.
List of 12 reptile and 8 amphibian species collected from Elephant Marsh on the lower Shire and Dedza.
LZam, LShire, checklist, Malawi, reptiles, amphibians

148. Broadley, D.G. (1996). A review of the tribe Atherini (Serpentes: Viperidae) with the descriptions of two new genera. *African Journal of Herpetology* **45**(2): 40-48.
Review of a group of snakes, including a species from the lower Zambezi.
SAfrica, LZam, reptiles

149. Broadley, D.G. (1997). A review of the worm snakes of Mozambique (Serpentes: Leptotyphlopidae) with the description of a new species. *Arnoldia (Zimbabwe)* **10**(11): 111-119.
Review of a group of fossorial snakes. 6 species are described from Mozambique including a new species only recorded from the Pungwe Flats.
LZam, Mozambique, Delta, reptiles

150. Broadley, D.G., Gans, C. and Visser, J. (1976). Studies on amphisbaenians (Amphisbaenia, Reptilia): 6 - The genera *Monopeltis* and *Dalophia* in southern Africa. *Bulletin of the American Museum of Natural History* **157**(5): 311-486.
Taxonomic revision of a group of fossorial reptiles, including species from the Zambezi basin.
SAfrica, reptiles

151. Brooke, R.K. (1969). Preliminary list of the birds of the Kafue National Park. *The Puku* **5**: 57-86.
Checklist of 418 bird species recorded from the Kafue NP during October 1964.
checklist, Zambia, UZam, Kafue, birds

152. Brown, C.J. (1992). The status of cranes in Namibia. In: *Proceedings of the First South African Crane Conference* (edited by Porter, D.J., Craven, H.S., Johnson, D.N. and Porter, M.J.). Southern African Crane Foundation, Durban, South Africa. pp.73-78.
Brief account with maps of the status of 3 crane species in Namibia. Distributions are plotted by quarter-degree squares for the period 1979-1988. Wattled Cranes occur in E Caprivi (6 squares); 6 breeding pairs are estimated on the Nkasa-Lupala islands (Kwando-Linyanti).
UZam, Namibia, Chobe, conservation, birds

153. Brown, C.J. and Jones, B.T.B. [editors] (1994). Results of a socio-ecological survey of the west Caprivi Strip, Namibia: a strategic community-based environment and development plan. Directorate of Environmental Affairs, Windhoek, Namibia. 205 pp.
Comprehensive report on social and natural resources of the W Caprivi up to the Kwando river. The Kwando floodplain is 2-5 km wide, and joins the Linyanti. It has a permanent swamp system along its lower reaches, as well as riparian woodland. Brief vegetation descriptions are given. There is a high invertebrate, reptile, amphibian and bird diversity along the rivers. Comprehensive lists are given of flowering plants, alien plants, fish (Kavango river only), amphibians, reptiles, birds and mammals.
UZam, Chobe, survey, checklist, Namibia, vegetation, human use/impact, conservation, Lmammals, Smammals, birds, fish, reptiles, amphibians, insects, Oinverts, plants

154. Brown, D.S. (1978). Freshwater molluscs. In: *Biogeography and Ecology of Southern Africa* (edited by Werger, M.J.A.). W. Junk, The Hague, Netherlands. ISBN 90-6193-083-9. pp.1153-1180.
Review of knowledge on freshwater molluscs of southern Africa. Both temperate and tropical faunas are recognised, but the diversity of molluscs in southern Africa in general is low. It is believed that the upper Zambezi is grossly under-collected, and its diversity is higher than presently recognised. Preliminary species lists for various areas are presented. Lake Malawi has a rich endemic molluscan fauna of over 20 species, principally found in deep water.
SAfrica, UZam, LMalawi, biogeography, molluscs

155. Brown, D.S., Curtis, B.A., Bethune, S. and Appleton, C.C. (1992). Freshwater snails of East Caprivi and the lower Okavango river basin in Namibia and Botswana. *Hydrobiologia* **246**: 9-40.
Detailed taxonomic account of the aquatic gastropods of the lower Okavango river in Namibia and Botswana, including the Okavango delta. Most of the 20 species found are widespread Afrotropical species; there are no endemics, but Bellamya monardi is only known from the Okavango and Cunene rivers.
UZam, survey, Namibia, Chobe, Botswana, Okavango, biogeography, molluscs

156. Bruessow, D.M. (1989). The reproductive capability of the Elephant Marsh crocodile population: report on an aerial survey. Wildlife Africa Ltd./National Parks, Malawi, London, UK.
Survey of crocodiles in the Elephant Marsh, where 168 breeding females were counted. Six major types of marsh habitat are described, and related to crocodile breeding needs.
LZam, survey, Malawi, LShire, reptiles

157. Cantrell, M.A. (1979). Possible environmental changes in response to hydro-electric development of the Shire River Basin (Malawi). 1 - The aquatic environment. In: *Proceedings of the International Conference on Kainji Lake and River Basin Development in Africa*. Kainji Lake Research Institute, New Bussa, Nigeria. pp.144-149.
Not seen. May contain lists of fish from the lower Shire valley.
LZam, Malawi, LShire, environmental assessment, fish

158. Carcasson, R.H. (1964). A preliminary survey of the zoogeography of African butterflies. *East African Wildlife Journal* **2**: 122-157.
Account of the relationship between butterfly distributions and vegetation (past and present). Special mention is made of the Zambezi wetlands.
SAfrica, biogeography, Zbasin, insects

159. Carey, T.G. (1967). Some observations on distribution and abundance of the invertebrate fauna. *Fisheries Research Bulletin, Zambia* **3**: 22-24.
Brief report on various invertebrates, especially insects, collected from both terrestrial and aquatic habitats on the Kafue floodplain.
UZam, Zambia, Kafue, insects, Oinverts

160. Carey, T.G. (1971). Hydrobiological survey of the Kafue flood plain. *Fisheries Research Bulletin, Zambia* **5**: 245-295.
Results of a hydrobiological survey of the Kafue to determine the ecological importance of seasonal flooding. Zooplankton and phytoplankton were most dense during low water stages, and the invertebrate fauna at the margins varied more seasonally than that in submerged vegetation. Breeding in most fish followed periods of flooding. Detailed results are presented.
UZam, survey, Zambia, Kafue, ecology, water quality, fish, insects, zooplankton, phytoplankton

161. Carvalho, M.F. (1961). Contribuçâo para o melhor conhecimento da flora lenhosa de Moçambique. *Boletim de Instituto de Investigaçâo Científica da Moçambique* **2**(2): 402-420.
List of woody plants with vernacular names, including from Inhaminga and Marromeu.
LZam, Delta, checklist, Mozambique, plants

162. Chabwela, H.N. and Ellenbroek, G.A. (1990). The impact of hydroelectric developments on the lechwe and its feeding grounds at Kafue Flats, Zambia. In: *Wetland Ecology and Management: case studies* (edited by Whigham, D.F., Good, R.E. and Kuet, J.). Kluwer Academic Publishers, Boston, USA. pp.95-101.
Not seen.
UZam, Zambia, Kafue, environmental assessment, Lmammals

163. Chabwela, H.N., Mwelwa, E., Mubamba, R., Ntalasha, H. and Thole, L. (1994). Status of wetlands of Zambia: management and conservation issues. Environmental Council of Zambia/Ministry of Environment and Natural Resources, Lusaka, Zambia. 202 pp.
Large report aimed at identifying issues affecting wetlands conservation in Zambia, covering the Barotse floodplain, Kafue Flats, Lukanga swamp, Bangweulu swamps, Luapula-Mweru, Mweru Wantipa and Lake Tanganyika. Major issues affecting wetlands are population management, poverty, famine and poor food production, pollution, drought and floods. Over 6% of Zambia is defined as wetland, but rises to 20% if dambos are included. Six major wetlands are discussed in detail, including the Barotse floodplains and the Kafue Flats.
Zbasin, Zambia, UZam, Barotse, Kafue, Bangweulu, human use/impact, conservation

164. Chabwela, H.N. and Siwela, A.A. (1986). The vegetative structure of the Kafue Flats North Bank, after the construction of the dams. In: *Proceedings of E.W.R.S./AAB 7th Symposium on Aquatic Weeds.* Loughborough University, Loughborough, UK. pp.61-72.
Not seen.
UZam, Zambia, Kafue, environmental assessment, vegetation

165. Chace, F.A. (1953). Zoological results of a fifth expedition to East Africa. VI - Decapod crustacea from Nyasaland and Tete. *Bulletin of Museum of Comparative Zoology, Harvard* **110**(6): 425-443.
Detailed records of collections made during an expedition.
LZam, MZam, checklist, Malawi, Mozambique, LShire, crustacea

166. Chambal, M.S. (1989). Preliminary survey of wildlife resources and management implications: a case study of Metuchira, Gorongosa National Park and Marromeu complex, Sofala Province. DNFFB, Maputo, Mozambique. 27 pp.
Report on conservation possibilities for Gorongosa NP and Marromeu based on existing wildlife numbers, wildlife utilisation and human expectations.
LZam, survey, Mozambique, Delta, conservation, Lmammals, agriculture, human use/impacts

167. Channing, A. (1989). New frog records from the Eastern Caprivi Strip, South West Africa/Namibia. *Madoqua* **16**(1): 1-4.
Report on 1986 amphibian survey resulting in 26 species being found, of which 4 are new Namibian records. An annotated list of species is given, and a link with the tropical frog fauna of Malawi is suggested.
UZam, survey, Namibia, Chobe, biogeography, amphibians

168. Channing, A. and Griffin, M. (1993). An annotated checklist of the frogs of Namibia. *Madoqua* **18**(2): 101-116.
Checklist and distribution maps for 43 species of frog in Namibia.
UZam, checklist, Namibia, Chobe, amphibians

169. Channing, A. and van Dijk, D.E. (1995). Amphibia. In: *Wetlands of South Africa* (edited by Cowan, G.I.). Department of Environmental Affairs and Tourism, Pretoria, South Africa. pp.193-206.
Good review of the distribution and ecology of frogs in South Africa, with applicability to the Zambezi basin. It also covers many aspects of amphibian conservation and use by humans, including for pharmaceutical research and as environmental indicators.
SAfrica, ecology, environmental assessment, human use/impact, conservation, pollution, amphibians

170. Chapman, D.W., Miller, W.H., Dudley, R.G. and Scully, R.J. (1971). Ecology of fishes in the Kafue River. FAO FI:SF/ZAM 11: Technical Report 2. FAO, Rome, Italy. 66 pp.
Not seen. Probably contains a list of fish species from the Kafue with notes on their ecology.
UZam, Zambia, Kafue, ecology, fish

171. Chifamba, P.C. (1995). The status of *Oreochromis niloticus* in Lake Kariba. Zambia-Zimbabwe SADC Fisheries Project. Project Report 35. 21 pp.
First record on the establishment of this exotic tilapia species, including comments on its potential impact.
MZam, Zimbabwe, Zambia, Kariba, environmental assessment, ecology, fish

172. Child, G. (1968a). Behaviour of large mammals during the formation of Lake Kariba. *Kariba Studies* **??**: 1-123.
Review of mammal behaviour observed during translocation exercises around Lake Kariba.
MZam, Zimbabwe, Kariba, Lmammals

173. Child, G. (1968b). An Ecological Survey of Northeastern Botswana. FAO Report TA 2563. FAO, Rome, Italy. 156 pp.
Detailed account of the ecology of the Chobe area, including vegetation and wildlife resources. Notes on distribution and biology of the larger mammals are given. Suggestions on the development and management of National Parks and tourism are included. Appendices include a checklist of 318 species of birds in the Chobe Game Reserve.
UZam, survey, Botswana, Chobe, ecology, conservation, vegetation, Lmammals, birds

174. Child, G. (1975). The decline of a lechwe population. *Mammalia* **39**(4): 706.
Account of decline of red lechwe population in the Chobe and E Caprivi area. Population declined by 85-90% between 1962 and 1969.
UZam, Botswana, Chobe, Lmammals

175. Child, G., Robbel, H. and Hepburn, C.P. (1972). Observations on the biology of tsessebe, *Damaliscus lunatus lunatus*, in northern Botswana. *Mammalia* **36**: 342-388.
Account of the habits and habitat requirements of tsessebe in Chobe and Moremi. The species principally feeds on the woodland/grassland ecotone.
UZam, Botswana, Chobe, ecology, Lmammals

176. Child, G., Smith, P. and Von Richter, W. (1969). Tsetse control hunting as a measure of large mammal population trends in the Okavango Delta, Botswana. *Mammalia* **34**: 34-75.
Study on the effects of hunting of large mammals (buffalo, warthog, kudu, reedbuck, impala, tsessebe, wildebeest, lechwe, duiker, steenbok) in the Maun area. It concludes that hunting returns can provide reliable estimates of population trends.
UZam, Botswana, Okavango, human use/impact, ecology, Lmammals

177. Child, G. and von Richter, W. (1969). Observations on the ecology and behaviour of lechwe, puku and waterbuck along the Chobe River, Botswana. *Zeitschrifte für Säugertierkunde* **34**: 275-295.
Study comparing 3 species of Kobus antelope on the Chobe floodplain. Habitat differences are mentioned. Both puku and lechwe populations are declining; puku are now isolated from other populations.
UZam, Botswana, Chobe, ecology, Lmammals

178. Chipamba, J. (1997). Bibliography of the Lower Shire. IUCN-ROSA, Harare, Zimbabwe.
Computerised document of 208 references concerning the lower Shire valley in Malawi, compiled for the IUCN Wetlands project. References are categorised by subject and each is extensively annotated. There is no index.
bibliography, LZam, Malawi, LShire, history, environmental assessment, hydrology, human use/impact, agriculture, fisheries, vegetation, conservation, ecology

179. Chipungu, P.M. (1981). The impact of the Kafue Gorge dam on the Kafue floodplain fishery. CIFA Technical Paper No. 8. FAO, Rome, Italy. pp.120-129.
Review of the effects on fisheries of damming the Kafue river. The Kafue floodplains produced 8000 tons of fish annually and was important for commercial farming. Although feasibility studies predicted an increase in fish production after dam closure, this has not materialised.
UZam, Zambia, Kafue, environmental assessment, fisheries, fish

180. Chipungu, P.M. (1992). Riverine wetlands of Zambia. In: *Wetlands of Zambia: Report of the Zambia Wetlands Conservation Seminar, Siavonga, 17-19 June 1992* (edited by Matiza, T.). ROSA Wetlands Report No. 2. IUCN ROSA, Harare, Zimbabwe.
Abstract only. Unpublished paper covering the main types of riverine wetlands in Zambia. Utilization by local populations is described.
Zbasin, Zambia, vegetation, human use/impact

181. Clancey, P.A. (1996). *The Birds of Southern Mozambique*. African Bird Book Publishing, Westville, Natal. ISBN 0-620-19918-0. 329 pp.
Detailed illustrated account of the birds found in Mozambique south of the Zambezi; an up-date of Clancey (1971). Distribution maps of some species are given; a gazeteer is included.
checklist, LZam, Mozambique, birds

182. Clarke, J.E. (1975). Zambia's wetlands. *Black Lechwe* **12**(1): 14-17.
Brief account of the 9 major wetlands of Zambia, giving size and conservation importance.
Zbasin, Zambia, conservation

183. Coates-Palgrave, K. (1988). *Trees of Southern Africa*. Struik, Cape Town, South Africa. ISBN 0-86977-081-0. 959 pp.
Detailed, illustrated identification guide to the woody plants south of the Zambezi. Simplified distribution maps are given.
SAfrica, checklist, plants

184. Coaton, W.G.H. and Sheasby, J.L. (1973). National survey of the Isoptera of Southern Africa: part 1. *Cimbebasia* **3**(1): 1-7.

First part of a 18 part series of papers (from Cimbebasia 1973-78 and Entomology Memoirs 48-53) on the termites of southern Africa. Very few records from Botswana (including Okavango/Chobe), Zimbabwe and Mozambique are cited.
SAfrica, checklist, insects

185. Coche, A.G. (1971). Lake Kariba Basin: a multidisciplinary bibliography, annotated and indexed, 1954-1968. *Fisheries Research Bulletin, Zambia* **5**: 11-87.
Annotated bibliography of the Lake Kariba basin including chronology of the main events and agencies involved. Author, subject and chronological indices are given.
MZam, bibliography, Zambia, Zimbabwe, Kariba, fisheries, fish

186. Coche, A.G. (1974). Semi aquatic and aquatic vegetation. In: *Lake Kariba: a Man-made Tropical Ecosystem in Central Africa* (edited by Balon, E.K. and Coche, A.G.). W. Junk, The Hague, Netherlands. 43-46 pp.
Not seen.

187. Coke, M. (1968). The distribution of fish on a bush-cleared area of Lake Kariba, Central Africa. *American Fisheries Society, Transactions* **97**: 460-465.
Distribution and yield of commercially important fish caught in 6 inch gillnets is presented. Yields were greater near the bottom than the water surface, but decreased with water depth. The highest yields were from nets set at 1.5 m depth.
MZam, survey, Zimbabwe, Kariba, fisheries, fish

188. Cole, M.M. (1963). Vegetation and geomorphology in Northern Rhodesia: an aspect of the distribution of the savanna of Central Africa. *Geographical Journal* **129**(3): 290-310.
Account of the factors determining vegetation structure across Zambia. Geomorphology is shown to be of great importance, as in the floodplain grasslands which are subject to seasonally poor drainage. Older floral elements may persist on old exhausted soils with poor drainage. Most of the grasslands lie on sandy to sandy-clay soils with a bed of nodular laterite below the surface; soils are acid and low in exchangeable bases, having suffered leaching over a long period. The grasslands of the Kafue Flats, however, lie on black clay soils which are base-rich and sometimes calcareous. The dynamic nature of vegetation on a changing landscape is stressed.
Zambia, UZam, Zbasin, biogeography, vegetation, ecology

189. Collar, N.J., Crosby, M.J. and Stattersfield, A.J. (1994). *Birds to Watch 2: The World List of Threatened Birds.* BirdLife International, Cambridge, UK. ISBN 0-946888-30-2. 407 pp.
Authoritative account on threatened birds worldwide. Uses the new IUCN criteria of threat status for each country including Botswana, Malawi, Mozambique, Namibia and Zambia, and lists the threatened and near-threatened species. Among waterbirds, Slaty Egret (in 3 countries), Wattled Crane (in 5), Corncrake (in 3) and White-winged Flufftail (in 1) are all threatened and described in some detail. For near-threatened waterbirds, Madagascar Pond Heron (in 1), Shoebill (in 2), Lesser Flamingo (in all 5), Great Snipe (in 4) and Black-winged Pratincole (in 3) are simply listed. Each species is also categorised according to any of 9 threats.
SAfrica, conservation, birds

190. Collar, N.J. and Stuart, S.N. (1985). *Threatened Birds of Africa and Related Islands*. International Council for Bird Preservation/IUCN, Cambridge, UK. ISBN 2-88032-604-4. 761 pp. The ICBP/IUCN Red Data Book, part 1.
Comprehensive book giving details of conservation status and type of threat for many bird species. Covers wetland birds and bird habitats of the Zambezi wetlands, including Slaty Egret (indeterminate), Shoebill Stork (special concern), Wattled Crane (special concern) and White-winged Flufftail (indeterminate).
SAfrica, conservation, birds

191. Connant, R.A. (1975). Preliminary counts of the Liuwa Plain. National Parks and Wildlife Service, Lusaka, Zambia. Unpublished report.
Not seen.
Zambia, UZam, Barotse, Lmammals

192. Cooke, H.J. (1976). The palaeogeography of the Middle Kalahari of northern Botswana and adjacent areas. In: *The Okavango Delta and its Future Utilisation* (edited by Botswana Society). Botswana Society, Gaborone, Botswana. pp.21-28.
Account of the geomorphology of much of N Botswana and the processes which formed it, with particular reference to the Okavango.
UZam, Botswana, Okavango, palaeogeography

193. Cooper, R. (1973). *Butterflies of Rhodesia*. Bundu Series Longman, Harare, Zimbabwe. ISBN 0-582-64107-1. 138 pp.
Illustrated guide to the butterflies of Zimbabwe, with introductory sections on anatomy, variation and collecting.
Zbasin, checklist, Zimbabwe, insects

194. Coppinger, M.P., Williams, G.D. and Maclean, G.L. (1988). Distribution and breeding biology of the African Skimmer on the upper and middle Zambezi river. *Ostrich* **59**(3): 85-96.

Survey of a water bird along the Zambezi from the source to the Luangwa confluence in 1986-87. 1000 birds were counted in Barotseland and 230 in E Caprivi; 33 of 35 breeding colonies found were on the Barotse floodplain.
survey, UZam, MZam, Barotse, Mana, Chobe, birds

195. Coppinger, M. and Williams, J. (1993). *Zambezi: River of Africa*. Struik, Cape Town, South Africa. ISBN 1-86825-503-4.
Not seen.
Zbasin

196. Cott, H.B. (1932). The Zoological Society's expedition to the Zambezi, 1927: No.4 - On the ecology of tree-frogs in the Lower Zambezi Valley, with special reference to predatory habits considered in relation to the theory of warning colours and mimicry. *Proceedings of the Zoological Society of London* **1932**: 471-541.
Account of a collecting trip for tree frogs in the Marromeu area; 7 species are mentioned.
LZam, Mozambique, Delta, ecology, amphibians

197. Cott, H.B. (1934). The Zoological Society's expedition to the Zambezi, 1927: No.5 - On a collection of lizards, mainly from Portuguese East Africa, with descriptions of new species of *Zonurus, Monopeltis*, and *Chirindia*. *Proceedings of the Zoological Society of London* **1934**: 145-173.
Account of reptiles collected during a trip to the lower Shire valley and Zambezi delta; 24 species are listed, 17 from the delta.
LZam, Malawi, Mozambique, LShire, Delta, reptiles

198. Cott, H.B. (1935). The Zoological Society's expedition to the Zambezi, 1927: No.6 - On a collection of snakes from Portuguese East Africa. *Proceedings of the Zoological Society of London* **1934**(4): 963-975.
Account of snakes collected during a trip to the Zambezi Delta; 29 species are described. A checklist of amphibians (32 species) and reptiles (69 species), principally from the lower Zambezi and delta, is given.
LZam, checklist, Mozambique, Delta, amphibians, reptiles

199. Cott, H.B. (1961). Scientific results of an enquiry into the ecology and economic status of the Nile Crocodile (*Crocodilus niloticus*) in Uganda and Northern Rhodesia. *Transactions of the Zoological Society of London* **29**(4): 211-337.
Detailed study on diet and biology of the crocodile, including data from the Bangweulu swamps, Luangwa valley, Kafue Flats and the upper Zambezi.
Zbasin, survey, Luangwa, Kafue, UZam, Bangweulu, Zambia, ecology, reptiles

200. Coulson, I. (1992). Linyanti/Kwando vegetation survey. Kalahari Conservation Society, Gaborone, Botswana. Unpublished report + map.
Not seen.
UZam, survey, Botswana, Chobe, vegetation

201. Coulter, G.W., Allanson, B.R., Bruton, M.N., Hart, R.C., Jackson, P.B.N. and Ribbink, A.J. (1986). Unique qualities and special problems of the African Great Lakes. *Environmental Biology of Fishes* **17**(3): 161-183.
Useful general account of the African lakes, including Lake Malawi, and their biodiversity problems.
SAfrica, Malawi, LMalawi, biogeography, conservation, ecology, fish

202. Cowx, I.G. and Kapasa, C.K. (1995). Species changes in reservoir fisheries following impoundment: the case of Lake Itezhi-tezhi, Zambia. In: *The Impact of Species Changes in African Lakes* (edited by Pitcher, T.J. and Hart, P.J.B.). Fish and Fisheries Series No. 18. Chapman & Hall, London, UK. ISBN 0-412-55050-4. pp.322-332.
Study of the changes in fish species composition and abundance following damming of the Kafue river. A marked decline in fish catches was noted following initial high productivity. There was also a decline in species diversity with cichlids becoming dominant, ascribed to fluctuating lake-levels. There is an unfilled niche for plankton-feeding open-water species.
UZam, Zambia, Kafue, fisheries, environmental assessment, fish

203. Crawford-Cabral, J. (1989). A list of Angolan Chiroptera with notes on their distribution. *Garcia de Orta, Série Zoologia, Lisboa* **13**(1-2): 7-48.
Detailed summary of the distributions (with maps) of 61 species or subspecies of Angolan bats. Ecogeographic zones and palaeo-ecological determinants are mentioned. The dearth of any specimens from the SE portion of the country is highlighted. A detailed bibliography and a gazetteer is included.
UZam, Angola, Smammals

204. Cronberg, G. (1997). Phytoplankton in Lake Kariba, 1986-1990. In: *Advances in the Ecology of Lake Kariba* (edited by Moreau, J.). University of Zimbabwe Publications, Harare, Zimbabwe. ISBN 0-908307-54-3. 66-101 pp.

Account of studies into phytoplankton around the lake and at various times of year. The plankton has a riverine origin, and is mesotrophic. Composition shows a typical seasonal pattern with blue-green algae dominating in the warm rainy period and diatoms in the cold dry season. 155 species of algae are listed.
MZam, Zimbabwe, Kariba, ecology, water quality, phytoplankton

205. Cumming, D.H.M., Mackie, C., Magane, S. and Taylor, R.D. (1994). Aerial census of large herbivores in the Gorongosa National Park and the Marromeu area of the Zambezi delta in Mozambique: June 1994. In: *Description of Gorongosa-Marromeu Natural Resource Management Area* IUCN ROSA, Harare, Zimbabwe. 10 pp.
Results of an aerial census of Gorongosa and central Marromeu. Buffalo, hippo and wildebeest have disappeared from Gorongosa NP and populations of elephant, hartebeest, waterbuck and zebra are now at very low densities (c.1 animal/10 km²), a drastic decline on the 1979 census. Elephant numbers were estimated at 108, and buffalo at 2346. Continued drastic declines in buffalo and waterbuck in Marromeu are noted; the declines seem to have occurred before 1990.
LZam, survey, Mozambique, Delta, Lmammals

206. Curson, H.H. (1947). Notes on Eastern Caprivi Strip. *South African Journal of Science* **43**: 124-157.
Early detailed account of the topography, flood levels, climate, soils and vegetation. A list of 218 plant species is included.
UZam, survey, checklist, Namibia, Chobe, hydrology, agriculture, vegetation, plants

207. Curtis, B.A. (1991). Freshwater macro-invertebrates of Namibia. *Madoqua* **17**(2): 163-187.
Account of the larger invertebrates found in freshwater and wetlands from all over Namibia. There are sections on sponges, Coelenterates, flatworms, ectoprocta, roundworms, annelids, molluscs, crustacea and insects. Composition is also discussed by wetland/river type. An extensive bibliography is given. A list of 646 species is presented (127 from E Caprivi); about 50 of these species are thought to be endemic to Namibia. The E Caprivi wetlands are probably grossly under-recorded, but are not considered comparatively rich or specialised.
UZam, survey, checklist, bibliography, Namibia, Chobe, Okavango, ecology, insects, crustacea, molluscs, Oinverts

208. Da Silva, J.A. (1986). River runoff and shrimp abundance in a tropical coastal ecosystem - the example of the Sofala Bank (Central Mozambique). (edited by Skreslet, S.). NATO ASI Series 67. Springer-Verlag, Berlin, Germany. 329-344 pp.
Account of the abundance of the shallow water shrimp as related to outflows of the Zambezi. Flows directly affect the number of recruits or induce changes size at migration. It is not clear, but the paper seems to say that reduced flood flows replaced by a more continual flow regime since Cabora Bassa has had a detrimental affect on the shrimp fishing industry.
LZam, Mozambique, Delta, hydrology, fisheries, crustacea

209. Dangerfield, J.M. (1993). Elephants, soil animals and biodiversity. *Kalahari Conservation Society Newsletter* **41**: 24-25.
Popular account of research on the effects of elephant on ecological processes in Chobe NP using soil macrofauna as indicators.
UZam, Botswana, Chobe, ecology, Lmammals, insects

210. Dangerfield, J.M. (1997). Abundance and diversity of soil macrofauna in northern Botswana. *Journal of Tropical Ecology* **13**(4): 527-538.
Account of the composition and relative abundance of soil fauna taken in various parts of N Botswana including in riparian woodland.
UZam, Botswana, Chobe, Okavango, insects, Oinverts

211. Dangerfield, J.M., McCarthy, T.S. and Ellery, W.N. (1998, in press). The mound building termite *Macrotermes michaelseni* as an ecosystem engineer. *Journal of Tropical Ecology*
Account of the effects of a species of termite on the floodplains of the Okavango. Their mounds modify nutrient flow rates and distribution, and landscape topography.
UZam, Botswana, Okavango, ecology, insects

212. Davies, B.R. (1975a). Cahora Bassa hazards. *Nature* **254**: 447-448.
Letter pointing out the detrimental effects of the closure of Cabora Bassa dam in 1974.
LZam, Mozambique, Cabora, Delta, environmental assessment, human use/impact, conservation

213. Davies, B.R. (1975b). They pulled the plug out of the Lower Zambezi. *African Wildlife* **29**(2): 26-27.
Popular article on the environmental impact of the closure of Cabora Bassa dam.
LZam, Mozambique, Cabora, Delta, environmental assessment

214. Davies, B.R. (1986). The Zambezi river system. In: *The Ecology of River Systems* (edited by Davies, B.R. and Walker, K.F.). W. Junk, Dordrecht, Netherlands. pp.225-267.
Not seen.
Zbasin, hydrology

215. Davies, B.R., Hall, A. and Jackson, P.B.N. (1975). Some ecological aspects of the Cabora Bassa dam. *Biological Conservation* **8**: 189-201.

Account of the potential impacts of the impoundment of the Zambezi at Cabora Bassa. Discussion includes sections on aquatic weeds, fisheries, bush clearing, wildlife, human health and downstream effects.
MZam, LZam, Mozambique, Cabora, environmental assessment, human use/impact, hydrology, ecology

216. Davies, J.E. and Bowles, J. (1976). Ecology of the tsetse fly in the Okavango Delta. In: *The Okavango Delta and its Future Utilisation* (edited by Botswana Society). Botswana Society, Gaborone, Botswana. pp.141-152.
General account of the biology and ecology of the tsetse fly with particular reference to its distribution and control in the Okavango delta.
UZam, Botswana, Okavango, human use/impact, ecology, insects

217. Davison, E. (1950). A maze of reeds: the home of the sitatunga. *African Wild Life* **4**: 57-59.
Popular account on the natural history of the sitatunga in the Chobe area.
UZam, Botswana, Namibia, Chobe, Lmammals

218. De Moor, F.C. (1978). Botswana Meloidae (Coleoptera). *Occasional Papers of the National Museums and Monuments of Rhodesia* **6**(3): 80-127.
Account of blister beetles from Botswana, including some from the Okavango and Chobe swamps area.
UZam, checklist, Botswana, insects

219. De Vos, A. and Dowsett, R.J. (1966). The behaviour and population structure of three species of the genus *Kobus*. *Mammalia* **30**: 30-55.
Account of study on the behaviour and population structures of lechwe, waterbuck and puku in Zambia. Compares social organisation, territorial behaviour and habitat selection.
UZam, Zambia, Lmammals

220. Debenham, F. (1952a). Study of an African swamp. *Report of the Cambridge University Expedition to the Bangweulu Swamps, Northern Rhodesia, 1949* HMSO, London, UK.
Not seen.
UZam, Zambia, Bangweulu

221. Debenham, F. (1952b). Studies of an African swamp. *The Northern Rhodesia Journal* **??**: 88.
Not seen.
UZam, Zambia, Bangweulu

222. Deloitte & Touche (1991). Chobe National Park: Management Plan. Department of Wildlife & National Parks, Gaborone, Botswana. 2 volumes
Consultants' report giving a detailed management plan for a National Park. Appendices include a list of 460 bird species (taken from various sources and Bird Club records), list of 17 amphibians and 64 reptile species (taken from Auerbach 1987), list of 74 fish species (taken from Bell-Cross & Minshull 1988), and a list of 44 large mammal species (taken from Smithers 1971).
UZam, checklist, Botswana, Chobe, birds, reptiles. amphibians, fish, Lmammals

223. Dennis, N. and Tarboton, W. (1993). *Waterbirds.* Struik, Cape Town. ISBN 1-86825-337-6.
Not seen.
SAfrica, birds

224. Denny, P. [editor] (1985). *The Ecology and Management of African Wetland Vegetation.* Geobotany Vol. 6. W. Junk, Dordrecht, Netherlands. ISBN 90-6193-509-1. 344 pp.
Compiled book containing 10 detailed and definitive papers on various aspects of the vegetation, botany and ecology of wetlands throughout Africa. A botanical/ecological approach is taken, rather than a geographical approach.
SAfrica, vegetation, ecology, conservation, probspp, plants

225. Department of Biology [compiler] (1996). Lake Chilwa Ramsar site study: executive summary. University of Malawi, Zomba, Malawi. 32 pp.
Report on various aspects of the biology and ecology of Lake Chilwa. The importance of the lake for waterfowl, particularly Palaearctic migrants, and fishery is emphasised. Sections on ecology, vegetation, invertebrates, fish, amphibians, reptiles, mammals and birds are included.
Malawi, LChilwa, fisheries, ecology, conservation, vegetation, fish, birds, reptiles, amphibians, Lmammals, insects, Oinverts

226. Dodman, T. (1996a). Distribution of cranes in Zambia. In: *Proceedings of 1993 African Crane and Wetland Training Workshop* (edited by Beilfuss, R.D., Tarboton, W.R. and Gichuki, N.N.). International Crane Foundation, Baraboo, WI, USA. pp.251-254.
Zambia has extensive habitat for two species of crane; the Kafue Flats being the most important area. The Wattled Crane is found in many of the wetlands, while the Grey Crowned Crane is concentrated in the Luangwa valley.
UZam, MZam, Zambia, Kafue, Luangwa, birds

227. Dodman, T. (1996b). Present status and distribution of cranes in the Kafue Flats, Zambia with reference to population estimates of the 1980's. In: *Proceedings of 1993 African Crane and Wetland Training*

Workshop (edited by Beilfuss, R.D., Tarboton, W.R. and Gichuki, N.N.). International Crane Foundation, Baraboo, WI, USA. pp.255-259.
Brief account of distribution and numbers of Wattled Crane and Grey Crowned Crane on the Kafue Flats in 1992/93. Notes on breeding behaviour are included.
UZam, Zambia, Kafue, conservation, birds

228. Dodman, T. and Taylor, V. (1995). *African Waterfowl Census, 1995*. International Waterfowl Research Bureau, Slimbridge, UK. ISBN 1-900442-02-7. 192 pp.
Counts were made in the Lochinvar and Blue Lagoon NPs on the Kafue Flats in Zambia in July 1994 (29,591 birds of 57 spp) and in January 1995 (49,181 birds of 82 spp).
survey, Zbasin, Kafue, UZam, conservation, birds

229. Dodman, T. and Taylor, V. (1996). *African Waterfowl Census, 1996*. Wetlands International, Wageningen, Netherlands. ISBN 1-900442-11-6. 206 pp.
Counts were made in the Elephant Marsh in Malawi in July 1995 (210 birds of 42 spp) and in the Lochinvar and Blue Lagoon NPs on the Kafue Flats in Zambia in July 1995 (4667 birds of 46 spp) and January 1996 (27,175 birds of 63 spp).
LZam, UZam, survey, Zbasin, conservation, birds

230. Donnelly, B.G. and Hustler, K. (1986). Notes on the diet of the Reed Cormorant and Darter on Lake Kariba during 1970 and 1971. *Arnoldia (Zimbabwe)* **9**(24): 319-324.
Study of stomach contents of 128 cormorants and 28 darters from Lake Kariba. Mostly non-commercial fish species were found.
MZam, Zimbabwe, Kariba, ecology, birds

231. Doria, C. and Nyirenda, P. (1995). *A Guide to Snakes of Luangwa Valley*. Wildlife Conservation Society of Zambia, Lusaka, Zambia. 107 pp.
An illustrated guide to the snakes of the South Luangwa NP, Zambia.
MZam, Luangwa, checklist, Zambia, reptiles

232. Douthwaite, R.J. (1974). An endangered population of Wattled Cranes (*Grus carunculatus*). *Biological Conservation* **6**(2): 134-142.
Account of Wattled Cranes on the Kafue Flats. Up to 3000 were estimated for the dry season. They are threatened by an upstream dam and the changed flooding regime; breeding success is higher in good flood years. Food plants are listed.
UZam, survey, Zambia, Kafue, conservation, ecology, birds

233. Douthwaite, R.J. (1977). Filter-feeding ducks of the Kafue Flats, Zambia, 1971-1973. *Ibis* **119**(1): 44-66.

Account of the occurrence and feeding habits of 7 species of duck, mainly at Lochinvar NP. At times, the numbers of 3 species (Fulvous and White-faced Whistling Ducks, Red-billed Teal) exceeded 25,000 and Pochard reached 6500. Despite similarities in diet, the ducks differed in feeding behaviour. Fruits, seeds, herbs and aquatic grasses were the most important food plants.
UZam, Zambia, Kafue, ecology, birds

234. Douthwaite, R.J. (1982a). Changes in Pied Kingfisher (*Ceryle rudis*) feeding related to endosulfan pollution from tsetse fly control operations in the Okavango Delta, Botswana. *Journal of Applied Ecology* **19**: 133-141.
Not seen.
UZam, Botswana, Okavango, pollution, ecology, birds

235. Douthwaite, R.J. (1982b). Waterbirds: their ecology and future on the Kafue Flats. In: *Proceedings of the National Seminar on Environment and Change: the Consequences of Hydroelectric Power Development on the Utilization of the Kafue Flats* (edited by Howard, G.W. and Williams, G.J.). Kafue Basin Research Committee, Lusaka, Zambia. pp.137-140.
Account of waterbirds found on the Kafue Flats. Over 400 species of bird have been recorded, 125 are waterbirds. The Flats are the most important site for Wattled Crane.
UZam, Zambia, Kafue, ecology, birds

236. Douthwaite, R.J. (1992). Effects of DDT on the Fish Eagle *Haliaeetus vocifer* population of Lake Kariba in Zimbabwe. *Ibis* **134**: 250-258.
Account of the impacts of DDT application for tsetse fly control on the Fish Eagle on Lake Kariba. High DDT residues were found in some eggs.
MZam, Zimbabwe, Kariba, pollution, ecology, birds

237. Douthwaite, R.J., Hustler, C.W., Kruger, J. and Renzoni, A. (1992). DDT residues and mercury levels in Reed Cormorants on Lake Kariba: a hazard assessment. *Ostrich* **63**: 123-127.
Account of the impacts of DDT and mercury on the Reed Cormorant in Lake Kariba. DDT residues were detected in all samples, along with 4 insecticides in some. Adult female fat contained sufficient to cause egg thinning and breeding failure.

MZam, Zimbabwe, Kariba, pollution, ecology, birds

238. Douthwaite, R.J. and Tingle, C.C.D. [editors] (1994). *DDT in the Tropics: The impact on wildlife in Zimbabwe of ground- spraying for tsetse fly control.* Natural Resources Institute, Chatham, UK. ISBN 0-85954-364-1. 195 pp.
Multidisciplinary study on the effects of DDT spraying on a range of organisms (bats, birds, lizards, fish, insects) in the middle Zambezi catchment. Adverse effects were found in populations of 4 birds and 1 lizard species, and species numbers were low for some.
MZam, Zimbabwe, Kariba, pollution, environmental assessment, ecology, birds, fish, reptiles, insects, Smammals

239. Douthwaite, R.J. and Van Lavieren, L.P. (1977). A description of the vegetation of Lochinvar National Park, Zambia. Technical Report No.34. National Council for Scientific Research, Lusaka, Zambia. 66 pp.
Not seen.
UZam, survey, Zambia, Kafue, vegetation

240. Dowsett, R.J. (1966a). A preliminary list of the birds of the Kafue Flats. *The Puku* **4**: 101-124.
Checklist of 337 species from the Kafue Flats from personal observation and other publications, of which 119 are waterbirds. Brief indications of habitat are given.
UZam, checklist, Zambia, Kafue, birds

241. Dowsett, R.J. (1966b). The status and distribution of the Hottentot teal *Anas punctata* in Zambia. *The Puku* **4**: 125-127.
Brief account of the status of a migratory duck, mostly found in the upper Kafue.
UZam, Zambia, Kafue, birds

242. Dowsett, R.J. (1966c). The status of four species of aquatic bird in Zambia as suggested by ringing recoveries. *The Puku* **4**: 129-133.
Brief account of migrant birds (Cattle Egret, Sacred Ibis, African Spoonbill, Red-billed Teal) ringed in South Africa that have been recovered in Barotseland and elsewhere.
UZam, Zambia, Barotse, birds

243. Dowsett, R.J. (1966d). Wet season game populations and biomass in the Ngoma area of the Kafue National Park. *The Puku* **4**: 135-145.
Study on the biomass and composition of large mammal populations on grasslands in the Kafue NP. 26 species are noted.
UZam, survey, Zambia, Kafue, Lmammals

244. Dowsett, R.J. (1969). Ringed Sacred Ibis *Threskiornis aethiopica* recovered in Zambia. *The Puku* **5**: 59-63.
Account of 48 recoveries from birds ringed in South Africa, 42 of which were found in Barotseland. There are both a high number of waterbirds and high hunting pressures there.
UZam, Zambia, Barotse, birds

245. Dowsett, R.J. (1993). Afrotropical avifaunas: annotated country checklists. In: *A contribution to the Distribution and Taxonomy of Afrotropical and Malagasy Birds* (edited by Dowsett, R.J. and Dowsett-Lemaire, F.). Tauraco Press, Liège, Belgium. ISBN 2-87225-010-X. pp.1-322.
A series of country bird checklists (including Angola, Botswana, Namibia, Zambia, Zimbabwe, Malawi and Mozambique), with common names, status and bibliographic references. Summary statistics are given.
SAfrica, checklist, Angola, Botswana, Namibia, Zambia, Zimbabwe, Malawi, Mozambique, biogeography, birds

246. Dowsett, R.J. and De Vos, A. (1965). The ecology and numbers of aquatic birds on the Kafue Flats, Zambia. In: *Wildfowl Trust 16th Annual Report, 1963-1964.* 67-73 pp.
Up to 33 species censussed on the flats and along the Kafue River.
UZam, survey, Zambia, Kafue, ecology, birds

247. Du Toit, R.F. [compiler] (1982). *A preliminary assessment of the environmental implications of the proposed Mupata and Batoka hydroelectric schemes (Zambezi river, Zimbabwe).* Natural Resources Board, Harare, Zimbabwe. 209 pp.
Study of the environmental impacts of two potential dams. Vegetation, terrestrial invertebrates, amphibians and reptiles, birds and mammals were looked at. The Mupata scheme would have a severe negative effect on the ecology of the Mana floodplain. Birds (16 spp) would be affected adversely (5 spp beneficially). The negative effects from the Batoka Gorge scheme would be relatively minor.
MZam, Mana, Zimbabwe, environmental assessment

248. Du Toit, R.F. (1983). The Zambezi schemes. *Zimbabwe Wildlife* **32**: 2-7.
Synopsis of the findings of an environmental impact assessment of the Batoka and Mupata dams on the Zambezi in Zimbabwe. The Batoka scheme is considered far less detrimental environmentally.
MZam, Mana, Zimbabwe, environmental assessment

249. Du Toit, R.F. (1994). Mid-Zambezi and Mana Pools: ecology and conservation status. In: *Wetlands Ecology and Priorities for Conservation in Zimbabwe: Proceedings of a seminar on wetlands in Zimbabwe* (edited by Matiza, T. and Crafter, S.A.). IUCN Wetlands Programme No. 14. IUCN, Gland, Switzerland. ISBN 2-8317-0202-X. pp.35-42.
Brief account of the mid-Zambezi valley in Zimbabwe, with particular reference to the lake shore habitats of Lake Kariba, the alluvial terraces below Kariba, and inland mopane pans. Wetlands are shown to be of limited extent, the largest being Mana Pools.
MZam, Mana, Zimbabwe, environmental assessment, conservation, vegetation

250. Dudley, C.O. (1978). The herpetofauna of the Lake Chilwa Basin. *Nyala* **4**(2): 87-99.
Account of the reptiles and amphibians of Lake Chilwa. The general area is said to be rich as it forms part of a zoogeographic transition zone. A checklist is given, and some species discussed.
checklist, Malawi, LChilwa, biogeography, ecology, reptiles, amphibians

251. Dudley, C.O. (1994). The flora of Liwonde National Park. Malawi.
Not seen.
checklist, LZam, MShire, Malawi, plants

252. Dudley, R.G. (1974). Growth of *Tilapia* of the Kafue floodplain, Zambia: predicted affects of the Kafue Gorge dam. *Transactions of the American Fisheries Society* **103**(2): 281-291.
Account of the growth of 3 tilapia species. It is predicted that their growth and survival would be enhanced by flooding for the Kafue Gorge dam.
UZam, Zambia, Kafue, environmental assessment, fisheries, fish

253. Dudley, R.G. (1976). Status of major fishes of the Kafue floodplain, Zambia five years after completion of the Kafue Gorge dam. National Science Foundation, Washington DC, USA. 71 pp.
Not seen. Report which may give lists of important fish species and data on changes after the closure of the Kafue Gorge dam.
UZam, Zambia, Kafue, environmental assessment, human use/impact, fisheries, fish

254. Dudley, R.G. (1979). Changes in growth and size distribution of *Sarotherodon macrochir* and *Sarotherodon andersoni* from the Kafue floodplain, Zambia, since construction of the Kafue Gorge dam. *Journal of Fish Biology* **14**: 205-223.
Account of the growth of 2 tilapia species since dam closure (see Dudley 1974). There appears to be no obvious change in growth rates, and reproductive success is said to have become more erratic owing to changes in flood regime.
UZam, Zambia, Kafue, environmental assessment, fisheries, fish

255. Dudley, R.G., Manning, I. and McCormick, S. (1991). Kapichira environmental assessment: Malawi Power V Project. Associates in Rural Development, Burlington, Vermont, USA. 2 volumes
Consultants' report giving a good assessment of the possible effects of the Kapichira power station on the wetlands of the lower Shire valley. Contains summaries of basic data on Elephant Marsh (physiography, geology, hydrology, biology, socio-economic). On biodiversity, concentrates on hippo, crocodiles and fisheries. They found that unless Lake Malawi water levels drop significantly, no negative effects on the wetlands could be expected. But as flow rates and water levels fluctuate considerably in the short term, possible disturbance to the marshes would include lower fish catches, river bank erosion, reduced crocodile breeding and reduction in extent of marsh land. Simplified lists of vegetation/plant species, larger mammals and fish are given in appendices.
LZam, Malawi, LShire, environmental assessment, human use/impact, hydrology, fisheries, vegetation, Lmammals, fish

256. Dudley, R.G. and Scully, R.J. (1980). Changes in experimental gillnet catches from the Kafue floodplain, Zambia, since construction of the Kafue Gorge Dam. *Journal of Fish Biology* **16**: 521-537.
Study on changes in fish catches on the Kafue floodplain after dam construction. Of 9 species abundantly caught pre-impoundment (1969/70), only 1 species increased in frequency after impoundment (1975/76), while 3 predator species decreased. It is not clear if this is due to changes in flooding patterns or earlier dry conditions. Annual fish yield was around 5000 tons.
UZam, Zambia, Kafue, fisheries, human use/impact, environmental assessment, fish

257. Dunham, K.M. (1986). Movements of elephant cows in the unflooded Middle Zambezi Valley, Zimbabwe. *African Journal of Ecology* **24**: 287-291.
Radio tracking study to investigate possible long distance movements between Zambezi riparian fringe and escarpment woodlands. Cow herds did not move between the two areas.
MZam, Mana, Zimbabwe, Lmammals

258. Dunham, K.M. (1989). Vegetation-environment relations of a middle Zambezi floodplain. *Vegetatio* **82**(1): 13-24.
A study of the relationships between environmental factors and plant species composition of alluvial vegetation in the Mana Pools area along the Zambezi river. Grass and sedge species composition was shown to be related to soil moisture regime. Faidherbia albida is a pioneer species on low-lying sandbanks, and woody species diversity increased with height above the river. A list of plant species found is given.
MZam, Mana, checklist, Zimbabwe, vegetation, ecology, plants

259. Dunham, K.M. (1990). Biomass dynamics of herbaceous vegetation in Zambezi riverine woodlands. *African Journal of Ecology* **28**: 200-212.
Account of biomass, productivity and large mammal utilisation of floodplain herbaceous vegetation on the Mana floodplain, Zimbabwe. Production was greater in perennial than in annual grasslands, with utilisation varying between 53 and 99% of annual production.
MZam, Mana, Zimbabwe, vegetation, plants, Lmammals

260. Dunham, K.M. (1994). The effect of drought on the large mammal populations of Zambezi riverine woodlands. *Journal of Zoology, London* **234**: 489-526.
Account of densities of large mammal populations on alluvial woodlands on the Mana floodplain, Zimbabwe. Density decreased during the dry season and during drought. The effects of flood control by Kariba are shown, and has resulted in a long-term decline of grazers.
MZam, Mana, Zimbabwe, ecology, Lmammals

261. Dunham, K.M. and Tsindi, N. (1984). Record of the puku (*Kobus vardoni*) from Zimbabwe. *Zimbabwe Science News* **18**(3/4): 35.
First visual record of puku on the Zimbabwe side of Zambezi. Suggested that it had moved west from the Luangwa-Zambezi confluence.
MZam, Mana, Zimbabwe, Zambia, Lmammals

262. Dutton, P., Ramsey, S. and Falçâo, R. (1994). Aerial survey of hunting areas (coutadas) 6, 7, 9 and 15 conducted on behalf of Sociedade de Safaris de Moçambique (Safrique). Sociedade de Safaris de Moçambique, Beira, Mozambique. 26 pp.
Account of a 6% survey of larger mammals (grey duiker, impala, reedbuck, elephant and nyala) of the area north of Gorongosa. Estimates of total numbers (all species) are low at 408 head. Uncontrolled hunting is a major problem compounding diminuition of numbers owing to the war. Hardwoods are being illegally exploited. There is still good potential for use of the area for hunting.
LZam, survey, Mozambique, Delta, Lmammals

263. Duval, C.T. (1969). Recent ornithological records from the Southern Province. *The Puku* **5**: 223-226.
Brief notes on 20 species of bird from S Zambia, including some from wetlands.
UZam, Zambia, checklist, birds

264. Eagle, V. (1985). A survey of the spider fauna of Botswana: project report, June 1984. *Botswana Notes and Records* **17**: 131-139.
Report on collections of spiders from Botswana, including the Okavango.
UZam, Okavango, survey, Botswana, Oinverts

265. East, R. [editor] (1989). Antelopes Global Survey and Regional Action Plans: part 2, Southern and Central Africa. IUCN/SSC Antelope Specialist Group, IUCN, Gland, Switzerland.
Detailed reports for ten countries, including Angola, Botswana, Malawi, Mozambique, Namibia, Zambia and Zimbabwe. Reviews protected areas, threats and includes crude distribution maps of all species within each country report.
SAfrica, conservation, Lmammals

266. Eccles, D.H. (1985). Lake flies, water fleas and sardines - a cautionary note. *Biological Conservation* **33**: 309-333.
Discussion on the proposal to introduce kapenta into Lake Malawi and the impact this may have on the lake fish communities.
Malawi, LMalawi, conservation, environmental assessment, fisheries, ecology, fish, crustacea, insects

267. Eccles, D.H. and Trewavas, E. (1989). *Malawian Cichlid Fishes: the Classification of some Haplochrome Genera*. Lake Fish Movies/H.W. Dieckhoff, Herten, Germany. 334 pp.
Taxonomic book covering some of the commercially important genera of fish.
checklist, Malawi, LMalawi, fish

268. Edmonds, A.C.R. [compiler] (1976). *Republic of Zambia: Vegetation map*. Forest Department, Lusaka, Zambia. 9 sheets
Series of 9 colour maps at 1:500,000 scale bound in large format cover of the vegetation of Zambia. Accompanying text is printed on the reverse of each sheet. The legend shows 17 vegetation types, based primarily on the Yangambi classification system, grouped into 6 physiognomic classes. Most of the Barotse floodplains are mapped as grassland (type 17) with inclusions of Kalahari sand woodland (type 13), which becomes more common upstream. The Kafue flats (downstream) and the Lukanga swamps are both mapped as grassland (17), surrounded principally by munga woodland (type 15). Classification follows Fanshawe (1971).
Zbasin, survey, Zambia, vegetation

269. Edwards, D. (1972). Report by November 1972 joint Botswana-South Africa survey of the extent and degree of occurrence of *Salvinia molesta* (Kariba weed) in the Chobe-Linyanti-Kwando river system. Unpublished report, South Africa. 14 pp.

Report, including airphotos, on extent and distribution of Salvinia in the river system, showing distribution in parts on airphoto mosaics. Salvinia extended about 50 km upstream of Lake Liambezi.
UZam, survey, Namibia, Botswana, Chobe, probspp, plants

270. Edwards, D. and Thomas, P.A. (1977). The *Salvinia molesta* problem in northern Botswana and eastern Caprivi area. In: *Proceedings of the Second National Weeds Conference of South Africa* (edited by Annecke, D.). A.A. Balkema, Cape Town, South Africa. 221-239
Account of the distribution and history of Salvinia in the Kwando-Linyanti-Chobe river system, including results from control measures.
UZam, Namibia, Botswana, Chobe, probspp, plants

271. Elenbaas, P.F.M. and Grundel, C. (1994). Zooplankton composition and abundance in two impoundments in Zimbabwe. *Hydrobiologia* **272**: 265-275.
Account of the zooplankton, including rotifers and crustacea, of two man-made lakes near Harare, Lake Chivero and Cleveland Dam.
MZam, Chivero, Zimbabwe, ecology, zooplankton

272. Ellenbroek, G.A. (1987). *Ecology and productivity of an African wetland system: the Kafue Flats, Zambia.* Geobotany No. 9. W. Junk, Dordrecht, Netherlands. ISBN 90-6193-638-1. 267 pp.
Detailed quantitative ecological study on the vegetation of the Kafue Flats. About 3000-5000 km² out of 7000 km² is inundated for 1-7 months/year. Account covers physical environment, vegetation zones, phytosociology, plant phenology, plant productivity, decomposition and fire. One finding is that C3 grasses dominate on the floodplain.

UZam, Zambia, Kafue, vegetation, ecology

273. Ellery, W.N., Ellery, K., McCarthy, T.S., Cairncross, B. and Oelofse, R. (1989). A peat fire in the Okavango delta, Botswana, and its importance as an ecosystem process. *African Journal of Ecology* **27**: 7-21.
Account of peat fires in the Okavango swamps. These are shown to be long-lasting and to cause transformation of the habitat, and possibly later reflooding.
UZam, Botswana, Okavango, ecology, vegetation

274. Ellery, W.N. and McCarthy, T.S. (1996). Wetland dynamics and conservation: identifying key factors in the Okavango Delta, Botswana. In: *Proceedings of 1993 African Crane and Wetland Training Workshop* (edited by Beilfuss, R.D., Tarboton, W.R. and Gichuki, N.N.). International Crane Foundation, Baraboo, WI, USA. pp.323-332.
Account of ecosystem processes and dynamics in the Okavango delta as related to hydrology. The changing and mosaic nature of swamps are highlighted.
UZam, Botswana, Okavango, ecology, hydrology, conservation, palaeogeography

275. Ellery, W.N., McCarthy, T.S. and Dangerfield, J.M. (1997, in review). Biotic factors in mima mound development: evidence from floodplains of the Okavango Delta, Botswana. *International Journal of Environmental Science*
Not seen.
UZam, Botswana, Okavango, insects

276. Eriksson, M.O.G. (1994). Waterbird densities at Lake Kariba, Zimbabwe, during a period of extremely low waterlevel in 1984-85. *Honeyguide* **40**: 4-15.
Study on water bird numbers along the S bank of Lake Kariba. 25 species are recorded; no general patterns between waterbird occurrence and aquatic macrophytes.
MZam, Zimbabwe, Kariba, ecology, birds

277. Evans, R.E. (1982). The rehabilitation of the Savory Dam. *Zimbabwe Agricultural Journal* **79**: 47-56.

Gives a list with abundance of all fish species collected when a small dam near Harare was drained.
MZam, Zimbabwe, fish

278. Fanshawe, D.B. (1967). The vegetable ivory palm - *Hyphaene ventricosa* Kirk - its ecology, silviculture and utilisation. *Kirkia* **6**(1): 105-116.
Detailed account of the botany and ecology of the Hyphaene palm, with particular reference to Zambia. Includes information on growth rates, regeneration and utilisation.
Zambia, Zbasin, ecology, human use/impact, plants

279. Fanshawe, D.B. (1968). The vegetation of Sesheke District. Forest Research Pamphlet No. 16. Forest Department, Ndola, Zambia. 34 pp.
Account of the vegetation of Sesheke District in the south of Barotseland. The district is principally comprised of Kalahari sands, with some old alluvium. The vegetation is described under 12 types (Cryptosepalum forest, Baikiaea

forest, riparian woodland, miombo/kalahari woodland, suffrutex savanna, mopane woodland, munga woodland, kalahari termitaria, mopane termitaria, munga termitaria, dambo and floodplain) with species lists for each type.
survey, checklist, Zambia, UZam, Barotse, vegetation, plants

280. Fanshawe, D.B. (1969a). The Vegetation of Zambia. Forest Research Bulletin No. 7. Division of Forest Research, Kitwe, Zambia. 67 pp.
Comprehensive account of the vegetation of Zambia. There are 18 vegetation types described, grouped into 6 classes; these are mapped in Edmonds (1976) map of vegetation at scale 1:500,000. Floodplain grasslands often comprise swards of bunch grasses; Hyparrhenia rufa is characteristic of shallowly flooded margins and Echinochloa pyramidalis of the floodplain proper. Vossia is found in the "sump". Tristachya and Themeda are characteristic of the sandy floodplains of Barotseland. Swamps (e.g. Lukanga, Busanga) contain Cyperus papyrus, Oryza longistaminata, Leersia hexandra, Pennisetum glaucocladum, Phragmites mauritianus and Vossia cuspidata.
Zbasin, survey, Zambia, UZam, vegetation, plants

281. Fanshawe, D.B. (1969b). The vegetation of Kalabo District. Forest Research Pamphlet No. 22. Forest Department, Ndola, Zambia. 19 pp.
Account of the vegetation of Kalabo District in the northwest part of Barotseland. The district is very flat, around 75% being sand plain or floodplain, and poor in woody species. The vegetation is described under 9 types (swamp woodland, riparian woodland, seepage dambos, Kalahari woodland, Kalahari suffrutex savanna, dry dambo, munga termitaria, munga/riparian termitaria, and flood plains), with species lists for each type.
survey, checklist, Zambia, UZam, Barotse, vegetation, plants

282. Fanshawe, D.B. (1969c). The vegetation of Mongu-Lealui District. Forest Research Pamphlet No. 23. Forest Department, Ndola, Zambia. 22 pp.
Account of the vegetation of the Mongu area in W Zambia, lying principally on Kalahari Sand. 14 vegetation types are described (Cryptosepalum forest, Kalahari sand chipya, Baikiaea forest, Pteleopsis woodland, swamp woodland, riparian woodland, seepage dambo, miombo woodland, Kalahari sand woodland, munga woodland, dry dambo, miombo termitaria, munga termitaria and floodplain), each with species lists.
survey, checklist, Zambia, UZam, Barotse, vegetation, plants

283. Fanshawe, D.B. (1969d). The vegetation of Senanga District. Forest Research Pamphlet No. 26. Forest Department, Ndola, Zambia. 26 pp.
Account of the vegetation of Senanga District in central Western Province. About 40% of the district is liable to seasonal waterlogging or flooding. The vegetation is described under 15 types (Cryptosepalum forest, Baikiaea forest, secondary Baikiaea forest, riparian woodland, miombo/Kalahari woodland, Kalahari woodland, mopane woodland, munga woodland, mopane termitaria, munga termitaria, riparian termitaria, dambo termitaria, sand plains, dambos and flood plains), each with species lists. In the sand plains and dambos suffrutex species are characteristic. The flood plains contain many sweet grasses.
survey, checklist, Zambia, UZam, Barotse, vegetation, plants

284. Fanshawe, D.B. (1969e). The vegetation of Mwinilunga District. Forest Research Pamphlet No. 27. Forest Department, Ndola, Zambia. 35 pp.
Account of the vegetation of Mwinilunga District at the headwaters of the Zambezi. The vegetation is described under 15 types (Cryptosepalum forest, Kalahari sand chipya, chipya scrub, swamp forest, riparian forest, seepage dambo, miombo woodland, hill miombo, miombo/Kalahari woodland, watershed plain, dry dambos, miombo/kalahari termitaria, riparian termitaria, dambo grassland, riverine grassland), each with species lists. The district is perhaps the richest in plant species in Zambia with over 50 woody endemics.
survey, checklist, Zambia, UZam, headwater, vegetation, plants

285. Fanshawe, D.B. (1972). The biology of the reed - *Phragmites mauritianus* Kunth. *Kirkia* **8**: 147-150.
Account of the biology of the common reed, often found flanking river channels, with brief notes on its ecology, uses and control.
Zbasin, ecology, human use/impact, plants

286. Fanshawe, D.B. (1973a). The vegetation of Kabompo District. Forest Research Pamphlet No. 55. Forest Department, Ndola, Zambia. 21 pp.
Account of the vegetation of Kabompo District in northwest Barotseland. Almost the whole district is underlain by Kalahari sand. The vegetation is described under 13 types (dry evergreen forest, chipya woodland, dry deciduous forest, swamp forest, riparian forest, moist dambos, miombo woodland, Kalahari woodland, munga woodland, dry dambos, termitaria, dambo grassland, riverine grassland), with species lists for each type.
survey, checklist, Zambia, UZam, Barotse, vegetation, plants

287. Fanshawe, D.B. (1973b). The vegetation of Balovale District. Forest Research Pamphlet No. 56. Forest Department, Ndola, Zambia. 23 pp.
Account of the vegetation of Balovale (Zambezi) District in central North West Province. Most of the district is underlain by Kalahari sands. The vegetation is described under 18 types (dry evergreen forest, dry deciduous forest, swamp forest, riparian forest, moist dambos, miombo woodland, hill miombo woodland, Kalahari woodland, Kalahari/miombo woodland, Burkea-Erythrophleum woodland, Burkea-Diplorhynchus scrub, suffrutex savanna, bush groups, Kalahari sands munga woodland, dry dambos, miombo termitaria, dambo grassland, riverine grassland), each with species lists.
survey, checklist, Zambia, UZam, Barotse, vegetation, plants

288. Fanshawe, D.B. and Mutimushi, J.M. (1971). A check list of plant names in the Lozi languages. Forest Research Bulletin No. 23. Division of Forest Research, Kitwe, Zambia. 29 pp.
Comprehensive list of vernacular names of flowering plants from Western Province. Incorporated in Bingham's (1990) species list.
checklist, Zambia, UZam, Barotse, plants

289. FAO (1968). Wildlife, fisheries and livestock production. Vol. 5. *Multipurpose Survey of the Kafue River Basin, Zambia.* Report FAO SF: 35/ZAM FAO, Rome, Italy. 7 volumes.
Not seen. Should contain much important information on fisheries and wildlife.
UZam, Zambia, Kafue, fisheries, ecology, range/livestock, Lmammals, fish

290. Faulkner, H. (1868). *Elephant haunts: being a sportsman's narrative of the search for Dr. Livingstone.* Hurst & Blackett, London, UK. 324 pp.
Reports a few (8) elephant in the lower Shire, and small numbers of hippos and crocodiles. He describes thick woodland up to the rivers' edge but also many people present.
LZam, Malawi, LShire, history

291. Fenton, M.B., Thomas, D.W. and Sasseen, R. (1981). Nycteris grandis (Nycteridae): an African carnivorous bat. *Journal of Zoology, London* **194**: 461-465.
First report on a carnivorous bat which utilizes the alluvial floodplain at Mana Pools.
MZam, Mana, Zimbabwe, Smammals

292. Feresu, S.B. and Van Sickle, J. (1990). Coliforms as a measure of sewage contamination of the River Zambezi. *Journal of Applied Bacteriology* **68**: 397-403.
Study of faecal bacteria from untreated sewage in river water below Victoria Falls town.
MZam, Zimbabwe, water quality, human use/impact

293. Ferreira, G.d.V. (1964a). Catalogo dos Ortópteros de Moçambique. *Revista de Entomológica de Moçambique* **7**(1): 217-296.
Paper in Portuguese on the Orthoptera (grasshoppers, etc.) of Mozambique. Very few are recorded from wetlands.

LZam, checklist, Mozambique, insects

294. Ferreira, G.d.V. (1964b). Longicornios de Moçambique. *Revista de Entomológica de Moçambique* **7**(2): 451-838.
Paper in Portuguese on longicorn beetles of Mozambique. Very few are recorded from wetlands. A further account was published in 1966.
LZam, checklist, Mozambique, insects

295. Ferreira, M.C. (1963). Catalogo dos Coleopteros de Moçambique. *Revista de Entomológica de Moçambique* **6**(1): 1-532.
Lengthy account in Portuguese on many of the beetles of Mozambique. A further 2 papers (including one on scarabs) were written (1963-67). Keys are given.
LZam, checklist, Mozambique, insects

296. Filmer, M.R. (1991). *Southern African Spiders: an identification guide.* Baobab Books, Harare, Zimbabwe. ISBN 0-620-15886-7. 128 pp.
Illustrated identification guide by family to the spiders of southern Africa, principally South Africa.
SAfrica, Oinverts

297. Flora Zambesiaca Managing Committee (1960-to date). *Flora Zambesiaca* (edited by Pope, G.V.). Flora Zambesiaca Managing Committee, London, UK.
An on-going series of taxonomic publications covering the flora of Caprivi, Botswana, Zambia, Zimbabwe, Malawi and Mozambique. Each part covers a family or group of families. 154 out of 233 families have been published to date.

checklist, Zbasin, plants

298. Fox, P.J. and Matthiessen, P. (1982). Acute toxicity to fish of low-dose aerosol application of endosulfan to control tsetse fly in the Okavango Delta, Botswana. *Environmental Pollution (series 4)* **27**: 129-142.

Study shows significant fish mortality in lagoons in the Okavango delta after ultra-low volume spraying of endosulfan for tsetse fly control.
UZam, Botswana, Okavango, pollution, fish

299. Fox, P.J. and Watt, E.H. (1976). Some effects of *Salvinia molesta* on fish populations in the Linyanti. Unpublished report, Maun, Botswana. 2 pp.
Brief results of a fish catching trial in open and Salvinia-covered waters along the Linyanti river. Oxygen concentrations are given; those under Salvinia are 7% compared to 34-41% in open water. 11 fish species were caught in open water compared to 2 species under Salvinia, with only 12% of open-water weight.
UZam, survey, Botswana, Chobe, probspp, fish, plants

300. Frost, P.G.H. (1992). A policy framework for fire management in the Western Province of Zambia. RDP Livestock Services/Livestock Development Project Western Province, Mongu, Zambia. 71 pp.
Detailed consultants' report on the role and actions of fire, with particular reference to vegetation structure, composition and productivity in Western Province.
Zambia, UZam, Barotse, range/livestock, vegetation

301. Fry, C.H., Hosken, J.H. and Skinner, D. (1986). Further observations on the breeding of Slaty Egrets *Egretta vinaceigula* and Rufous-bellied Herons *Ardeola rufiventris*. *Ostrich* **57**(1): 61-64.
Detailed description of a breeding locality of these two species in the Okavango swamps.
UZam, Botswana, Okavango, birds

302. Fryer, G. (1957a). Freeliving freshwater crustacea from Lake Nyasa and adjoining waters. Part I - Copepoda. *Archiv für Hydrobiologie* **53**: 62-86.
Not seen. Considered an important publication on Lake Malawi.
Malawi, LMalawi, crustacea

303. Fryer, G. (1957b). Freeliving freshwater crustacea from Lake Nyasa and adjoining waters. Part II - Cladocera and Conchostraca. *Archiv für Hydrobiologie* **53**: 223-239.
Not seen. Considered an important publication on Lake Malawi.
Malawi, LMalawi, crustacea

304. Fryer, G. (1957c). Freeliving freshwater crustacea from Lake Nyasa and adjoining waters. Part III - General remarks with notes on certain Malacostraca. *Archiv für Hydrobiologie* **53**: 527-536.
Not seen. Considered an important publication on Lake Malawi.
Malawi, LMalawi, crustacea

305. Fryer, G. (1959). The trophic interrelationships and ecology of some littoral fish communities of Lake Nyasa with special reference to the fishes, and a discussion of the evolution of a group of rock-frequenting Cichlidae. *Proceedings of the Zoological Society of London* **132**: 153-281.
One of the first detailed accounts of the littoral fish communities of Lake Malawi.
Malawi, LMalawi, biogeography, ecology, fish

306. Fryer, G. (1972). Conservation of the Great Lakes of East Africa: a lesson and warning. *Biological Conservation* **4**(4): 457-475.
Account of the conservation problems facing the African great lakes, including Lake Malawi.
Malawi, LMalawi, conservation, ecology

307. Fryer, G. and Iles, T.D. (1972). *The Cichlid Fishes of the Great Lakes of Africa: Their Biology and Evolution.* Oliver & Boyd, Edingburgh, UK. ISBN 0-05-002347-0. 641 pp.
A major book on cichlid fish which has stimulated much of the later research. It gives accounts of the evolution, biology and commercial importance of these species in the African great lakes.
Malawi, LMalawi, ecology, biogeography, fisheries, fish

308. Gabinete do Plano do Zambèze (1973). Relatorios sobre o potential de pascigo dos Blocos 1-8. Recursos agrarios e planeamento do uso da terra, Bacia do Rio Zambèze. Empresa Técnica de Levantamentos Aereas/R.F. Loxton, Hunting & Associates, Lisbon, Portugal. 8 vols.
Consultants' report on the grazing potentials of part of the lower Zambezi valley.
LZam, Mozambique, Delta, agriculture, range/livestock

309. Gabinete do Plano do Zambèze (1975). Relatorio sobre o potential de pascigo dos Blocos 9-11. A.O.C. Technical Services/R.F. Loxton, Hunting & Associates, Lisbon, Portugal. 3 vols.
Consultants' report on the grazing potentials of part of the lower Zambezi valley.
LZam, Mozambique, Delta, agriculture, range/livestock

310. Games, I. (1983). Observations on the sitatunga *Tragelaphus spekei selousi* in the Okavango Delta of Botswana. *Biological Conservation* **27**: 157-170.
Account of the distribution and habits of sitatunga in the Okavango swamps. Seasonal movement and feeding patterns are affected by the annual flood regime. Conflicts with cattle are examined.
UZam, Botswana, Okavango, ecology, Lmammals

311. Games, I. (1984). Feeding and movement patterns of the Okavango sitatunga. *Botswana Notes & Records* **16**: 131-137.
Account of sitatunga populations in the Okavango, showing that their distribution is determined by flood regime. The species is a non-selective feeder.
UZam, Botswana, Okavango, ecology, Lmammals

312. Games, I. and Moreau, J. (1997). The feeding ecology of two nile crocodile populations in the Zambezi valley. In: *Advances in the Ecology of Lake Kariba* (edited by Moreau, J.). University of Zimbabwe Publications, Harare, Zimbabwe. ISBN 0-908307-54-3. 183-195 pp.
Study of the effects of crocodiles in Lake Kariba on the fish and fisheries. Fish form the major part of the diet, but the Kariba crocodiles probably only consume 10-15% of fish offtake from artesanal fishing.
MZam, Zimbabwe, Kariba, ecology, reptiles

313. Gammelsrod, T. (1992). Improving shrimp production by Zambezi river regulation. *Ambio* **21**(2): 145-147.
Study on variation in shrimp production off the Zambezi delta. Annual variations in abundance are correlated with wet season runoff. Control of flow from Cabora Bassa dam to fit in with the shrimp life cycle could improve potential productivity.
LZam, Mozambique, Delta, environmental assessment, fisheries, crustacea

314. Gammelsrod, T. (1992). Variation in shrimp abundance on the Sofala bank, Mozambique, and its relation to the Zambezi runoff. *Estuarine, Coastal and Shelf Science* **35**: 91-103.
Study on the relationship between water flows of the Zambezi and shrimp (Penaeus indicus) production on the Sofala Bank off the mouth of the Zambezi delta. Catch rate is positively related to river runoff, but not to rainfall. Annual shrimp abundance can be related to wet season river runoff, and in years with a late wet season there is a tendency towards larger shrimps. Controlled water release from Cabora Bassa could enhance shrimp production.
LZam, Mozambique, Delta, environmental assessment, fisheries, water quality, crustacea

315. Gibbs-Russell, G.E. (1975). Distribution of vascular aquatic plants in Rhodesia. *South African Journal of Science* **71**: 270-271.
Not seen.
MZam, Zimbabwe, plants

316. Gibbs-Russell, G.E. (1975). Taxonomic bibliography of vascular aquatic plants in southern Africa. *Journal of Limnological Society of Southern Africa* **1**: 53-65.
Not seen.
SAfrica, bibliography, plants

317. Gibbs-Russell, G.E. (1977). Keys to vascular aquatic plants in Rhodesia. *Kirkia* **10**(2): 411-502.
Comprehensive keys to the genera and species of aquatic plants recorded from Zimbabwe. Each species is briefly described.
MZam, checklist, Zimbabwe, plants

318. Gibbs-Russell, G.E. and Mitchell, D.S. (1976). Common aquatic plants on Rhodesian pans and lakes. *Rhodesia Agricultural Journal* **73**(1): 13-17.
Brief account of water plants found in Zimbabwe lakes and pans, with descriptions of the common species.
MZam, survey, Zimbabwe, plants

319. Gibson, D. (1989). The status and distribution of small carnivores. *Zimbabwe Wildlife* **57**: 25-29.
Account of museum specimens of 24 species of small carnivore. Acute inconsistencies in sampling effort per unit area are highlighted. Records include middle Zambezi valley and Kazungula/Chobe.
MZam, UZam, Zimbabwe, Smammals

320. Giess, W. (1971). A preliminary vegetation map of South West Africa. *Dinteria* **4**: 5-64.
Vegetation map of Namibia (scale 1:3 million). The vegetation is described briefly under 13 physiognomic types, but the Chobe/Linyanti swamps and Caprivi Strip are not covered.
survey, Namibia, vegetation

321. Gifford, D. (1965). *Butterflies of Malawi*. Society of Malawi, Blantyre, Malawi. 144 pp.
Lists 521 butterfly species for Malawi, but very few from the lower Shire.
LZam, LShire, checklist, Malawi, insects

322. Gliwicz, Z.M. (1984). Limnological study of Cahora Bassa reservoir with special regard to sardine fishery expansion. FAO/GCP/MOZ/006/SWE Field Document No. 8. FAO, Rome, Italy. 75 pp.
Consultants' report on the feasibility of introducing kapenta into Cabora Bassa. Water quality is discussed, along with phytoplankton, primary productivity, zooplankton and kapenta biology.
MZam, Mozambique, Cabora, environmental assessment, water quality, fisheries, phytoplankton, zooplankton, fish, insects, crustacea

323. Goodman, P.S. (1992). Wattled Cranes on the Marromeu floodplain. In: *Proceedings of the First Southern African Crane Conference* (edited by Porter, D.J., Craven, H.S., Johnson, D.N. and Porter, M.J.). Southern African Crane Foundation, Durban, South Africa. pp.155-156.
Brief account of a census of Wattled Cranes in Marromeu with a map of habitats. 2570 birds were estimated, along with other wetland birds.
LZam, survey, Mozambique, Delta, birds

324. Government of Malawi (1983). Biotic communities of Malawi. *The National Atlas of Malawi* Department of Surveys, Lilongwe, Malawi. 42-43 pp.
Two map sheets at scale 1:1 million showing vegetation. The legend covers 19 vegetation types, grouped into 9 classes, with details on species composition and structure in the text. The lower Shire valley is mapped as perennially wet to swampy grassland (type 7c). Major components are Typha australis, Vossia cuspidata, Pennisetum purpureum, Cyperus papyrus and Echinochloa pyramidalis, with scattered Hyphaene and Borassus palms.
LZam, LShire, survey, Malawi, vegetation

325. Graham, J. and Graham, B. (1986). Bird observations 1985: northern Chobe. *Babbler* **11**: 32.
Notes on nine species, including three waterbirds.
UZam, Botswana, Chobe, birds

326. Gray, W.N. (1981). The bilharzia transmitting snails and their related species in Malawi. *Nyala* **7**(2): 109-128.
Lists and discusses 10 species of snail, of which 4 occur in the lower Shire.
LZam, Malawi, LShire, molluscs

327. Graz, F.P. (1996). Fresh water fish distribution maps, Eastern Caprivi: data processing and map production. Technical Notes NRSC No.6. National Remote Sensing Centre, Windhoek, Namibia.
Series of maps of the E Caprivi area at 1:650,000 scale, one for each fish species. Map shows location of 1995 sampling sites.
UZam, survey, Namibia, Chobe, biogeography, fish

328. Green, J. (1985). Horizontal variations in associations of zooplankton in Lake Kariba. *Journal of Zoological Society of London* **206**: 225-239.
Study on the zooplankton of Lake Kariba. Crustacea were generally sparse. Zooplankton composition is greatly influenced by the presence of kapenta. 62 species of zooplankton are listed (40 rotifers, 18 crustacea, 3 diptera, 1 hydrozoan).
MZam, Zimbabwe, Kariba, ecology, zooplankton, crustacea, Oinverts

329. Green, J. (1990). Zooplankton associations in Zimbabwe. *Journal of Zoology* **222**: 259-283.
Study on the species composition of zooplankton in 18 Zimbabwe reservoirs, most in the Zambezi catchment.
MZam, Zimbabwe, zooplankton, crustacea, Oinverts

330. Green, J. and Carey, T.G. (1967). Preliminary checklist of Crustacea and Rotifera in zooplankton samples. *Fisheries Research Bulletin, Zambia* **3**: 24-26.
Checklist of crustacea and rotifers in zooplankton from the Kafue river floodplain. 12 species of crustacea and 23 species of rotifera are listed.
UZam, checklist, Zambia, Kafue, zooplankton, crustacea

331. Greenwood, P.H. (1961). A revision of the genus *Dinotopterus* Blgr. (Pisces, Clariidae) with notes on the comparative anatomy of the suprabranchial organs. *Bulletin of the British Museum (Natural History), Zoology* **7**: 217-241.
Taxonomic revision of a small but important group of deepwater catfish in Lake Malawi.
Malawi, LMalawi, fish

332. Greenwood, P.H. (1981). *The Haplochrome Fishes of the East African Lakes*. British Museum (Natural History)/Kraus International Publications, London, UK/Munich, Germany. 839 pp.
Considered an important book on the cichlid fishes of Lake Malawi.
checklist, Malawi, LMalawi, biogeography, fish

333. Griffin, M. (1995). Review of Namibian anuran diversity. *Madoqua* **19**(1): 31-32.
Brief account of amphibian diversity, showing a water-dependent fauna in the Caprivi derived from the rich fauna of the Zambezi. Perennial rivers are probably the most important conduits for distribution.
UZam, Namibia, Chobe, biogeography, amphibians

334. Griffin, M. and Channing, A. (1991). Wetland-associated reptiles and amphibians of Namibia - a national review. *Madoqua* **17**(2): 221-225.
Review of amphibians and reptiles associated with Namibian wetlands. 88% of amphibians are not restricted to wetlands, but some species of both reptiles and amphibians are dependent on perennial water. No species are considered endangered. A list of 64 species is given, of which 46 are found (or expected to be found) in the E Caprivi/Kwando area.
UZam, Namibia, Chobe, reptiles, amphibians

335. Griffin, M. and Grobler, H.J.W. (1991). Wetland-associated mammals of Namibia - a national review. *Madoqua* **17**(2): 233-237.
Review of mammals (large and small) associated with Namibian wetlands. About 10% of the total mammal fauna is thought to be dependent on wetlands. The highest species diversity of this group is in the Kavango-Caprivi area, including puku, sitatunga, bushbuck, oribi, waterbuck and red lechwe. Larger mammals are under threat from both habitat destruction and hunting. A list of 37 species is given, of which 34 are found in the E Caprivi/Kwando area.

UZam, Chobe, Namibia, conservation, Smammals, Lmammals

336. Grimsdell, J.J.R. and Bell, R.H.V. (1972a). Population growth of red lechwe, *Kobus leche leche* Gray, in the Busanga Plain, Zambia. *East African Wildlife Journal* **10**: 117-122.
Reports on large increase of an isolated population of red lechwe protected since 1948.
UZam, Zambia, Kafue, human use/impact, Lmammals

337. Grimsdell, J.J.R. and Bell, R.H.V. (1972b). The status of black lechwe in the Bangweulu flood plains. *Black Lechwe* **??**(2): 29.
Brief report on progress and concerns of the Black Lechwe Conservation Project, and threats and prospects for the population.
UZam, Zambia, Bangweulu, conservation, Lmammals

338. Grimsdell, J.J.R. and Bell, R.H.V. (1972c). The black lechwe and the Bangweulu flood plains. *Black Lechwe* **??**(4): 6-9.
Account of the Bangweulu swamps and the biology of the black lechwe. Lechwe are confined to the floodplain. The Black Lechwe Conservation Project is described.
UZam, Zambia, Bangweulu, ecology, conservation, Lmammals

339. Grimsdell, J.J.R. and Bell, R.H.V. (1975). Ecology of the Black Lechwe in the Bangweulu Basin of Zambia. Black Lechwe Research Project: Final Report. Animal Productivity Research Report, ARI NCSR/TR 31. National Council for Scientific Research, Lusaka, Zambia. 175 pp.
Not seen.
UZam, survey, Zambia, Bangweulu, ecology, Lmammals

340. Grimsdell, J.J.R. and Bell, R.H.V. (1976). The Bangweulu basin of Zambia. In: *The Okavango Delta and its Future Utilisation* (edited by Botswana Society). Botswana Society, Gaborone, Botswana. pp.257-262.
Overview of the ecology of the Bangweulu swamps, with particular reference to the black lechwe.
UZam, Zambia, Bangweulu, ecology, human use/impact, Lmammals

341. Grimwood, I.R., Benson, C.W. and Ansell, W.F.H. (1958). The present-day status of ungulates in Northern Rhodesia. *Mammalia* **22**: 451-468.
Brief reports on all species of antelope, hippo, suids, elephant, hyrax and rhino. Drastic reductions in some populations are reported.
Zbasin, survey, Zambia, conservation, Lmammals

342. Grobler, M. and Ferreira, J. (1990). The dying of Lake Liambezi. *Custos* **19**(6): 40-44.
Popular account on the drying up of Lake Liambezi in Caprivi by 1985. About 1000 kg of fish were harvested each day at its height, and was a very important local source of protein. Drying out was rapid, followed by peat fires on the bed. The lake is said to only appear after good flood years, after which it can be maintained by lesser annual inflows. Hunting of elephant and hippo has caused blockage of river channels, so refilling may now be less likely.

UZam, Namibia, Chobe, fisheries, human use/impact

343. Guy, P.R. (1977). Notes on the vegetation types of the Zambezi Valley, Rhodesia, between the Kariba and Mpata gorges. *Kirkia* **10**(2): 543-557.
Vegetation survey of the mid-Zambezi valley area below the escarpment in Zimbabwe from Kariba Gorge to near Kanyemba. There are 18 vegetation types described. The Zambezi floodplains are described as Faidherbia albida woodland. Lining the watercourses are the perennial grasses Vetiveria nigritana and Setaria sphacelata.
MZam, Mana, survey, Zimbabwe, vegetation, ecology, plants

344. Haacke, W.D. (1982). *Bufo lemairii* Boulenger, 1901, a new amphibian record for southern Africa. *Journal of the Herpetological Association of Africa* **27**: 11-12.
First records for this species of toad, found in the Okavango delta.
UZam, Botswana, Okavango, amphibians

345. Haacke, W.D., Rautenbach, I.L. and Kemp, A.C. (1971). The Transvaal Museum Expedition to the Eastern Caprivi Strip: Observations on Mammals of the Eastern Caprivi strip; Observations on Birds of the Eastern Caprivi Strip. *Transvaal Museum Bulletin* **11**: 4-8.
General description of the topography and vegetation. Includes species lists with 48 mammals and 260 birds.
UZam, checklist, Namibia, Chobe, birds, Lmammals, Smammals

346. Hall, A. and Davies, B.R. (1974). Cabora Bassa: apreciaçâo global do seu impacto no vale do Zambeze. *E.M.* (July): 15-25.
General account of the possible effects and economic opportunities associated with the Cabora Bassa dam. Concerns on aquatic weeds are discussed, as is the potential introduction of kapenta.
MZam, Mozambique, Cabora, environmental assessment, fisheries, ecology, probspp, fish

347. Hall, A., Davies, B.R. and Valente, I. (1976). Cabora Bassa: some preliminary physico-chemical and zooplankton pre-impoundment survey results. *Hydrobiologia* **48**(1): 17-25.
Account of 1974 survey on the physical and chemical parameters, and zooplankton composition, of the waters of the Zambezi river. Major enrichment of waters in the lower Zambezi occurs where the Shire river enters.
LZam, Mozambique, Cabora, LShire, ecology, water quality, zooplankton

348. Hall, A., Valente, I. and Davies, B.R. (1977). The Zambezi river in Moçambique: the physico-chemical status of the middle and lower Zambezi prior to the closure of the Cabora Bassa dam. *Freshwater Biology* **7**: 187-206.
Account of 1974 pre-Cabora Bassa research into water quality of the waters of the Zambezi. Temperatures increase going downstream and average pH is 7.8. The river is well oxygenated, but transparency is low. Water quality of the mid Zambezi was principally determined by Lake Kariba, and that of the lower Zambezi below the Shire confluence by the ionically-rich Shire river.
LZam, MZam, Mozambique, Cabora, LShire, water quality

349. Hall-Martin, A.J. and Drummond, R.B. (1980). Annotated list of plants collected in Lengwe National Park, Malawi. *Kirkia* **12**(1): 151-181.
An annotated list of over 500 plant species found during the course of a vegetation survey of Lengwe NP in the lower Shire valley. A summary of the major vegetation types is also given. Seasonally inundated grasslands or dambos are one type, and are characterised by the grasses Setaria palustris and Ischaemum afrum. Woody plants are restricted to termitaria. The floodplain of the Nkombedzi-wa-Fodia river is dominated by the tall grasses Sorghum sudanensis and Pennisetum purpureum, while sandbanks in the river support Phragmites mauritianus and Cyperus spp.
LZam, checklist, Malawi, LShire, vegetation, plants

350. Hancock, F.D. (1979). Diatom associations and succession in Lake Kariba, south central Africa. *Hydrobiologia* **67**(1): 33-50.
Account of some diatom associations in 4 sites in Lake Kariba, and a comparison with two stretches of the Zambezi river.
MZam, Zimbabwe, Kariba, phytoplankton

351. Hancock, F.D. (1985). Diatom associations in the aufwuchs of inundated trees and underwater leaves of *Salvinia*, drowned Mwenda River, Lake Kariba, Zimbabwe. *Hydrobiologia* **121**: 65-76.
Describes the diatom species associated with submerged trees and Salvinia in Lake Kariba between 1963 and 1972.

MZam, Zimbabwe, Kariba, phytoplankton

352. Handlos, D.M., Handlos, W.L. and Howard, G.W. (1976). A study of the diet of the Kafue lechwe *(Kobus leche*) by analysis of rumen contents. In: *Proceedings of the Fourth Regional Wildlife Conference for Eastern and Central Africa*. Zambia Printing Company, Lusaka, Zambia. pp.197-211.
Study on the diet of Kafue lechwe at Lochinvar NP as estimated from rumen contents. Seasonal variation was reported.
UZam, Zambia, Kafue, ecology, Lmammals

353. Handlos, W.L. (1977). Aspects of Kafue basin ecology. In: *Development and Ecology in the Lower Kafue Basin in the Nineteen Seventies* (edited by Williams, G.J. and Howard, G.W.). Kafue Basin Research Committee, Lusaka, Zambia. pp.29-39.
Not seen. Presumably similar to Handlos 1982.
UZam, Zambia, Kafue, ecology

354. Handlos, W.L. (1982). Introduction to the ecology of the Kafue Flats. In: *Proceedings of the National Seminar on Environment and Change: the Consequences of Hydroelectric Power Development on the utilization of the Kafue Flats* (edited by Howard, G.W. and Williams, G.J.). Kafue Basin Research Committee, Lusaka, Zambia. pp.5-29.
General review of the ecology of the Kafue Flats covering geology, climate, vegetation and animal life (particularly invertebrates). Productivity, nutrient cycles and symbioses are discussed.
UZam, Zambia, Kafue, ecology, vegetation

355. Hanks, J. (1968). Bangweulu survey. *Black Lechwe* **7**(1): 9-12.
Popular account of an aerial survey of black lechwe.
UZam, survey, Zambia, Bangweulu, Lmammals

356. Hanks, J. (1969a). Addenda and corrigenda to "A first list of plants collected in Kafue National Park". *The Puku* **5**: 91-121.
List giving 342 additions to Mitchell's 1963 plant checklist.
UZam, Kafue, checklist, Zambia, plants

357. Hanks, J. (1969b). Recent lechwe counts in Zambia. *The Puku* **5**: 231-235.
Brief notes on counts of various lechwe subspecies in Zambia in 1966-68.
UZam, survey, Zambia, Kafue, Bangweulu, Lmammals

358. Hanks, J., Stanley Price, M. and Wrangham, R.W. (1969). Some aspects of the ecology and behaviour of the defassa waterbuck (*Kobus defassa*) in Zambia. *Mammalia* **33**: 471-494.
Study on the behaviour, reproduction, feeding habits and predation of waterbuck in the Kafue NP, Zambia.
UZam, Zambia, Kafue, ecology, Lmammals

359. Hanmer, D.B. (1976). Birds of the Lower Zambezi. *Southern Birds* No. 2. Witwatersrand Bird Club, Johannesburg, South Africa. ISBN 0-620-02541-7. 66 pp.
A checklist of 322 species was made from 5 habitats at Mopeia and from the Shire confluence to Luabo in 1972-73, including 94 species of waterbirds. Some habitat information is included.
LZam, Mozambique, Delta, vegetation, ecology, birds

360. Hanmer, D.B. (1977a). Man-induced changes in the Lower Shire valley with special reference to the avifauna. *Nyala* **3**(1): 33-37.
Account, concentrating on birds, of the changes in the river and marsh systems of the lower Shire due to the activities of rural people and the SUCOMA sugar estate. Most effects have been negative, but cane fields have provided habitats for some species.
LZam, Malawi, LShire, environmental assessment, birds

361. Hanmer, D.B. (1977b). The Skimmer (*Rynchops flavirostris*) in Malawi. *Nyala* **3**: 41-43.
At Nchalo 'vast numbers' have been seen.
LZam, Malawi, LShire, birds

362. Hanmer, D.B. (1979a). Two birds new to Malawi. *Nyala* **5**: 40-41.
A Rudd's Apalis was caught in December 1977 and a Grey Sunbird in November 1978.
LZam, Malawi, LShire, birds

363. Hanmer, D.B. (1979b). A trapping study of Palaearctic passerines at Nchalo, southern Malawi. *Scopus* **3**: 81-92.
Nine species were caught over a five-year period (no waterbirds).
LZam, Malawi, LShire, birds

364. Hanmer, D.B. (1981a). A new subspecies for Malawi of the African Reed Warbler (*Acrocephalus baeticatus*). *Nyala* **7**: 51-52.
In October 1979, at Nchalo, an individual was identified as A. b. suahelicus.
LZam, Malawi, LShire, birds

365. Hanmer, D.B. (1981b). Longevity from retraps. *Safring News* **10**: 12-22.
Brief report on bird trapping at Nchalo, lower Shire. By September 1981, nearly 20,000 birds had been trapped, with 30% as re-traps. 56 species are listed, of which 5 are small waterbirds. Longevities are >5 years.
LZam, Malawi, LShire, birds

366. Hanmer, D.B. (1982). First record of the African Skimmer breeding in Malawi. *Ostrich* **53**: 189.
Actually at the confluence of the Shire and Mwanza. But 'major concentrations' are seen south to Nchalo.
LZam, Malawi, LShire, birds

367. Hanmer, D.B. (1985). Shooting breeding White-faced Ducks (*Dendrocygna viduata*). *Nyala* **11**: 25-26.
Shooting season for ducks ends after some have started to breed.
LZam, Malawi, LShire, birds

368. Hanmer, D.B. (1986). Migrant palaearctic passerines at Nchalo, Malawi. *Safring News* **15**: 19-28.
Not seen.
LZam, Malawi, LShire, birds

369. Hanmer, D.B. (1989). The African Skimmer breeding in Malawi. *Nyala* **13**: 78-79.
Account of breeding of a waterbird on the lower Shire. Breeding occurred in 1981 and in 1982-86.
LZam, Malawi, LShire, birds

370. Hanmer, D.B. (1989). The Nchalo ringing station - bird longevity and migrant return. *Nyala* **14**(1): 21-27.
Account of bird ringing at Nchalo in the lower Shire. In 16 years, 38 000 birds of 300 species were caught by mist nets. Longevity can be 12-13 years for small birds.
LZam, Malawi, LShire, birds

371. Hanmer, D.B. and Roseveare, M. (1989). First record of the Shoebill *Balaeniceps rex* in Malawi. *Scopus* **12**: 92-93.
Includes possible sightings in Liwonde NP.
LZam, MShire, Malawi, birds

372. Hanney, P. (1965). The Muridae of Malawi (Africa: Nyasaland). *Journal of Zoology, London* **146**: 577-633.
Gives information on the distribution of 32 rodent species in Malawi, but the collections from wetlands were very limited. 9 species may occur in the lower Shire valley wetlands.
LZam, LShire, checklist, Malawi, Smammals

373. Happold, D.C.D., Happold, M. and Hill, J.E. (1987). The bats of Malawi. *Mammalia* **51**: 337-414.
Account of the bats in Malawi including biological and ecological data. 55 species are listed, with the lower Shire valley being the richest area with 35 species. Most live in woodland savanna but may forage over the wetlands.
LZam, LShire, checklist, Malawi, biogeography, ecology, Smammals

374. Happold, D.C.D. and Happold, M. (1989). The bats (Chiroptera) of Malawi, Central Africa: checklist and keys for identification. *Nyala* **14**(2): 89-112.
List with illustrated keys to 55 species of bats from Malawi.
LZam, checklist, Malawi, Smammals

375. Happold, D.C.D. and Happold, M. (1990). An ecological study of small rodents in the woodland savanna of Liwonde National Park, Malawi. *Journal of Zoology, London* **221**: 219-235.
Study on small rodents in Liwonde, middle Shire. Abundance and seasonal changes in numbers was reported, with 3 species accounting for 78% of captures.
LZam, MShire, Malawi, ecology, Smammals

376. Happold, D.C.D. and Happold, M. (1991). An ecological study of small rodents in the thicket-clump savanna of Lengwe National Park, Malawi. *Journal of Zoology, London* **223**: 527-547.
Study of population dynamics of rodent communities in Lengwe NP, lower Shire. Abundance and seasonal changes in numbers were reported and related to seasonal flooding and changes in the grassland.
LZam, LShire, Malawi, ecology, Smammals

377. Happold, M. and Happold, D.C.D. (1997). New records of bats (Chiroptera: Mammalia) from Malawi, east-central Africa, with an assessment of their status and conservation. *Journal of Natural History* **31**: 805-836.
Account of the distribution and status of the 59 bat species recorded from Malawi; relative abundance was determined by catch effort. Based on high species diversity and rarity, conservation of several sites in S and C Malawi is recommended. Chiromo in the lower Shire has a high diversity (30 spp), with the remaining woodlands being particularly important habitats.
survey, checklist, Malawi, LZam, LShire, biogeography, conservation, Smammals

378. Harding, D. (1964). Hydrology and fisheries in Lake Kariba. *Verh. International Verein. Limnology* **15**: 139-149.
Early record of the limnology and fishery of the filling Lake Kariba. Comparison of fish catches with pre-impoundment days shows higher yields. Catch composition changed continuously as the lake filled.
MZam, Zimbabwe, Kariba, hydrology, fisheries

379. Harrison, A.D. (1978). Freshwater invertebrates (except molluscs). In: *Biogeography and Ecology of Southern Africa* (edited by Werger, M.J.A.). W. Junk, The Hague, Netherlands. ISBN 90-6193-083-9. pp.1139-1152.
Review of knowledge on most groups of freshwater invertebrates found in southern Africa. The two groups are the south temperate Gondwana fauna and the tropical pan-Ethiopian fauna; the biology and ecology of these groups are discussed.
SAfrica, ecology, biogeography, insects, crustacea, Oinverts

380. Harrison, J.A., Allan, D.G., Underhill, L.G., Herremans, M., Tree, A.J., Parker, V. and Brown, C.J. (1997). *The Atlas of Southern African Birds*. BirdLife South Africa, Johannesburg, South Africa. ISBN 0-620-20729-9. 2 volumes
Detailed illustrated account of distribution, with maps, of all southern African birds based on observations from across the region.
SAfrica, biogeography, checklist, birds

381. Hastings, R.E. (1973). Fisheries Research Unit, Lower Shire: Interim report 1970-1973. Fisheries Department, Lilongwe, Malawi. 117 pp.
Report on various research projects on the fish and fisheries of the lower Shire. Aspects of the biology of 9 important fish species are described, including the economically most important, a catfish. There are sections on primary productivity, physical and chemical features of the water, and the effect of various factors (flooding, water level, temperature), with particular emphasis on Elephant Marsh. The vegetation of Elephant Marsh is described in detail. A list is provided of fish species collected in the lower Shire.
LZam, Malawi, LShire, fisheries, water quality, fish, vegetation, plants

382. Hatton, J. and Guerra-Marques, L. (1992). Wetlands, coastal zone systems and marine fisheries. *Angolan Environmental Status Quo Assessment.* IUCN ROSA, Harare, Zimbabwe. 45 pp.

Account of the wetlands of Angola. Within the Zambezi hydrogeographic basin various types of wetland are found, including "chanas" (seasonally inundated edaphic grasslands) and "anharas" (seasonally flooded grassland of large extent). Lakes include Lake Cameia on the Chonga (Lumeje) river and Lake Dilolo. Cameia NP comprises seasonally inundated floodplains and three lakes (Cuamba, Calundo and Chaluvanda), now with few large mammals. In the Zambeze numerous dambos are found in the headwater region. Hippo and crocodile are common in the rivers and lakes, with red lechwe, bushpig, roan antelope, reedbuck and sitatunga associated with the floodplains. Fish are common, and fishing is an important economic activity. Many people are now farming on the "chanas" and over-exploitation and soil erosion are becoming common.
Angola, UZam, vegetation, Lmammals, plants, fish

383. Hayes, G.D. (1978). *A Guide to Malawi's National Parks and Game Reserves*. Montfort Press, Limbe, Malawi. 166 pp.
Included in this book are historical observations on wildlife populations in the lower Shire. Livingstone in 1859 noted over 800 elephant on one floodplain as well as buffalo and antelope. Elephant Marsh was one of the two first gazetted Game Reserves in 1897, but was deproclaimed in 1922.
LZam, Malawi, LShire, history, Lmammals

384. Hayman, R.W. (1963). Mammals from Angola, mainly from the Lunda District. *Publicaçoes Culturais de Compania de Diamantes de Angola* **66**: 84-140.
Account of 91 species and subspecies of smaller mammals (principally insectivores, bats and rodents) collected from Lunda District in NE Angola. 14 species are recorded from Angola for the first time. A gazeteer of collecting localities is included. Although much of the study area lies in the Zaire drainage system, some information is provided on the upper Zambezi catchment, particularly from vicinity of Calundo, Cazombo and Macondo.
checklist, UZam, Angola, Smammals

385. Haynes, G. (1996). Quaternary climates and environmental changes in Hwange National Park, Zimbabwe. In: *Aspects of African Archaeology. Papers from the 10th Congress of the PanAfrican Association for Prehistory and Related Studies* (edited by Pwiti, G. and Soper, R.). University of Zimbabwe Publications, Harare, Zimbabwe. pp.71-81.
Account of Quaternary environmental changes in NW Zimbabwe, giving dates for various pluvial and dry periods. This is related to the formation of the Zambezi and to human settlement.
MZam, Botswana, Zimbabwe, palaeogeography

386. Heery, S. (1979). Vegetation ecology of dambos around Choma, Zambia, 1976-1979. Research Branch, Department of Agriculture, Lusaka, Zambia. 67 pp.
Unpublished report - said to be one of the best studies on dambo ecology in Zambia.
MZam, Zambia, ecology, vegetation

387. Herremans, M. (1992). New records of the European Reed Warbler *Acrocephalus scirpaceus* from Botswana. *Babbler* **24**: 10-13.
Caught at Chobe in March 1992.
UZam, Botswana, Chobe, birds

388. Hill, J.E. and Carter, T.D. (1941). The mammals of Angola, Africa. *Bulletin of American Museum of Natural History* **78**: 1-211.
Remains the main review of Angolan mammals.
checklist, Angola, Smammals, Lmammals

389. Hillman, C. (1996). *Heavy metals and organochlorine pesticides in Lake Chivero*. MSc thesis, University of Zimbabwe.
Study shows that heavy metal and pesticide levels in aquatic birds and fish in Lake Chivero have increased; attributed to industrialisation of Harare and Chitingwiza.
MZam, Chivero, Zimbabwe, water quality, pollution

390. Hines, C.J.H. (1993). Temporary wetlands of Bushmanland and Kavango, northeast Namibia. *Madoqua* **18**(2): 57-69.
Good account of the ecology and species (plant, bird, herps and mammals) found in seasonal pans in an area of the Kalahari adjacent to the Zambezi basin. The importance of these seasonal and shallow waterbodies for conservation is shown. Lists of amphibians, reptiles, birds and mammals using the wetlands are given.
survey, checklist, Namibia, vegetation, conservation, reptiles, amphibians, birds, Smammals, Lmammals

391. Hines, C.J.H. (1996). Cranes in Namibia. In: *Proceedings of 1993 African Crane and Wetland Training Workshop* (edited by Beilfuss, R.D., Tarboton, W.R. and Gichuki, N.N.). International Crane Foundation, Baraboo, WI, USA. pp.305-306.
Three species of crane occur in Namibia, associated with the three wetland areas, including the Chobe/Linyanti system. The numbers of Wattled Crane fluctuate, being lowest in the dry season. Breeding takes place, but numbers are low (10-12 pairs). The Grey Crowned Crane is occasionally seen along the Chobe and Okavango rivers.
UZam, Namibia, Chobe, birds

392. Hines, C.J.H. (1996). Namibia's Caprivi Strip. *Bulletin of ABC* **3**(2): 113-128.
Popular account of ornithological sites and species of interest in the Caprivi. Many bird species are mentioned.

UZam, checklist, Namibia, Chobe, birds

393. Hines, C.J.H. (1996). Wetlands in arid lands: values, threats, and conservation. In: *Proceedings of 1993 African Crane and Wetland Training Workshop* (edited by Beilfuss, R.D., Tarboton, W.R. and Gichuki, N.N.). International Crane Foundation, Baraboo, WI, USA. pp.307-313.
Account of arid zone wetlands in Namibia and their importance, including mention of the Kwando, Linyanti and Chobe-Zambezi floodplains.
Namibia, conservation, birds

394. Hines, C.J.H. (1997). Vegetation survey. In: *An Environmental Profile and Atlas of the Caprivi* (edited by Mendelsohn, J.M. and Roberts, C.S.). Directorate of Environmental Affairs, Windhoek, Namibia. pp. 20-21, A1-A4.
Detailed vegetation survey (chapter 5) and map of the Caprivi, giving 36 types grouped into Kalahari, mopane and riparian woodlands, and floodplains. Species descriptions are given of each type.
survey, Namibia, Chobe, UZam, vegetation, ecology

395. Hines, C.J.H., Schlettwein, G. and Kruger, W. (1985). Invasive alien plants in Bushmanland, Owambo, Kavango and Caprivi. In: *Invasive Alien Organisms in South West Africa/Namibia* (edited by Brown, C.J., MacDonald, A.W. and Brown, S.E.). South African National Scientific Programmes No. 119. CSIR, Pretoria, South Africa. pp.6-12.
Not seen.
UZam, Namibia, Chobe, probspp, plants

396. Hockey, P.A.R., Brooke, R.K., Cooper, J., Sinclair, J.C. and Tree, A.J. (1986). Rare and vagrant scolopacid waders in southern Africa. *Ostrich* **57**(1): 37-55.
Account of unusual wader birds, incorporating 374 records of 15 species. Occurrence is analysed and habitat requirements described. Great Snipe, Black-tailed Godwit, Redshank and Green Sandpiper have been recorded along the Zambezi and Chobe Rivers in Botswana and Zimbabwe.
SAfrica, UZam, Botswana, Chobe, biogeography, birds

397. Hocutt, C.H. and Johnson, P.N. (1993). Fisheries resource assessment of the Kavango and Caprivi Provinces, Namibia. Department of Fisheries, Windhoek, Namibia. 138 pp.
Consultants' report on fisheries potential for the Caprivi region. A brief account of the ecology and fish species found is given.
UZam, Namibia, Chobe, fisheries, fish

398. Holshausen, K. (1996). Conservation of cranes in Zimbabwe. In: *Proceedings of 1993 African Crane and Wetland Training Workshop* (edited by Beilfuss, R.D., Tarboton, W.R. and Gichuki, N.N.). International Crane Foundation, Baraboo, WI, USA. pp.333-335.
Both the Wattled Crane and Grey Crowned Crane (c.5000 individuals) occur in Zimbabwe. Because they generally do not occur in protected areas the future of their wetland habitat on the central plateau depends partly on commercial farmers. Some captive breeding is being carried out.
MZam, Zimbabwe, conservation, birds

399. Holtzhausen, J.A. (1991). Freshwater fishes of Namibian wetlands - a review. *Madoqua* **17**(2): 189-191.
Review of the fish found in Namibian wetlands. 59 species are found in the E Caprivi of which 78% are associated with floodplains, although the Kavango river system has a higher diversity. There are two endemic species in Caprivi; the striped killifish is also endangered.
UZam, Namibia, Chobe, biogeography, conservation, fish

400. Howard, G.W. (1985). The Kafue Flats of Zambia - a wetland ecosystem comparable with floodplain areas of northern Australia. *Proceedings of the Ecological Society of Australia* **13**: 293-306.
Not seen.
UZam, Zambia, Kafue, ecology

401. Howard, G.W. (1989). Recent counts of Wattled Cranes *Bugeranus carunculatus* on the Kafue Flats, Zambia - November 1987. *Scopus* **12**: 69-72.
Account of an stratified aerial census of the Kafue Flats. 2508 Wattled Crane were estimated present; one third of those counted were in pairs.
UZam, Zambia, Kafue, survey, birds

402. Howard, G.W. (1992). Ecology and biodiversity in the conservation of wetlands. In: *Wetlands of Zambia: Report of the Zambia Wetlands Conservation Seminar, Siavonga, 17-19 June 1992* (edited by Matiza, T.). ROSA Wetlands Report No. 2. IUCN ROSA, Harare, Zimbabwe.
Unpublished abstract covering the types of wetland ecosystems in Zambia. Zambia's wetlands have the highest biodiversity in the region.
Zbasin, Zambia, vegetation, conservation

403. Howard, G.W. and Aspinwall, D.R. (1984). Aerial censuses of shoebills, saddlebilled storks and wattled cranes at the Bangweulu Swamps and Kafue Flats, Zambia. *Ostrich* **55**: 207-212.
Census of 3 bird species in Zambian wetlands. 3282 Wattled Cranes were estimated for the Kafue Flats in May 1982, similar to that 9 years before. The Bangweulu swamps contained 232 Shoebills, 275 Saddlebilled Storks and 1718 Wattled Cranes.
UZam, survey, Zambia, Bangweulu, Kafue, birds

404. Howard, G.W., Jeffery, R.C.V. and Grimsdell, J.J.R. (1984). Census and population trends of black lechwe in Zambia. *African Journal of Ecology* **22**: 175-179.
Account of an aerial census in October 1983 which shows a large increase in population since 1973.
UZam, survey, Zambia, Bangweulu, Lmammals

405. Howard, G.W. and Jeffrey, R.C.V. (1981). Present distribution of lechwe on the Kafue Flats. *Black Lechwe* **1**: 17-20.
Not seen.
UZam, Zambia, Kafue, Lmammals

406. Howard, G.W. and Sidorowicz, J.A. (1976). Geographical variation in lechwe (*Kobus leche* Gray) in Zambia. *Mammalia* **40**(1): 69-77.
Account of morphological differences in various lechwe populations, suggesting that the red and Kafue lechwe are similar, but the black lechwe is a distinct subspecies.
UZam, Zambia, Kafue, Bangweulu, Lmammals

407. Howard, G.W. and Williams, G.J. [editors] (1982). *Proceedings of the National Seminar on Environment and Change: the Consequences of Hydroelectric Power Development on the Utilization of the Kafue Flats*. Kafue Basin Research Committee, Lusaka, Zambia.
Series of papers on the ecology of the Kafue Flats and possible effects arising from dam construction.
UZam, Zambia, Kafue, ecology, conservation, environmental assessment

408. Howard-Williams, C. (1972). Limnological studies in an African swamp: seasonal and spatial changes in the swamps of Lake Chilwa, Malawi. *Archiv für Hydrobiologie* **70**: 379-391.
Not seen.
Malawi, LChilwa, ecology

409. Howard-Williams, C. (1973). Preliminary botanical description of the Elephant Marsh. In: *Fisheries Research Unit, Lower Shire: interim report 1970-1973* (edited by Hastings, R.). Fisheries Bulletin No. 4. Fisheries Department, Lilongwe, Malawi.
Brief account of the vegetation of Elephant Marsh listing 33 species. There is a brief discussion on the development of sudd.
LZam, survey, Malawi, LShire, vegetation, plants

410. Howard-Williams, C. (1973). *Vegetation and environment in the marginal areas of a tropical African lake (L. Chilwa, Malawi)*. PhD thesis, University of London. London, UK.
Not seen.
Malawi, LChilwa, vegetation, ecology

411. Howard-Williams, C. (1975). Seasonal and spatial changes in the composition of the aquatic and semi-aquatic vegetation of Lake Chilwa, Malawi. *Vegetatio* **30**: 33-39.
Not seen.
Malawi, LChilwa, vegetation

412. Howard-Williams, C. (1975). Vegetation changes in a shallow African lake: response of the vegetation to a recent dry period. *Hydrobiologia* **47**: 381-398.
Not seen.
Malawi, LChilwa, vegetation

413. Howard-Williams, C. (1977). A checklist of the vascular plants of Lake Chilwa, Malawi, with special reference to the influence of environmental factors on the distribution of taxa. *Kirkia* **10**(2): 563-579.
An annotated list of 270 plants, aquatic and terrestrial, of Lake Chilwa in S Malawi. Some of the environmental conditions affecting plants are discussed. The lake is shallow (1-5 m deep) in a closed drainage basin, covers around 600 km², and is surrounded by around 500 km² of marsh and swamps, principally of Typha domingensis. There is a low number of submerged and free-floating aquatics.
checklist, Malawi, LChilwa, plants

414. Howard-Williams, C. (1979). The distribution of aquatic macrophytes in Lake Chilwa: annual and long-term environmental fluctuations. In: *Lake Chilwa: Studies of changes in a tropical ecosystem* (edited by Kalk, M., McLachlan, A.J. and Howard-Williams, C.). W. Junk, The Hague, Netherlands. pp.105-122.
Not seen.
Malawi, LChilwa, vegetation

415. Howard-Williams, C. (1979). Interactions between swamp and lake. In: *Lake Chilwa: Studies of changes in a tropical ecosystem* (edited by Kalk, M., McLachlan, A.J. and Howard-Williams, C.). W.Junk, The Hague, Netherlands. pp.231-245.
Not seen.
Malawi, LChilwa, vegetation

416. Howard-Williams, C. and Howard-Williams, W.A. (1978). Nutrient leaching from the swamp vegetation of Lake Chilwa, a shallow African lake. *Aquatic Botany* **4**: 257-267.
Not seen.
Malawi, LChilwa, vegetation

417. Howard-Williams, C. and Lenton, G.M. (1975). The role of the littoral zone in the functioning of a shallow tropical lake ecosystem. *Freshwater Biology* **5**: 445-459.
Not seen.
Malawi, LChilwa, ecology

418. Howard-Williams, C. and Walker, B.H. (1974). The vegetation of a tropical African lake: classification and ordination of the vegetation of Lake Chilwa (Malawi). *Journal of Ecology* **62**: 831-854.
Study involving classification of the marginal vegetation of Lake Chilwa. Water depth was the major determining factor, but salinity and disturbance were also important.
survey, Malawi, LChilwa, vegetation, plants

419. Hughes, G.R. (1971). Preliminary report on the turtles and dugongs of Mocambique. *Veterinaria Moçambicana* **4**(2): 45-62.
Not seen.
LZam, Mozambique, Lmammals, reptiles

420. Hughes, R.H. and Hughes, J.S. (1992). *A Directory of African Wetlands*. IUCN/UNEP/WCMC, Gland, Switzerland. ISBN 2-88032-949-3. 820 pp.
A major reference source, covering most of the wetlands and topics of biodiversity interest to the IUCN wetlands project. Wetlands are discussed by country, with semi-detailed accounts of individual areas, including extent and major species. Southern Africa is covered in section 5, which gives a good overview with a geographic perspective.

Zbasin, conservation, ecology, vegetation, Lmammals, reptiles, amphibians, fish, birds, plants

421. Hunter, C. (1991). A summary of the ecological literature on Botswana's wetlands and wildlife. University of Florida, Gainesville, USA. 53 pp.
Unpublished detailed review of available literature on the wetlands of northen Botswana, principally the Okavango, but with some reference to the Linyanti and Chobe. Ecological impacts are discussed.
UZam, bibliography, Botswana, Okavango, Chobe, human use/impact, vegetation, birds, Lmammals

422. Hunting Technical Services (1957). The soil survey and land classification report of the Elephant Marsh area, Lower Shire Valley, Nyasaland. Hunting Technical Services, London, UK. 92 pp.
Consultants' report on a soil survey of the marsh with transects taken by boat. Vegetation types are briefly described. A soil map at scale 1:50,000 is included, along with a land classification map showing land capability for irrigated agriculture if the marshes are drained. A brief recent history of the swamps is given, describing the periodic drying out.
LZam, survey, Malawi, LShire, history, agriculture, vegetation

423. Hustler, C.W. (1991). *The ecology of fish-eating birds on Lake Kariba, with special reference to the diving Pelecaniformes*. DPhil thesis, University of Zimbabwe. Harare, Zimbabwe.
14 species made up 97% of all fish-eating birds seen, with Reed Cormorants comprising 51%; another 12 species made up the remainder. Reed Cormorants and Darters (11%) increased to maximum numbers in November-December, and during the year accounted for 85% of the fish removed by birds. Total removed in 1987 was estimated at 1460 tonnes.

MZam, Zimbabwe, Kariba, ecology, birds

424. Hustler, K. (1995). First breeding record, incubation period and density of the Greater Swamp Warbler in Zimbabwe. *Honeyguide* **41**: 161-163.
Data on Acrocephalus rufescens at Kazungula to Katombora, where it is common.
UZam, Chobe, Zimbabwe, birds

425. Hustler, K. (1997). The ecology of fish-eating birds and their impact on the inshore fisheries of Lake Kariba. In: *Advances in the Ecology of Lake Kariba* (edited by Moreau, J.). University of Zimbabwe Publications, Harare, Zimbabwe. ISBN 0-908307-54-3. pp.196-218.
Study on the effect of fish-eating birds on the fisheries of Lake Kariba. The extent of suitable habitats determines feeding. Cormorants and darters were the most numerous species and eat between 10 and 20% of their weight in fish daily. However such fish species are generally not commercially utilized.
MZam, Zimbabwe, Kariba, ecology, birds

426. Hustler, K. and Carson, D. (1996). Status of the Swamp Nightjar in Zimbabwe. *Honeyguide* **42**: 96-100.

Occurring on the Kazangula floodplain.
UZam, Chobe, Zimbabwe, birds

427. Hutton, J.M. (1986). The status and distribution of bats in Zimbabwe. *Cimbebasia Series A* **8**: 219-236.

Account giving several new distribution records, some from the Zambezi valley.
MZam, checklist, Zimbabwe, Smammals

428. Irvine, K. (1995). Ecology of the lakefly, *Chaoborus edulis*. In: *The Fishery Potential and Productivity of the Pelagic Zone of Lake Malawi/Niassa* (edited by Menz, A.). Natural Resources Institute, Chatham, UK. pp.109-140.
Detailed account of the biology of the lakefly, a conspicuous and important component of the zooplankton of Lake Malawi, and which frequently forms dense swarms over the lake.
Malawi, LMalawi, zooplankton, insects

429. Irvine, K. (1995). Standing biomasses, production, spatial and temporal distributions of the crustacean zooplankton. In: *The Fishery Potential and Productivity of the Pelagic Zone of Lake Malawi/Niassa* (edited by Menz, A.). Natural Resources Institute, Chatham, UK. pp.85-108.
Account of the crustacea in the zooplankton of Lake Malawi, including data on their abundance, biomass, production and seasonal variation.
Malawi, LMalawi, zooplankton, insects, crustacea

430. Irvine, K. and Waya, R. (1995). The zooplankton: general sampling methods and estimation of biomass and development rates. In: *The Fishery Potential and Productivity of the Pelagic Zone of Lake Malawi/Niassa* (edited by Menz, A.). Natural Resources Institute, Chatham, UK. pp.69-83.
Account containing some data on the composition of zooplankton of Lake Malawi, including data on its biomass and rates of growth.
Malawi, LMalawi, zooplankton

431. Irvine, K., Waya, R. and Hart, R.C. (1995). Additional studies into the ecology of *Tropodiaptomus cunningtoni*. In: *The Fishery Potential and Productivity of the Pelagic Zone of Lake Malawi/Niassa* (edited by Menz, A.). Natural Resources Institute, Chatham, UK. pp.141-158.
Detailed account of the biology of the most abundant crustacean species in the zooplankton of Lake Malawi, with data on its population structure, development, food dependence and diet.
Malawi, LMalawi, ecology, zooplankton, crustacea

432. Irwin, M.P.S. (1987). *The Birds of Zimbabwe*. Quest Publishing, Harare, Zimbabwe. ISBN 0-908306-01-6. 464 pp.
Illustrated guide to the birds of Zimbabwe with distribution maps.
Zbasin, checklist, Zimbabwe, birds

433. Irwin, M.P.S. and Benson, C.W. (1966a). Notes on the birds of Zambia. *Arnoldia (Rhodesia)* **2**(32): 1-19.
Includes brief notes on African Sedge Warbler.
Zbasin, Zambia, birds

434. Irwin, M.P.S. and Benson, C.W. (1966b). Notes on the birds of Zambia: part II. *Arnoldia (Rhodesia)* **2**(37): 1-21.
Includes notes on 6 species of waterbirds.
Zbasin, Zambia, birds

435. Irwin, M.P.S. and Benson, C.W. (1967). Notes on the birds of Zambia: part IV. *Arnoldia (Rhodesia)* **3**(8): 1-27.
Includes notes on 4 species of waterbirds.
Zbasin, Zambia, birds

436. Irwin, M.P.S., Niven, P.N.F. and Winterbottom, J.M. (1969). Some birds of the lower Chobe river area, Botswana. *Arnoldia (Rhodesia)* **4**(21): 1-40.
Report on bird collecting expeditions to the lower Chobe area between Kasane and Ngoma, including Lake Liambezi. Includes an account of previous ornithological work, avian zoogeography, and a brief ecological account of the 11 habitats. 460 species are recorded including 82 speies of waterbird, many with brief notes.
UZam, checklist, survey, Botswana, Chobe, ecology, birds

437. Jackson, G. (1969). The grasslands of Malawi: Part III. *Society of Malawi Journal* **22**(2): 73-81.
Discussion of important grass species found in wet or edaphic grasslands, but contains little specifically related to the lower Shire wetlands.
Zbasin, Malawi, plants

438. Jackson, G., Wiehe, P.O. and Hubbard, C.E. (1959). An annotated check list of Nyasaland grasses: indigenous and cultivated. Government Printer, Zomba, Malawi. 75 pp.
List of all known grass species from Malawi at that time. Only 18 species listed that could have been collected from the Lower Shire.
Zbasin, checklist, Malawi, plants

439. Jackson, P.B.N. (1958). A lungfish (*Protopterus*) from the middle Zambezi. *Nature, London* **182**: 123-124.
Brief account of the first lungfish record from the Gwembe Valley in the mid Zambezi. Nearest records are the Zambezi delta, lower Shire and in N Zambia.
MZam, biogeography, fish

440. Jackson, P.B.N. (1961a). *The Fishes of Northern Rhodesia: a check list of indigenous species.* Department of Game and Fisheries, Lusaka, Zambia. 140 pp.
Keys and annotated descriptions of all 156 fish species recorded in Zambia at that time (plus 25 spp of uncertain status, but excluding Lake Tanganyika), including common and vernacular names. A brief introduction to fish systematics and zoogeography is given, along with a comprehensive bibliography.
Zbasin, checklist, Zambia, UZam, fish

441. Jackson, P.B.N. (1961b). Check-list of the fishes of Nyasaland. *Occasional Papers of the National Museums of Southern Rhodesia* **3**: 535-621.
Checklist of the fish recorded from Malawi, particularly Lake Malawi.
LZam, checklist, Malawi, LMalawi, fish

442. Jackson, P.B.N. (1961c). Ichthyology: the fish of the middle Zambezi. *Kariba Studies* **1**: 1-36.
Account of the fish species collected in the mid Zambezi prior to the creation of Lake Kariba. The lack of small fish is ascribed to predation by tigerfish.
MZam, survey, Zambia, Zimbabwe, Kariba, biogeography, fish

443. Jackson, P.B.N. (1962). Ecological factors affecting the distribution of freshwater fishes in tropical southern Africa. *Annals of the Cape Province Museum* **2**: 223-228.
Not seen.
Zbasin, biogeography, ecology, fish

444. Jackson, P.B.N. (1964). Water control and impoundments: the aquatic side. International Union for the Conservation of Nature No. 4. IUCN, Morges, Switzerland.
Report discussing the impacts of river impoundments with Lake Kariba as case study. Mentions invasion by Salvinia.

Zimbabwe, MZam, Kariba, fisheries, hydrology, probspp, plants, fish

445. Jackson, P.B.N. (1965). The establishment of fisheries in man-made lakes in the tropics. In: *Man-Made Lakes* (edited by Ackermann, W.C., White, G.F. and Worthington, E.B.). Academic Press, London, UK. pp.53-69.
Describes the thermocline on Lake Kariba and the possible disappearance of eels owing to the dam. Tree clearing in productive fishing areas is recommended, along with stocking with kapenta.
MZam, Zimbabwe, Kariba, fisheries, hydrology, ecology, fish

446. Jackson, P.B.N. (1975). Relatorio sobre o plano de desenvolvimento para indústria piscatória em Cabora Bassa. R.F. Loxton, Hunting & Associates/Gabinete do Plano do Zambeze, Maputo, Mozambique. 23 pp.
Consultancy study on the fisheries potential of the Cabora Bassa dam. The detrimental effect of aquatic weeds is highlighted. Various fish species found, or with potential, are listed.
MZam, Cabora, Mozambique, probspp, plants, fisheries, fish

447. Jackson, P.B.N. (1989). Prediction of regulation effects on natural biological rhythms in south-central African freshwater fish. *Regulated Rivers: Research & Management* **3**: 205-220.
Not seen.
Zbasin, ecology, fish

448. Jackson, P.B.N. and Davies, B.R. (1976). Cabora Bassa in its first year: some ecological aspects and comparisons. *Rhodesia Science News* **10**(5): 128-133.
General account of the early ecological effects of Cabora Bassa dam, including details of aquatic weed infestation and changes in fish populations.
MZam, Cabora, Mozambique, environmental assessment, fisheries, ecology, probspp, fish, plants

449. Jackson, P.B.N., Iles, T.D., Harding, D. and Fryer, G. (1963). Report on a survey of northern Lake Nyasa. Government Printer, Zomba, Malawi. 171 pp.
The earliest survey of northern Lake Malawi, with data on plankton and fish species.
survey, Malawi, LMalawi, fish, zooplankton

450. Jackson, P.B.N. and Ribbink, A.J. (1975). *Mbuna: the Rock-dwelling Cichlids of Lake Malawi, Africa*. Tropical Fish Hobbyist Publications, Neptune City, New Jersey, USA. ISBN 0-87666-454-0. 128 pp.
Not seen. Should provide an illustrated guide to the most important mbuna species.
checklist, Malawi, LMalawi, fish

451. Jackson, P.B.N. and Rogers, K.H. (1976). Cabora Bassa fish populations before and during the first filling stage. *Zoologica Africana* **11**(2): 373-397.
Study of the effects on fish species and populations of the filling of Cabora Bassa dam. The effects over a short period are shown to be marked, with rapid disappearance of some species and population increase of others. Breeding patterns were also disrupted. 38 species are listed pre-impoundment. Aquatic weeds also have had an effect.
MZam, survey, Cabora, Mozambique, environmental assessment, fish

452. Jamusana, H.K.S. (1994). *Population status, distribution and abundance of hippopotamus and its management as a vertebrate pest in the Southern Region of Malawi*. MSc thesis, University of Kent. Canterbury, UK. 176 pp.
Counts of hippo showed 1411 individuals in the marshes of the lower Shire.
LZam, survey, Malawi, LShire, human use/impacts, probspp, Lmammals

453. Jarman, P.J. (1968). *The effect of the creation of Lake Kariba upon the ecology of the Middle Zambezi, with particular reference to the large mammals*. PhD thesis, University of Manchester. Manchester, UK. pp.
Thesis looks at the effect of the formation of Lake Kariba on large mammals, principally in the Sinamwenda area. No major impact was detected.
MZam, survey, Zimbabwe, Kariba, environmental assessment, Lmammals

454. Jarman, P.J. (1972a). Seasonal distribution of large mammal populations in the unflooded Middle Zambezi Valley. *Journal of Applied Ecology* **9**: 283-299.
Not seen.
MZam, Zimbabwe, Kariba, Lmammals

455. Jarman, P.J. (1972b). The use of drinking sites, wallows and salt licks by herbivores in the flooded middle Zambezi valley. *East African Wildlife Journal* **10**: 193-209.
Reports on herbivore use of shore of Lake Kariba since inundation of the alluvial zone. The role of availability of sodium to herbivores is discussed. Data were collected in Chete area of Zimbabwe between 1963 and 1967.
MZam, Zimbabwe, Kariba, ecology, Lmammals

456. Jarvis, M.J.F. (1982). Avifauna of Lake McIlwaine. In: *Lake McIlwaine: the eutrophication and recovery of a tropical African lake* (edited by Thornton, J.A.). W. Junk, The Hague, Netherlands. ISBN 90-6193-102-9. pp.188-194.
Brief account of the birdlife associated with Lake Chivero. Changes in species composition are shown to be sometimes linked to changes in nutrient levels and aquatic plants. Data on abundance of selected waterfowl is given.

MZam, Chivero, Zimbabwe, ecology, birds

457. Jarvis, M.J.F., Mitchell, D.S. and Thornton, J.A. (1982). Aquatic macrophytes and *Eichhornia crassipes*. In: *Lake McIlwaine: the eutrophication and recovery of a tropical African lake* (edited by Thornton, J.A.). W. Junk, The Hague, Netherlands. ISBN 90-6193-102-9. pp.137-144.
Account of the aquatic and littoral plants associated with Lake Chivero. The spread of Polygonum senegalense and Eichhornia is described, along with various control measures.
MZam, Chivero, Zimbabwe, vegetation, ecology, probspp, plants

458. Jeanes, K.W. and Baars, R.M.T. (1991a). The vegetation ecology and rangeland resources, Western Province, Zambia. Vol. 1. RDP Livestock Services/Livestock Development Project, Western Province, Mongu, Zambia. 208 pp.2 volumes.
Detailed report on the rangeland resources and potentials for livestock production of Western Province. Land systems and land units are described and mapped (see separate entry), and the vegetation of each described in detail, both woody (5 types) and herbaceous (5 types). Herbaceous production is estimated. Dry season water availability is discussed, as is the extent and influence of tsetse fly. An accompanying detailed map (scale 1:500,000) shows 71 species-defined vegetation types, grouped structurally.
UZam, Barotse, survey, Zambia, range/livestock, vegetation

459. Jeanes, K.W. and Baars, R.M.T. (1991b). The vegetation ecology and rangeland resources, Western Province, Zambia. Vol. 2 (appendices). RDP Livestock Services/Livestock Development Project, Western Province, Mongu, Zambia. 2 volumes.
Contains lists of species with vernacular names (including tree species, browse species, grasses, poisonous plants), range types and land units. All field sheets are included.
UZam, Barotse, checklist, Zambia, vegetation, plants

460. Jeffery, R.C.V. (1992). The Kafue Flats of Zambia: a case study. In: *Wetlands Conservation Conference for Southern Africa: Proceedings of a conference, Gaborone, Botswana, 3-5 June*

1991 (edited by Matiza, T. and Chabwela, H.N.). IUCN Wetlands Programme No. 4. IUCN, Gland, Switzerland. ISBN 2-8317-0125-2. pp.57-70.
Account of the WWF Wetlands Conservation project in the Kafue. The importance of the Kafue for the unique Kafue lechwe (50,000) and wattled cranes (3000) is pointed out.
UZam, Zambia, Kafue, conservation, Lmammals, birds

461. Jeffery, R.C.V., Chabwela, H.N., Howard, G. and Dugan, P.J. [editors] (1992). *Managing the Wetlands of Kafue Flats and Bangweulu Basin: Proceedings of the WWF-Zambia Wetlands Project Workshop* IUCN Wetlands Programme No. 1. IUCN, Gland, Switzerland.
Not seen. Proceedings of a workshop; 11 papers.
UZam, Zambia, Kafue, Bangweulu, conservation

462. Jeffery, R.C.V., Kampamba. G., Kamweneshe, B. and Nefdt, R.J.C. (1990). Large wild mammal surveys of the Kafue Flats. Unpublished report. WWF Wetlands Project/National Parks and Wildlife Service, Chilanga, Zambia.
Not seen.
UZam, survey, Zambia, Kafue, Lmammals

463. Jeffery, R.C.V., Kamweneshe, B., Mupembo, F., Malambo, C.M. and Nefdt, R.J.C. (1989a). Wild mammal surveys of the Bangweulu Swamps. Unpublished report. WWF Wetlands Project/National Parks and Wildlife Service, Chilanga, Zambia.
Not seen.
UZam, survey, Zambia, Bangweulu, Lmammals

464. Jeffery, R.C.V., Malambo, C.M. and Nefdt, R.J.C. (1989b). Wild mammal surveys of the Kafue Flats. Unpublished report. WWF Wetlands Project/National Parks and Wildlife Service, Chilanga, Zambia.
Not seen.
UZam, survey, Zambia, Kafue, Lmammals

465. Johnsen, P. (1982). Acridoidea of Zambia: 1-3. Zoology Department, Aarhus University, Aarhus, Denmark.
First of 5 reports (1982-87) on this Orthopteran group (grasshoppers) from Zambia.
Zbasin, checklist, Zambia, insects

466. Johnsen, P. (1990). The Acridoidea of Botswana. Part 1. Aarhus University, Aarhus, Denmark. ISBN 87-983532-09. 129 pp.
Account of this Orthopteran group (grasshoppers) from Botswana. 160 species are mentioned, many from the Okavango/Chobe area.
UZam, checklist, Botswana, insects

467. Joos-Vandewalle, M.E. (1988). *Abundance and distribution of large herbivores in relation to environmental factors in Savuti, Chobe National Park, Botswana*. MSc thesis, University of Witwatersrand. Johannesburg, South Africa.
Not seen.
UZam, Botswana, Chobe, vegetation, ecology, Lmammals

468. Jubb, R.A. (1952). A note on the distribution of *Hydrocynus vittatus*, Castelnau, the well-known tigerfish of the Zambezi and Limpopo rivers. *South African Journal of Science* **49**(2): 50-51.
Not seen.
Zbasin, biogeography, fish

469. Jubb, R.A. (1958). A preliminary report on the collections of freshwater fishes made by the Bernard Carp Expeditions to the Caprivi Strip, 1949, the Lower Sabi River, 1950 and to Barotseland, 1952. *Occasional Paper of the National Museums of Southern Rhodesia* **22B**: 177-189.
Not seen.
Namibia, Chobe, Zambia, Barotse, UZam, fish

470. Jubb, R.A. (1960). Some Lake Kariba fish problems. *Piscator* **47**: 112-119.
Account of the introduction of 2 Tilapia species, weed infestation, and the possible disappearance of eels from the new lake.
MZam, Zambia, Zimbabwe, Kariba, probspp, plants, ecology, fish

471. Jubb, R.A. (1961). *An Illustrated Guide to the Freshwater Fishes of the Zambezi River, Lake Kariba, Sabi, Lundi and Limpopo Rivers*. Stewart Manning, Bulawayo, Zimbabwe. 171 pp.
Illustrated guide to the fishes of Zimbabwe, including from the upper Zambezi.
Zbasin, Kariba, checklist, Zimbabwe, fish

472. Jubb, R.A. (1964). Freshwater fishes and drainage basins in Southern Africa. *South African Journal of Science* **60**: 17-21.
Not seen.

SAfrica, Zbasin, biogeography, fish

473. Jubb, R.A. (1967). *Freshwater Fishes of Southern Africa.* A.A. Balkema, Cape Town, South Africa. 248 pp.
Expanded and revised version of Jubb (1961), which includes most, but not all, of the fish species from the Zambezi system.
SAfrica, biogeography, checklist, fish

474. Junor, F.J.R. (1960). Preliminary observation on the behaviour of non-aquatic mammals under man-made flood conditions, as noted at Kariba during the period 2 December 1958 and 17 July 1959. In: *Proceedings of First Federal Science Congress*. Rhodesia Scientific Association, Harare, Zimbabwe. pp.285-286.

Account of behavioural response by large mammals to flooding of the Zambezi valley by Lake Kariba.
MZam, Zimbabwe, Kariba, Lmammals

475. Kalk, M.J. (1972). The challenge of Lake Chilwa, Malawi. *African Journal of Tropical Hydrobiology and Fisheries* **1**: 141-146.
Not seen.
Malawi, LChilwa

476. Kalk, M.J., McLachlan, A.J. and Howard-Williams, C. [editors] (1979). *Lake Chilwa: Studies of changes in a tropical ecosystem.* W.Junk, The Hague, Netherlands. 462 pp.
Monograph on Lake Chilwa which adopts a holistic approach.
survey, Malawi, LChilwa, ecology, vegetation, fisheries, water quality

477. Kalk, M.J. and Schulten-Senden, C.M. (1977). Zooplankton in a tropical endorheic lake (Lake Chilwa, Malawi) during drying and recovery phases. *Journal of Limnological Society of Southern Africa* **3**: 1-7.

Not seen.
Malawi, LChilwa, zooplankton, ecology

478. Kampamba, G. and Pope, A.J. (1996). The conservation management of cranes in Zambia. In: *Proceedings of 1993 African Crane and Wetland Training Workshop* (edited by Beilfuss, R.D., Tarboton, W.R. and Gichuki, N.N.). International Crane Foundation, Baraboo, WI, USA. pp.249-254.
Brief account of the conservation of cranes and threats to their habitats. There seems to be a link between the local distributions of Wattled Crane and black and Kafue lechwe.
UZam, Kafue, Zambia, birds, conservation

479. Kamweneshe, B.M. (1996). Status and ecology of wattled cranes in Bangweulu Basin, Zambia. In: *Proceedings of 1993 African Crane and Wetland Training Workshop* (edited by Beilfuss, R.D., Tarboton, W.R. and Gichuki, N.N.). International Crane Foundation, Baraboo, WI, USA. pp.261-265.
Brief account of Wattled Cranes. The Bangweulu Swamps and Kafue Flats have the highest populations in southern Africa, but their range is being reduced by human activity. From aerial and ground surveys, Bangweulu is estimated to have about 1455 birds.
UZam, Zambia, Bangweulu, conservation, birds

480. Kapetsky, J.M. (1974). The Kafue River floodplain: an example of pre-impoundment potential for fish production. In: *Lake Kariba: a Man-made Tropical Ecosystem in Central Africa* (edited by Balon, E.K. and Coche, A.G.). W. Junk, The Hague, Netherlands. pp.497-523.
Account of the general productivity of the Kafue Flats for fishery, and the relative abundance and biomass of fish in the river and lagoons.
UZam, Zambia, Kafue, fisheries, fish

481. Karenge, L. and Kolding, J. (1995a). Inshore fish population and species changes in Lake Kariba, Zimbabwe. In: *The Impact of Species Changes in African Lakes* (edited by Pitcher, T.J. and Hart, P.J.B.). Fish and Fisheries Series No. 18. Chapman & Hall, London, UK. ISBN 0-412-55050-4. pp.245-275.
Detailed study on changes in fish species composition and relative abundance on Lake Kariba. There were three phases - initial filling, increasing diversity and maturity. The changes were related to lake level, aquatic macrophytes, predation and competition, as well as to the effects of fishing. Lake-level fluctuations, with associated changes in nutrient inputs, have probably had the largest influence; the introduction of kapenta dos not seem to have greatly affected inshore fish production.
MZam, Zimbabwe, Kariba, fisheries, environmental assessment, fish

482. Karenge, L. and Kolding, J. (1995b). On the relationship between hydrology and fisheries in man-made Lake Kariba, Central Africa. *Fisheries Research* **22**: 205-226.
Study showing a positive relationship between fish catches and the hydrology of the Zambezi. Lake level fluctuations and resultant nutrient inputs are important in promoting fish production. All fish species found are listed.

MZam, Zimbabwe, Kariba, fisheries, fish, hydrology

483. Katanekwa, V. (1996). Reduction in distribution of the Crowned Crane: a case study of the Barotse floodplains. In: *Proceedings of 1993 African Crane and Wetland Training Workshop* (edited by Beilfuss, R.D., Tarboton, W.R. and Gichuki, N.N.). International Crane Foundation, Baraboo, WI, USA. pp.283-286.
Brief account of the Grey Crowned Crane in the Barotse floodplain, Liuwa, Luena and Matabele Plains. From a ground survey, distribution appears to have been reduced to a small part of the Liuwa Plains (80 birds). This is ascribed to human impacts such as agriculture and hunting, and to successive droughts.
UZam, Barotse, Zambia, conservation, birds

484. Kautsky, N. and Kiibus, M. (1997). Biomass, ecology and production of benthic fauna in Lake Kariba. In: *Advances in the Ecology of Lake Kariba* (edited by Moreau, J.). University of Zimbabwe Publications, Harare, Zimbabwe. ISBN 0-908307-54-3. pp.162-182.
Account of the distribution and biomass of bottom dwelling fauna, principally mussels. Total biomass was estimated at almost 119,000 tons, 96% of it comprising four species of mussel. This high value is ascribed to a lack of predators.

MZam, Zimbabwe, Kariba, ecology, molluscs

485. Kelley, D.W. (1968). Fishery development in the central Barotse floodplain. FAO/UNDP Report T.A. 2554. FAO, Rome, Italy. 83 pp.
Not seen. Report which may contain species lists.
Zambia, UZam, Barotse, fisheries, fish

486. Kenmuir, D.H.S. (1976). Fish spawning under artificial flood conditions on the Mana flood-plain, Zambezi river. *Kariba Studies* **5**: 86-97.
Account of the relationship between fish breeding on the mid Zambezi floodplain and the discharge of water from Kariba, with recommendations on the timing of discharge. Lists of fish species found at Mana Pools are given.
MZam, Mana, Zimbabwe, ecology, fish

487. Kenmuir, D.H.S. (1978). *A Wilderness Called Kariba: the wildlife and natural history of Lake Kariba*. Wilderness Publishers, Bulawayo, Zimbabwe. ISBN 0-7974-0379-5. 140 pp.
Popular book on the history and natural history of Lake Kariba, from its inception to the late 1970s. Particularly strong on fish and fish ecology.
MZam, Zimbabwe, Kariba, fisheries, history, probspp, environmental assessment, Lmammals, birds, fish, plants

488. Kenmuir, D.H.S. (1984). Fish population changes in the Sanyati Basin, Lake Kariba, Zimbabwe. *South African Journal of Zoology* **19**: 194-209.
Account of the populations of larger fish species in Lake Kariba with data on their relative abundance from 1960 to 1975. Changes that followed the creation of the lake are outlined.
MZam, Zimbabwe, Kariba, environmental assessment, fish

489. Kenmuir, D.H.S. (1989). *Fishes of Kariba.* Longman, Harare, Zimbabwe. ISBN 0-908310-38-2. 135 pp.
Popular illustrated account of the fish species and fish ecology of Lake Kariba. Contains much useful information.

MZam, Zimbabwe, Kariba, ecology, fish

490. Keogh, H.J. and Price, P.J. (1981). The multimammate mice; a review. *South African Journal of Science* **77**: 484-488.
Review of African mice of the genus Mastomys which are widely distributed in grassland and savanna habitats.
SAfrica, Smammals

491. Kerr, M.A. (1978). Reproduction of elephant in the Mana Pools National Park, Rhodesia. *Arnoldia (Rhodesia)* **8**(29): 1-11.
Study of reproduction in elephant on the Zambezi floodplain.
MZam, Mana, Zimbabwe, Lmammals

492. Kerr, M.A. and Fraser, J.A. (1975). Distribution of elephant in a part of the Zambezi valley, Rhodesia. *Arnoldia (Rhodesia)* **7**(21): 1-14.
Reports on 17 aerial surveys of elephant over a 5 year period, and documents seasonal concentration across the mid-Zambezi valley.
MZam, Mana, survey, Zimbabwe, Lmammals

493. Kershaw, P.S. (1922). On a collection of mammals from Chiromo and Cholo, Ruo, Nyasaland, made by Mr. Rodney C. Wood, with field-notes by the collector. *Annals & Magazine of Natural History, Series 9* (56): 177-192.
Collection notes on 60 mammal species from the lower Shire taken from Wood's collections.
LZam, checklist, Malawi, LShire, Smammals

494. Kimmins, D.E. (1958). On some Trichoptera from S. Rhodesia and Portuguese East Africa. *Bulletin of the British Museum (Natural History), Entomology* **7**(7): 359-368.
Account of 5 species of caddis fly collected from Victoria Falls.
MZam, Mozambique, Zimbabwe, insects

495. King, R.D. and Thomas, D.P. (1985). Environmental conditions and phytoplankton in the Mwenda River, a small intermittent river flowing into Lake Kariba. *Hydrobiologia* **126**: 81-89.
Lists the genera of phytoplankton, especially diatoms, found in a small river flowing in to Lake Kariba. Diatom populations consist of cosmopolitan tropical taxa.
MZam, Zimbabwe, Kariba, phytoplankton

496. Kiriakoff, S.G. (1975). New African Notodontidae XII (Lepidoptera: Notodontoidae). *Arnoldia (Rhodesia)* **7**(15): 1-9.
Account of 2 new species of moth from Mwinilunga, Zambia.
Zambia, headwater, UZam, insects

497. Kirk, J. (1864). List of mammals met with in Zambesia, East Tropical Africa. *Proceedings of Zoological Society of London* **1864**: 649-660.
Not seen.
LZam, Delta, Mozambique, Lmammals

498. Kirk, R.G. (1967). The zoogeographical affinities of the fishes of the Chilwa-Chiuta depression in Malawi. *Rev. Zool. Bot. afr.* **76**: 295-312.
Not seen.
Malawi, LChilwa, biogeography, fish

499. Knowles-Jordan, E. and Ansell, W.F.H. (1959). Notes on the distribution of game in northern Rhodesia, 1904-13. *The Northern Rhodesia Journal* **4**: 139-146.
Account of visual records of larger mammals from S, W and E Zambia, including the mid-Zambezi valley near Feira and near Victoria Falls. He suggests that large mammal densities were much higher in many areas before the widespread availability of firearms in the 1930s.
Zbasin, Zambia, human use/impact, Lmammals

500. Koch, H. and Schlettwein, C.H.G. (1983). The history of the *Salvinia molesta* problem in the eastern Caprivi Zipfel of South West Africa/Namibia from 1948 to 1981. In: *Proceedings of the 20th Annual Congress of the Limnological Society of Southern Africa*. Limnological Society, South Africa.
Account of the infestation of the Caprivi wetlands by Salvinia, including on various methods of control.
UZam, Namibia, Chobe, history, probspp, plants

501. Koen, J.H. (1988). Birds of the Eastern Caprivi. *Southern Birds* No. 15. Witwatersrand Bird Club, Benmore, South Africa. ISBN 0-620-10490-2. 73 pp.
Checklist of 260 species recorded from the E Caprivi in 1978-79, incorporating an additional 117 species from 5 previous lists. 120 species of waterbirds were included. An account of the area and its habitats is given.
UZam, checklist, Namibia, Chobe, vegetation, ecology, birds

502. Komen, J. (1990). Distribution of Greater Swamp Warblers in southern Africa. *Lanioturdus* **25**: 55-56.

Brief note on a wetland bird restricted to papyrus swamps. It was found in the E Caprivi wetlands in 1986-88, but within the Zambezi Basin is principally confined to the Okavango and Linyanti.
UZam, Namibia, Chobe, Okavango, Botswana, birds

503. Konings, A. (1990). *Cichlids and all the Fishes of Lake Malawi.* Tropical Fish Hobbyist Publication, Neptune City, USA.
Well illustrated book of cichlid fish species of Lake Malawi, particularly those of interest to aquarists.
checklist, Malawi, LMalawi, fish

504. Konrad, P.M. (1981). Status and ecology of Wattled Crane in Africa. In: *Crane Research Around the World* (edited by Lewis, J.C. and Masatomi, H.). International Crane Foundation, Baraboo, Wisconsin, USA. pp.220-237.
Not seen.
SAfrica, Zbasin, conservation, birds

505. Konrad, P.M. (1987). Wattled Cranes in peril - Kafue Flats, Zambia. In: *Proceedings of the 1983 International Crane Workshop* (edited by Archibald, G.W. and Pasquier, R.F.). International Crane Foundation, Baraboo, Wisconsin, USA. pp.349-352.
Account of the ecological importance of the Kafue Flats which supports the largest world population of Wattled Crane (c.3000), and describes the threats posed to the floodplain by the Kafue Gorge and Itezhi-tezhi dams.
UZam, Zambia, Kafue, conservation, birds

506. Kraus, O. (1957). Pholcidae (Smeringopodinae, Ninetinae). *Senckenbergiana biologica* **38**(3/4): 217-243.
Descriptions in German of a family of spiders from Africa and S America, including a new species of spider from the lower Shire.
SAfrica, Malawi, LShire, Oinverts

507. Lagler, K.F., Kapetsky, J.M. and Stewart, D.J. (1971). The fisheries of the Kafue River flats, Zambia, in relation to the Kafue Gorge dam. FAO FI:SF/ZAM 11 Technical Report No. 1. FAO, Rome, Italy. 161 pp.
Not seen. May contain a list of fish species from the Kafue with notes on the population changes after dam closure.

UZam, Zambia, Kafue, environmental assessment, fisheries, fish

508. Lamoral, B.H. (1981). *Paroecobius wilmotae*, a new genus and species of spider from the Okavango Delta, Botswana (Araneae: Oecobiidae: Oecobiinae). *Annals of the Natal Museum* **24**(2): 507-512.
Description of new species of spider from the Okavango.
UZam, Botswana, Okavango, Oinverts

509. Latham, E.W. (1957). Report on the flooding in the Chiromo/Makanga area as a result of the cyclone which crossed the territory on 5th April 1956. *Nyasaland Journal* **10**(1): 47-61.
Account of worst flood experienced in area at that date. The Elephant Marsh is important in providing a reservoir for overspill of flood waters.
LZam, Malawi, LShire, history

510. Laurent, R.F. (1951). Aperçu des formes actuellement reconnaissables dans le superespèce *Hyperolius marmoratus*. *Annales de la Société Royale Zoologique de Belgique* **82**(2): 379-397.
Account in French of a group of frogs.
UZam, amphibians

511. Laurent, R.F. (1954). Etude de quelques espèces méconnues du genre *Ptychadena*. *Annales du Musée Royal de Congo Belge; Sciences Zoologiques* **34**: 1-34.
Account in French of a group of frogs.
UZam, amphibians

512. Laurent, R.F. (1964). Reptiles et amphibiens de l'Angola (troisième contribution). *Publicaçoes Culturais de Compania de Diamantes de Angola* **67**: 1-165.
List of reptiles and amphibians from Angola, with records from the upper Zambezi.
checklist, Angola, UZam, reptiles, amphibians

513. Laurent, R.F. (1972). Tentative revision of the genus *Hemisus* Günther. *Annales du Musée Royal de l'Afrique Centrale; Sciences Zoologique* **194**: 1-67.
Taxonomic revision of a group of frogs.
UZam, amphibians

514. Lawrence, B. and Loveridge, A. (1953). Zoological results of a fifth expedition to East Africa. I - Mammals from Nyasaland and Tete. *Bulletin of Museum of Comparative Zoology, Harvard* **110**(1): 1-80.
Detailed records of collections made during an expedition.
checklist, Malawi, Mozambique, MZam, LZam, LShire, Lmammals, Smammals

515. Lawrence, R.F. (1953). Zoological results of a fifth expedition to East Africa. V - Chilopoda (Myriopoda) from Nyasaland and Tete. *Bulletin of Museum of Comparative Zoology, Harvard* **110**(5): 407-423.
Detailed records of collections made during an expedition.
checklist, Malawi, Mozambique, LZam, MZam, LShire, Oinverts

516. Lawton, R.M. (1959). A pollen analysis of the Lake Bangweulu peat deposits. *The Northern Rhodesia Journal* **4**: 33-43.
Not seen.
UZam, Zambia, Bangweulu, biogeography, plants

517. Lawton, R.M. (1963). Paleoecological and ecological studies in the Northern Province of Northern Rhodesia. *Kirkia* **3**: 46-76.
Study of the present vegetation of part of N Zambia, including the Bangweulu swamps. The account includes descriptions of vegetation types and ecological relations. Remnant vegetation types are described. Results from pollen analysis provide suggestions on previous vegetation cover. Lists of woody species from various types are given.
survey, UZam, Zambia, Bangweulu, biogeography, ecology, vegetation, plants

518. Leakey, L.S.B. (1958). Dugongs. *African Wild Life* **12**(1): 19-20.

Popular account of the natural history of dugong, which although marine may frequent estuarine habitats such as the Zambezi delta.
SAfrica, Lmammals

519. Lent, P.C. (1969). A preliminary study of the Okavango lechwe (*Kobus leche leche* Gray). *East African Wildlife Journal* **7**: 147-157.
Account of seasonal habitat selection, behaviour and reproduction of lechwe in the Moremi area. Lechwe are only found where the floodplain is still wide in the dry season and open water is present.
UZam, Botswana, Okavango, ecology, Lmammals

520. Letcher, O. (1987). *Big Game Hunting in North-Eastern Rhodesia.* St Martin's Press, New York, USA. 266 pp.
Early account of journey from Tete in Mozambique across eastern Zambia through Luangwa valley on an extended hunting trip. Anecdotal references to encounters with large mammals in the area and impressions of local people.
Luangwa, MZam, Mozambique, Zambia, history, Lmammals

521. Letcher, O. (1995). *Bonds of Africa.* Books of Zimbabwe, Bulawayo, Zimbabwe.
Early account of journey through Zimbabwe and Zambia and into Luangwa valley on an extended hunting trip. Anecdotal references to encounters with large mammals in the area and impressions of local people.
Luangwa, MZam, Zimbabwe, Zambia, history, Lmammals

522. Lewis, D., Reinthal, P. and Trendall, J. (1986). *A Guide to the Fishes of Lake Malawi National Park.* WWF, Gland, Switzerland.
General illustrated introduction to the fish of Lake Malawi NP at Cape Maclear, particularly the rock-dwelling 'mbuna' group.
Malawi, LMalawi, fish

523. Long, R.C. (1956). The breeding colonies of large water and marsh birds within the Port Herald District. *Nyasaland Journal* **9**(2): 29-50.
Discussion on biology of water birds from the area with a map of distribution of nests.
LZam, Malawi, LShire, birds

524. Long, R.C. (1960). The birds of the Port Herald district (Part I). *Ostrich* **31**: 85-104.
Account of the birds from the Nsanje area of the lower Shire (1951-1960). Gives information on 137 bird species (89 waterbirds) with a map and general description of the area, including vegetation.
LZam, Malawi, LShire, vegetation, birds

525. Long, R.C. (1961a). The birds of the Port Herald district (Part II). *Ostrich* **32**: 23-35.
Includes information on 12 species of waterbirds.
LZam, Malawi, LShire, birds

526. Long, R.C. (1961b). The birds of the Port Herald district (Part III). *Ostrich* **32**: 147-173.
Includes information on 12 species of waterbirds.
LZam, Malawi, LShire, birds

527. Long, R.C. (1967). The birds of the Port Herald district (Part IV). *Ostrich* **38**: 37-45.
An up-date in the period 1957-62, with information on 65 species of waterbirds.
LZam, Malawi, LShire, birds

528. Long, R.C. (1973a). The birds of the Port Herald District (Part 1). *Society of Malawi Journal* **26**(2): 56-63.
Habitat descriptions and notes on 1200 bird specimens from the area.
LZam, checklist, Malawi, LShire, birds

529. Long, R.C. (1973b). A list with notes of the mammals of the Nsanje (Port Herald) District, Malawi. *Society of Malawi Journal* **26**(1): 60-78.
Locality records of 183 mammal specimens from the area, few of which are from wetlands.
LZam, checklist, Malawi, LShire, Smammals

530. Long, R.C. (1974). The birds of Nsanje (Port Herald) district (part V). *Society of Malawi Journal* **27**(1): 74-88.
Includes notes on 8 species of waterbirds.
LZam, Malawi, LShire, birds

531. Lopes, A.P. (1936). Sirenios. Fauna Moçambique, Documentario Trimenstral No. 6. pp.27-36.
Not seen.
Mozambique, Lmammals

532. Loveridge, A. (1953a). Zoological results of a fifth expedition to East Africa. III - Reptiles from Nyasaland and Tete. *Bulletin of Museum of Comparative Zoology, Harvard* **110**(3): 141-322.
Detailed record of species collected during an expedition including 4 species from the lower Shire.
LZam, checklist, Malawi, Mozambique, LShire, reptiles

533. Loveridge, A. (1953b). Zoological results of a fifth expedition to East Africa. IV - Amphibians from Nyasaland and Tete. *Bulletin of Museum of Comparative Zoology, Harvard* **110**(4): 323-406.
Detailed records of collections made during an expedition including 5 species from the lower Shire.
LZam, checklist, Malawi, Mozambique, LShire, amphibians

534. Loveridge, A. (1953c). Herpetological results of the Berner-Carr entomological survey of the Shire Valley, Nyasaland. *Quarterly Journal of the Florida Academy of Sciences* **16**: 139-150.
Detailed record of species collected during an expedition, 25 of which are from the lower Shire valley.
LZam, checklist, Malawi, Mozambique, LShire, reptiles, amphibians

535. Loveridge, A. (1954). *I Drank the Zambezi*. Lutterworth Press, London, UK.
Account of travels in Malawi.
Zbasin, Malawi, history

536. Lowe, R.H. (1952). Report on the Tilapia and other fish and fisheries of Lake Nyasa. Fishery Publications of the Colonial Office, London No. 1. Colonial Office, London, UK.
One of the important early publications on tilapia and fisheries in Lake Malawi.
Malawi, LMalawi, fisheries, fish

537. Lydekker, R. (1908). *The Game Animals of Africa*. Rowland Ward, London, UK.
One of the original attempts to synthesize the knowledge available on the larger species of African mammals.
Zbasin, Lmammals

538. Lyell, D.D. (1913). *Wildlife in Central Africa*. The Field (Horace Cox), London, UK. 284 pp.
Details on travel and hunting in C Malawi (especially headwaters of the Ruo river), the Luangwa valley of E Zambia and Lake Bangweulu. Includes natural history notes on large and medium sized mammals.
Zbasin, Luangwa, Malawi, Zambia, Bangweulu, history, Lmammals

539. Lyell, D.D. (1929). *The Hunting and Spoor of Central African Game*. Seeley, Service & Co., London, UK. 234 pp.
Details on travel and hunting in C and S Malawi, Zambia (especially the Luangwa valley and Lake Bangweulu). Natural history notes and illustrated spoor and scats of large and medium-sized mammals.
Luangwa, Zbasin, Malawi, Zambia, Bangweulu, history, Lmammals

540. Maar, A. (1960). Introductory check list of the fishes of the Zambeze sub-region of the Ethiopian region. In: *Proceedings of the First Federal Science Conference* Rhodesia Scientific Association, Harare, Zimbabwe. pp.339-346.
List of fish recorded from the Zambezi basin; now out of date.
Zbasin, checklist, biogeography, fish

541. Macartney, P. (1968). Wattled Cranes in Zambia. *Bokmakierie* **20**: 38-41.
Includes photos of the development of a chick.
Zbasin, Zambia, birds

542. Macedo, J.d.A. (1974). Vegetaçâo aquatica em Cabora Bassa. Memorias No. 5. Instituto de Investigaçâo Agronómica de Moçambique, Maputo, Mozambique.
Not seen.
MZam, Mozambique, Cabora, probspp, plants

543. Machena, C. (1989). *Ecology of the hydrolittoral macrophyte communities in Lake Kariba*. PhD thesis, University of Uppsala. Uppsala, Sweden.
Thesis describes the dynamics of the aquatic shoreline vegetation of Lake Kariba. It shows an ecological gradient from the Zambezi river inlet to the Sanyati basin, reflecting the hydrological gradient of the lake.
MZam, Zimbabwe, Kariba, vegetation, ecology

544. Machena, C. (1992). Dam developments and their environmental effect: the Kariba experience. In: *Wetlands Conservation Conference for Southern Africa: Proceedings of the Southern African Development Coordination Conference held in Gaborone, Botswana, 3-5 June 1991* (edited by Matiza, T. and Chabwela, H.N.). IUCN Wetlands Programme No. 4. IUCN, Gland, Switzerland. ISBN 2-8317-0125-2. pp.27-42.
Account of the effects of the creation of Lake Kariba, with particular reference to fisheries and fish composition.
MZam, Zimbabwe, Kariba, environmental assessment, fisheries, fish

545. Machena, C. (1997). The organization and production of the submerged macrophyte communities of Lake Kariba. In: *Advances in the Ecology of Lake Kariba* (edited by Moreau, J.). University of Zimbabwe Publications, Harare, Zimbabwe. ISBN 0-908307-54-3. pp.139-161.
Account of the submerged aquatic plants of Lake Kariba, with sections on species diversity, distribution, zonation, and the biology and production of Lagarosiphon ilicifolius. A total of 7 submerged species have been recorded, a low number possibly resulting from annual lake level fluctuations.

MZam, Zimbabwe, Kariba, vegetation, plants

546. Machena, C. and Kautsky, N. (1988). A quantitative diving survey of benthic vegetation and fauna in Lake Kariba, a tropical man-made lake. *Freshwater Biology* **19**: 1-14.
Account of the distribution and abundance of benthos in relation to that of aquatic plants. Lists of molluscs and submerged plants are given.
MZam, Zimbabwe, Kariba, vegetation, ecology, molluscs, plants

547. Maclean, G.L. (1992). Eastern Caprivi revisited. *Birding in South Africa* **44**(1): 8-11.
Popular account of birdwatching in the E Caprivi. Many bird species are mentioned.
UZam, Namibia, Chobe, birds

548. Maclean, G.L. (1993). *Roberts' Birds of Southern Africa.* John Voelcker Bird Book Fund, Cape Town, South Africa. ISBN 0-620-07681-X.
The best compact book that gives distributions (maps), status, and biology of all species south of the Cunene-Zambezi.
SAfrica, checklist, birds

549. Magadza, C.H.D. (1968). *The relative abundance and distribution of Collembola (Insecta) in relation to the development of a littoral fauna on Lake Kariba, Rhodesia*. MPhil thesis, University of London. Harare, Zimbabwe.
Not seen.
MZam, survey, Zimbabwe, Kariba, ecology, insects

550. Magadza, C.H.D. (1970). A preliminary survey of the vegetation of the shore of Lake Kariba. *Kirkia* **7**(2): 253-267.
Study of the plants of the Lake Kariba shoreline around the Mwenda estuary, N Zimbabwe. Three zones are described, A Ludwigia zone of dicotyledons and Cyperaceae closest to the water, a Laggera ecotone zone comprising a mixture of species from zones both above and below, and a Gramineae zone closest to the still-existing mopane woodland. Floating colonies of Salvinia molesta with Typha latifolia or Phragmites australis are sometimes seen. A list of species from each zone is given. Zonation corresponds to lake level movements, and is also affected by intensity of wave action, gradient of shoreline, the presence of deposited Salvinia mats, and game activity. The colonizing ability of Panicum repens is described.
MZam, survey, Zimbabwe, Kariba, vegetation, ecology, plants

551. Magadza, C.H.D. (1977a). A note on entomostraca in samples from three dams in Rhodesia. *Arnoldia (Rhodesia)* **8**(14): 1-4.
Lists crustacean zooplankton species from Lake Chivero, Mazoe Dam and Connemara Dam, Zimbabwe.
MZam, Chivero, Zimbabwe, crustacea, zooplankton

552. Magadza, C.H.D. (1977b). Observations on the behaviour of macrophytes following impoundment of the Kafue River at Kafue Gorge (1974-1976). *Transactions of the Rhodesia Scientific Association* **58**(3): 17-23.
Account of study showing proliferation of some species from pre-impoundment floodplain vegetation. Dominant species were Vossia, Oryza and Aeschynomene.
MZam, Zambia, Kafue, environmental assessment, vegetation, plants

553. Magadza, C.H.D. (1978a). Field observations on the environmental effect of large-scale aerial applications of endosulfan in the eradication of *Glossina morsitans centralis* Westw. in the Western Province of Zambia in 1968. *Rhodesian Journal of Agricultural Research* **16**: 211-220.
Study of the impacts of thiodan application in both savanna and wetland vegetation in W Zambia along the Kwando river. Fish died in shallow pans in the sprayed areas.
UZam, Barotse, Zambia, Angola, pollution, environmental assessment, ecology, fish

554. Magadza, C.H.D. (1978b). Notes on molluscan intermediate hosts of trematodes in the Kafue Gorge dam, Zambia. *Transactions of the Rhodesia Scientific Association* **58**(8): 48-54.
Study on snail vectors of trematode worms in the Kafue Gorge dam. The 4 common snail species all carried flukes.

MZam, Zambia, Kafue, molluscs, Oinverts

555. Magadza, C.H.D. (1980). The distribution of zooplankton in the Sanyati Bay, Lake Kariba; a multivariate analysis. *Hydrobiologia* **70**: 57-67.
Gives a list of crustacean zooplankton species found in Lake Kariba with population densities. The distribution of plankton is linked to river inflow.
MZam, Zimbabwe, Kariba, zooplankton, crustacea

556. Magadza, C.H.D. (1981). A contribution to the check list of entomostraca of Zambia: free living Copepoda and Cladocera. *Transactions of the Zimbabwe Scientific Association* **60**(7): 41-48.
Preliminary checklist of 71 species of aquatic planktonic crustacea from various sites in Zambia.
Zbasin, checklist, Zambia, crustacea, zooplankton

557. Magadza, C.H.D. (1983). Toxicity of endosulfan to some aquatic organisms of southern Africa. *Zimbabwe Journal of Agricultural Research* **21**
Account of toxicity experiments with endosulfan in W Zambia.
UZam, Barotse, Zambia, pollution

558. Magadza, C.H.D. (1985). An analysis of plankton samples of the Lake Bangweulu area. In: *Hydrobiological Survey of the Lake Bangweulu Luapula Basin* (edited by Symoens, J.J.). Circle Hydrobiologique de Bruxelles, Brussels, Belgium. 32 pp.
Analysis of plankton samples from Lake Bangweulu showing spatial distribution of species. This could be linked to water chemistry and land use patterns.
UZam, survey, Zambia, Bangweulu, zooplankton

559. Magadza, C.H.D. (1992). Limnology of the Kafue Gorge dam, Zambia. In: *Lake Conservation and Management* (edited by Honliang, L., Yutian, Z. and Haisheng, L.). RAES/UNEP/ILEC, 654 pp.
Limnological study of Lake Kafue showing 3 zones (gorge area, floodplain and transition). Model based on nutrient status and sewage input suggests eutrophication is looming.
MZam, Zambia, Kafue, ecology, vegetation, water quality

560. Magadza, C.H.D. (1994). An evaluation of eutrophication control in Lake Chivero, using multivariate analysis of plankton samples. In: *Studies on the Ecology of Tropical Zooplankton* (edited by Dumont, H., Green, J. and Masundire, H.). Kluwer Academic Press, London, UK. 295 pp.
Account of reduction in eutrophication in Lake Chivero as seen from plankton data. A slight increase in nutrient inflow would result in rapid return to eutrophic conditions.
MZam, Chivero, Zimbabwe, human use/impact, water quality, zooplankton

561. Magadza, C.H.D. (1995a). Reservoir management using food chain manipulation. In: *Guidelines of Lake Management: Biomanipulation in Lakes and Reservoirs Management* (edited by De Bernardi, R. and Giussani, G.). Vol. 7. ILEC/UNEP, 211 pp.
Account of the introduction of kapenta into Lake Kariba which increased its trophic complexity. Introduction of other fish species enabled control of Salvinia through herbivory.
MZam, survey, Zimbabwe, Kariba, human use/impact, fisheries, fish, plants

562. Magadza, C.H.D. (1995b). DDT in the Tropics: a review of the NRI report on impacts of DDT in the Zambezi Valley, Zimbabwe. Zambezi Society, Harare, Zimbabwe. 31 pp.
Consultants' report critically reviewing a recent publication on the impacts of DDT on biota. The effects on organisms and ecology of DDT in the Zambezi valley are identified and shown to be not insubstantial.
Zimbabwe, MZam, Kariba, ecology, birds, reptiles, fish, Smammals

563. Main, M. (1987). *Kalahari: Life's Variety in Dune and Delta.* Southern Books, Johannesburg, South Africa. ISBN 1-86812-0015. 265 pp.
Popular account of the geology, ecology and natural history of the Kalahari with detailed chapter on the Okavango swamps and reference to Chobe-Linyanti system.
UZam, Botswana, Okavango, Namibia, ecology, palaeogeography

564. Main, M. (1992). *Zambezi: Journey of a River*. Southern Book Publishers, Halfway House, South Africa. ISBN 1-86812-257-3. 313 pp.
Popular account of the geology, ecology and natural history of the Zambezi river from source to mouth.
Zbasin, ecology, palaeogeography

565. Malambo, C.H. and Chabwela, H. (1992). Preliminary observations on the distribution and abundance of Wattled Cranes in Zambian wetlands. In: *Proceedings of the Seventh Pan-African Ornithological Congress* pp.71-74.
An aerial census (30 May-2 June 1988) was done in the central part of the Kafue Flats (1600 km²) - 663 cranes were seen, and 2724 were estimated. The flooding regime has changed, there is disturbance by cattle and an increase in fishermen and boats.
Zbasin, Kafue, survey, Zambia, birds

566. Mangubuli, M.J.J. (1996). Wattled cranes in Botswana: their status and needs for conservation. In: *Proceedings of 1993 African Crane and Wetland Training Workshop* (edited by Beilfuss, R.D., Tarboton, W.R. and Gichuki, N.N.). International Crane Foundation, Baraboo, WI, USA. pp.315-316.
Population size of Wattled Cranes in Botswana is around 1000-3000 visitors to the Okavango wetlands and 100-200 resident breeding pairs. Breeding has reduced in recent years, possibly because of disturbance and drought.
Okavango, UZam, Botswana, conservation, birds

567. Manning, I.P.A. (1975). Bangweulu: trails of the sitatunga. *Black Lechwe* **12**(2): 14-19.
Popular account of the sitatunga in the Bangweulu swamps, covering behaviour, ecology and conservation. The total population is 18,340-27,510.
UZam, Zambia, Bangweulu, Lmammals

568. Marshall, B.E. (1975). Observations on the freshwater mussles (Lamellibranchiata: Unionaceae) of Lake McIlwaine, Rhodesia. *Arnoldia (Rhodesia)* **7**(16): 1-16.
Describes the mussels found in Lake Chivero with data on their distribution and abundance.
MZam, Chivero, survey, Zimbabwe, molluscs

569. Marshall, B.E. (1978). Aspects of the benthic fauna in Lake McIlwaine, Rhodesia. *Freshwater Biology* **8**: 241-249.
Lists some of the benthic species found in Lake Chivero.
MZam, Chivero, survey, Zimbabwe, molluscs, Oinverts, insects

570. Marshall, B.E. (1979). Fish populations and fisheries potential of Lake Kariba. *South African Journal of Science* **75**: 485-488.
Not seen.
MZam, Zimbabwe, Kariba, fisheries, fish

571. Marshall, B.E. (1982a). The benthic fauna of Lake McIlwaine. In: *Lake McIlwaine: the eutrophication and recovery of a tropical African lake* (edited by Thornton, J.A.). W. Junk, The Hague, Netherlands. ISBN 90-6193-102-9. pp.144-155.
Account of the bottom-dwelling fauna of Lake Chivero, principally comprising worms, insect larvae and mussels. There is zonation according to water depth, and lake-level fluctuations and aquatic plants are shown to have an effect. The eutrophic state of the waters is mentioned.
MZam, Chivero, survey, Zimbabwe, ecology, insects, molluscs, Oinverts

572. Marshall, B.E. (1982b). The fish of Lake McIlwaine. In: *Lake McIlwaine: the eutrophication and recovery of a tropical African lake* (edited by Thornton, J.A.). W. Junk, The Hague, Netherlands. ISBN 90-6193-102-9. pp.155-188.
Detailed account of the fish and fish biology of Lake Chivero. Diets of the various species are described. The fisheries potential is discussed. A list of 26 species is given, 5 of them introduced.
MZam, Chivero, Zimbabwe, ecology, fisheries, fish

573. Marshall, B.E. (1991). The impact of the introduced sardine, *Limnothrissa miodon* on the ecology of Lake Kariba. *Biological Conservation* **55**: 151-165.
Account of the impact of introduced kapenta on the ecology of Lake Kariba, with particular reference to the severe reduction in the abundance and diversity of zooplankton and possible extinction of a Dipteran species.
MZam, Zimbabwe, Kariba, ecology, environmental assessment, fisheries, fish, insects, zooplankton

574. Marshall, B.E. (1995). Changes in the benthic fauna of Lake Chivero, Zimbabwe, over thirty years. *Southern African Journal of Aquatic Sciences* **21**(1/2): 22-28.
Account of the changes in bottom-dwelling fauna in Lake Chivero, which has become more eutrophic and calcium-rich in the intervening period. A dramatic increase in the population of snails was the most striking change.

MZam, Chivero, Zimbabwe, ecology, pollution, molluscs

575. Marshall, B.E. (1997). A review of zooplankton ecology in Lake Kariba. In: *Advances in the Ecology of Lake Kariba* (edited by Moreau, J.). University of Zimbabwe Publications, Harare, Zimbabwe. ISBN 0-908307-54-3. pp.102-119.
Account of the zooplankton in the lake since its formation. The effects on zooplankton composition of the introduction of kapenta and the development of a fishing industry based on it are discussed.
MZam, Zimbabwe, Kariba, environmental assessment, ecology, fish, zooplankton, Oinverts

576. Marshall, B.E. and Junor, F.J.R. (1981). The decline of *Salvinia molesta* on Lake Kariba. *Hydrobiologia* **83**: 477-484.
Account of invasion and decline of Salvinia. In 1962 it covered 22% of the lake, but declined to a stable 10-15%, 5% in 1973 and 1% in 1980. This is ascribed partly to control by a grasshopper, but mostly to nutrient stress as nutrient levels decreased.
MZam, Zimbabwe, Kariba, ecology, probspp, plants

577. Marshall, B.E., Junor, F.J.R. and Langerman, J.D. (1982). Fisheries and fish production on the Zimbabwean side of Lake Kariba. *Kariba Studies* **10**: 175-231.
Account of fisheries in Lake Kariba. Total catch of artesanal gill-net fishing is estimated at 1200 t/year. Industrial kapenta fisheries yields 7990 t/year, but is highly seasonal. Tiger fishing is an important recreational industry. Estimates of fish production from the whole lake vary from 6900-39,000 t/year, but inshore fishing over the whole lake is unlikely to yield more than 3000 t/year. A list of fish species is given.
MZam, Zimbabwe, Kariba, fisheries, fish

578. Marshall, B.E. and Lockett, C.A. (1976). Juvenile fish populations in the marginal areas of Lake McIlwaine, Rhodesia. *Journal of the Limnological Society of Southern Africa* **2**: 37-42.
Account of the abundance of juvenile fish in Lake Chivero with lists of species taken from shallow water.
MZam, Chivero, Zimbabwe, fish

579. Masinga, A.V.R. (1992). Dam developments and their environmental effects. In: *Wetlands Conservation Conference for Southern Africa: Proceedings of the Southern African Development Coordination Conference held in Gaborone, Botswana, 3-5 June 1991* (edited by Matiza, T. and Chabwela, H.N.). IUCN Wetlands Programme No. 4. IUCN, Gland, Switzerland. ISBN 2-8317-0125-2. pp.43-56.
Paper provides an overview of dam development including data on Zambezi dams, the effect of the Kafue dams on floodplain hydrology and their impact on grazing and fisheries.
Zbasin, human use/impacts, hydrology

580. Matthes, H. (1968). The food and feeding habits of the tiger-fish, *Hydrocynus vittatus* (Cast., 1861) in Lake Kariba. *Beaufortia* **15**: 143-153.
Not seen.
MZam, Zimbabwe, Kariba, ecology, fish

581. Matthiessen, P. (1985). Contamination of wildlife with DDT insecticide residues in relation to tsetse fly control operations in Zimbabwe. *Environmental Pollution (B)* **10**: 189-211.
Study shows the impacts of DDT application in the area around Lake Kariba. There appears to be a reproductive failure in migratory fish, and effects on hippo, predatory birds and bats.
MZam, Zimbabwe, Kariba, pollution, fish, Lmammals, Smammals, birds

582. Maughan, R.C.F. (1914). *Wild Game in Zambezia.* John Murray, London, UK. 376 pp.
Early account of hunting in middle Zambezi valley in Mozambique and Zimbabwe (near Mupata Gorge) and Zambia (including Luangwa valley) and Zambezi valley in Mozambique. Anecdotal impressions of large mammal populations in these regions.
MZam, Luangwa, Mozambique, Zambia, Zimbabwe, history, human use/impact, Lmammals

583. Maxwell, W.A. (1954). The Shire Valley Project: criticism. *Nyasaland Journal* **7**(2): 39-45.
Criticism of the report by Richards (1954) saying that the Shire river was much drier earlier than 1915. In 1907 in the Elephant Marsh near Chiromo there was no trace of water or marsh. The criticism focussed on the project's ability to stabilize the lake level, and on its effect on people downstream.
LZam, Malawi, LShire, hydrology

584. Maydon, H.C. [editor] (1951). *Big Game Shooting in Africa.* Jarrold & Sons, Norwich, UK. 445 pp.
Book on hunting with chapters on Zambia, Angola, Mozambique and Malawi written by local authorities.
SAfrica, Zambia, Angola, Mozambique, Malawi, Lmammals

585. McCarthy, T.S. (1992). Physical and biological processes controlling the Okavango Delta - a review of recent research. *Botswana Notes and Records* **24**: 57-86.
Study on the nature of the processes underpinning the Okavango delta. These are said to be external (graben faulting, geology, sedimentation) and internal variables (biotic). Plant communities regulate the dispersal of sediment and water, thus many of the features seen today are biotically controlled through vegetation and blockages.
UZam, Botswana, Okavango, hydrology, vegetation

586. McCarthy, T.S., Ellery, W.N. and Dangerfield, J.M. (1997, in press). The role of biota in shaping flood plain morphology on the Okavango alluvial fan, Botswana. *Earth Surface Processes and Landforms.*

Account of the role of termite mounds in island formation on a floodplain. The raised mound changes hydrological flows resulting in establishment of trees and shrubs. Termites are shown to be important components of the landscape.
UZam, Botswana, Okavango, ecology, insects

587. McCarthy, T.S., Stanistreet, I.G., Cairncross, B., Ellery, W.N., Oelofse, R. and Grobicki, T.S.A. (1988). Incremental aggradation on the Okavango Delta-fan, Botswana. *Geomorphology* : 267-278.
Not seen.
UZam, Botswana, Okavango, palaeogeography, hydrology

588. McFarlane, M.J. (1995). Pans and dambos of Western Province, Zambia. A preliminary consideration of their geomorphology/hydrogeology. Land & Water Management Project, Department of Agriculture, Mongu, Zambia. 27 pp.
Consultants' report on a brief survey of pans and dambos on the Kalahari sand plateau east of the Bulozi Plain. Although primarily concerned with rice production, the insights into the hydrology and soil nutrient distribution have important implications for biodiversity.
Barotse, Zambia, UZam, palaeogeography, hydrology

589. McKaye, K.R., Makwinja, R.D., Menyani, W.W. and Mhone, O.K. (1985). On the possible introduction of non-indigenous zooplankton-feeding fishes into Lake Malawi. *Biological Conservation* **33**: 289-307.

Discussion of the proposal to introduce kapenta into Lake Malawi and the impact this may have on the fish communities.
Malawi, LMalawi, environmental assessment, ecology, fish

590. McLachlan, A.J. (1969a). The effect of aquatic macrophytes on the variety and abundance of benthic fauna in a newly created lake in the tropics (Lake Kariba). *Archiv für Hydrobiologie* **66**(2): 212-231.
Account of the effect of 4 aquatic plants on the benthic communities of Lake Kariba. Faunal biomass and species number increases with appearance of aquatic vegetation. Chironomid larvae were particularly important.
MZam, Zimbabwe, Kariba, ecology, vegetation, plants, molluscs, insect, Oinverts

591. McLachlan, A.J. (1969b). Notes on some larval and pupal chironomids (Diptera) from Lake Kariba, Rhodesia. *Journal of Natural History* **3**: 261-293.
Taxonomic descriptions of the larvae and pupae of 34 chironomid species from Lake Kariba.
MZam, Zimbabwe, Kariba, insects

592. McLachlan, A.J. (1970). Submerged trees as a substrate for benthic fauna in the recently created Lake Kariba (Central Africa). *Journal of Applied Ecology* **7**: 253-266.
Account of 24 invertebrate species living on submerged trees together with data on their distribution and rate of colonisation. Chironomid larvae form a major part of the fauna.
MZam, survey, Zimbabwe, Kariba, ecology, Oinverts, insects

593. McLachlan, A.J. (1974). Recovery of the mud substrate and its associated fauna following a dry phase in a tropical lake. *Limnology and Oceanography* **20**: 74-83.
Account of the benthic fauna of Lake Chilwa after drying out. Chironomid larvae were pioneers, but disappeared after 3 months owing to particle precipitation.
Malawi, LChilwa, insects

594. McLachlan, A.J. (1975). The role of aquatic macrophytes in the recovery of the benthic fauna of a tropical lake after a dry phase. *Limnology and Oceanography* **20**: 54-63.
Not seen. Account of Lake Chilwa.
Malawi, LChilwa, plants, insects

595. McLachlan, A.J. and McLachlan, S.M. (1971). Benthic fauna and sediments in the newly created Lake Kariba (Central Africa). *Ecology* **52**: 800-809.
Account of a study on the development of bottom deposits and associated fauna from the newly-formed Lake Kariba. Chironomid larvae predominate. Faunal biomass is correlated to the amount of carbon, modified by a response to water depth. A list of species found is given.
MZam, Zimbabwe, Kariba, ecology, insects

596. McLachlan, G.R. (1966). The first ten years of ringing in South Africa. *Ostrich Supplement* **6**: 255-263.

Includes maps of recoveries of Cattle Egrets, Sacred Ibis, Spoonbill, and Red-billed Teal in the Zambezi basin from ringing places in South Africa.
SAfrica, survey, Zbasin, birds

597. Meester, J. (1973). Mammals collected during the Bernard Carp Expedition to the Western Province of Zambia. *The Puku* **7**: 137-149.
Report on collections from SE Angola, W Zambia and E Caprivi in 1953, covering 39 species.
UZam, Barotse, survey, Zambia, Lmammals, Smammals

598. Meine, C.D. and Archibald, G.W. [compilers] (1996). *The Cranes: Status Survey and Conservation Action Plan.* IUCN, Gland, Switzerland. ISBN 2-8317-0326-3. 294 pp.
Detailed accounts of the status of crane species with suggested conservation actions. Includes chapters on the Wattled and Grey Crowned Cranes, with current and priority conservation measures.
SAfrica, ecology, conservation, birds

599. Melton, D.A. (1985). The status of elephants in northern Botswana. *Biological Conservation* **31**: 317-333.
Account of a study on elephant distribution and abundance in N Botswana, with particular reference to Chobe NP. Management options are assessed.
UZam, Chobe, Botswana, conservation, Lmammals

600. Mendelsohn, J.M. and Roberts, C.S. (1997). *An Environmental Profile and Atlas of Caprivi.* Directorate of Environmental Affairs, Windhoek, Namibia. ISBN 0-86976-408-X. 51 pp.
Detailed compilation of all available information on the resources of the Caprivi, including a detailed vegetation map.

survey, Namibia, Chobe, UZam, environmental assessment, human use/impact, agriculture, range/livestock, vegetation, plants, ecology, hydrology

601. Menz, A. [editor] (1995). *The Fishery Potential and Productivity of the Pelagic Zone of Lake Malawi/Niassa.* Natural Resources Institute, Chatham, UK. ISBN 0-85954-432-X. 181 pp.
Report of a major investigation into the ecology of the pelagic waters of Lake Malawi. The 13 chapters cover the ecology of phytoplankton, zooplankton and fish. Fisheries potential is discussed.
Malawi, LMalawi, ecology, fisheries, fish, phytoplankton, zooplankton, insects, crustacea

602. Mepham, R.H. and Mepham, J.S. (1987). Swamps and floodplains of the Zambezi Basin and coastal Mozambique. In: *Directory of African wetlands and shallow water bodies* (edited by Burgis, M.J. and Symoens, J.J.). Travaux et Documents 211. ORSTOM, Paris, France. 615 pp.
Not seen.
Zbasin

603. Merron, G.S. (1986). Report on a fish kill after aerial spraying with insecticides in the lower Okavango swamps. Investigation Report No. 20. J.L.B. Smith Institute for Ichthyology, Grahamstown, South Africa. 15 pp.
Not seen.
UZam, Botswana, Okavango, pollution, fish

604. Merron, G.S. (1991). *The ecology and management of the fishes of the Okavango Delta, Botswana, with particular reference to the role of seasonal floods*. PhD thesis, Rhodes University. Grahamstown, South Africa. 166 pp.
Not seen.
UZam, Botswana, Okavango, ecology, hydrology, fish

605. Merron, G.S. (1992). Tsetse fly control and environmental implications for fish in the Okavango Delta, Botswana. *Botswana Notes and Records* **24**: 49-56.
Account of the effects of insecticide spraying on fish populations in the Okavango. Endosulfan was found to have undesirable effects, particularly in shallow floodplains, while deltamethrin was less toxic.
UZam, Botswana, Okavango, pollution, environmental assessment, fish

606. Mhlanga, T.A., Taylor, R.D. and Phelps, R.J. (1986). HCH and DDT residues in the freshwater kapenta at the Ume river mouth, Kariba. *Zimbabwe Science News* **20**: 46-49.
Study shows the presence of residues in the introduced kapenta at the Ume mouth, which is related to the use of DDT for tsetse fly control.
MZam, Zimbabwe, Kariba, pollution, fish

607. Mikkola, H. (n.d.). Checklist of Mozambican birds. Unpublished report, Maputo, Mozambique.
Preliminary checklist of the birds of Mozambique based on recent amateur records.
Zbasin, checklist, Mozambique, birds

608. Miller, P. (1977). Kafue Basin. *Black Lechwe* **12**(3): 18-20.
Brief overview of the Kafue basin from a conservation perspective. The basin is 154,000 km² in size and contains 3 National Parks (Kafue, Lochinvar and Blue Lagoon).
UZam, Zambia, Kafue, conservation

609. Minshull, J.L. (1987). A revised checklist of Zimbabwe fishes. *Arnoldia (Zimbabwe)* **9**(27): 343-352.
List of 132 fish species (including 10 introductions) found in Zimbabwe, including new records. The river systems they occur in are shown: 74 species are from the upper Zambezi, 61 from Lake Kariba, 53 from the mid Zambezi, and 48 from the lower Zambezi.
Zbasin, checklist, Zimbabwe, biogeography, fish

610. Missâo de Fomento e Povoamento do Zambèze (1961). Aspectos pecuários (1958-1960). *Bacia do Zambèze: elementos económico-sociais* Ministério do Ultramar, Província de Moçambique, Maputo, Mozambique. 12-28 pp.
Early report on suitability for livestock production of a large part of the Zambezi valley in Mozambique. The natural vegetation is described under 18 types, and under 5 veld types. Maps of the different types are provided.
LZam, Mozambique, agriculture, vegetation, range/livestock

611. Mitchell, B.L. (1946). A naturalist in Nyasaland. *Nyasaland Agricultural Quarterly Journal* **6**: 1-47.
Brief account of the natural history of some reptile species in the lower Shire.
LZam, Malawi, LShire, reptiles

612. Mitchell, B.L. (1963). A first list of plants collected in the Kafue National Park. *The Puku* **1**: 75-191.
Not seen.
UZam, checklist, Zambia, Kafue, plants

613. Mitchell, B.L., Shenton, J.B. and Uys, J.M.C. (n.d.). Predation on large mammals in Kafue National Park, Northern Rhodesia. Unpublished report.,
Not seen.

UZam, Zambia, Kafue, Lmammals

614. Mitchell, B.L. and Uys, J.M.C. (1961). The problem of the lechwe (*Kobus leche*) on the Kafue Flats. *Oryx* **6**: 171-183.
Account of the Kafue Flats and lechwe populations, focussing on its natural history, historic changes in numbers, hunting and conservation.
UZam, Zambia, Kafue, human use/impact, conservation, Lmammals

615. Mitchell, D.S. (1967). *Salvinia auriculata* in the estuaries of Lake Kariba. In: *Proceedings of the First Rhodesian Science Congress.* Rhodesia Scientific Association, Harare, Zimbabwe. pp.64.
Not seen.
MZam, Zimbabwe, Kariba, probspp, plants

616. Mitchell, D.S. (1967). A survey of *Salvinia auriculata* in the Chobe river system - March 1967. Unpublished report. Department of Wildlife and National Parks, Botswana. 7 pp.
First detailed report on Salvinia in the Chobe system, before it reached Lake Liambezi. The infestation was shown to be extensive between Liambezi and Kasane.
UZam, survey, Namibia, Botswana, Chobe, probspp, plants

617. Mitchell, D.S. (1968). Ecological studies of *Salvinia auriculata* with particular reference to Lake Kariba (Rhodesia-Zambia) and the Chobe River (Botswana). In: *Proceedings of the International Hydrological Decade Symposium, Ecology and Control of Aquatic Vegetation.* UNESCO, Paris. pp.64.
Not seen.
MZam, UZam, Zimbabwe, Botswana, Kariba, Chobe, ecology, probspp, plants

618. Mitchell, D.S. (1969). The development of shoreline vegetation. *Report of the Nuffield Lake Kariba Research Station, Sinamwenda, 1962-1968.* LKRS, Harare, Zimbabwe. 23-24 pp.
Not seen.
MZam, Zimbabwe, Kariba, vegetation, plants

619. Mitchell, D.S. (1969). The ecology of vascular hydrophytes on Lake Kariba. *Hydrobiologia* **34**(3/4): 448-464.
Account of the various types of aquatic plants found in or on Lake Kariba. Sudd formation is described, as is the possible development of vegetation. The importance of Salvinia is outlined.
MZam, Zimbabwe, Kariba, ecology, vegetation, probspp, plants

620. Mitchell, D.S. (1970). *Autecological studies of* Salvinia auriculata *Aubl.* PhD thesis, University of London. London, UK. 669 pp.
Not seen.
MZam, Zimbabwe, Kariba, probspp, ecology, plants

621. Mitchell, D.S. (1978). Freshwater plants. In: *Biogeography and Ecology of Southern Africa* (edited by Werger, M.J.A.).W. Junk, The Hague, Netherlands. ISBN 90-6193-083-9. pp.1113-1138.
Review of knowledge on the taxonomy, ecology and distribution of freshwater plants. Both microphytes and macrophytes are covered, and the flora of standing and flowing waters. Water weeds are discussed. Levels of endemism are low. There have been very few holistic studies in the region.
SAfrica, ecology, biogeography, vegetation, plants

622. Mitchell, D.S. and Marshall, B.E. (1974). Hydrobiological observations on three Rhodesian reservoirs. *Freshwater Biology* **4**: 61-72.
Account of the physico-chemical properties of 3 reservoirs, including Lake Chivero. Phytoplankton are related to these characteristics. Chivero has a high proportion of blue-green algae.
MZam, Chivero, Zimbabwe, water quality, phytoplankton

623. Mitchell, D.S. and Rose, D.J.W. (1979). Factors affecting fluctuations in extent of *Salvinia molesta* on Lake Kariba. *PANS* **25**(2): 171-177.
Account of changes in Salvinia populations on Lake Kariba, peaking in 1962. Reduction in extent is partly ascribed to the introducton of an aquatic grasshopper.
MZam, Zimbabwe, Kariba, probspp, plants

624. Mitchell, M.N. (1973). Annotated check list of Zambian hawk moths. *Zambia Museums Journal* **4**: 59-103.
List with keys and illustrations of the hawk moths of Zambia, with many species from the upper and mid Zambezi. 92 species are listed.
Zbasin, checklist, biogeography, Zambia, insects

625. Mitchell, S.A. (1976). The marginal fish fauna of Lake Kariba. *Kariba Studies* **8**: 109-162.
Account of fish living around the margins of Lake Kariba. Vegetation type and fish biomass were related, with the highest biomass under Salvinia mats. The effects of water depth and changes in lake level on fish are discussed. Stomach contents of various fish species are listed.

MZam, Zimbabwe, Kariba, ecology, fish, insects

626. Mkanda, F.X. (1994). An assessment of hippopotamus (*Hippopotamus amphibius* L.) and human needs and attitudes in the lower Shire valley, Malawi. Biodiversity Support Programme Final Report Department of National Parks and Wildlife, Lilongwe, Malawi. 10 pp.
Report on land use conflicts with hippo. A count in early 1994 showed 1620 hippo in Elephant Marsh, but a subsequent count in August 1994 showed only 448 individuals. The reduction was due to drought, drop in water levels and increased hippo-human conflicts, and to uncontrolled commercial shooting.
LZam, Malawi, LShire, conservation, human use/impact, Lmammals

627. Mlotshwa, D.H. (1996). The first record of *Barbus mattozi* Guimaraes, 1884 (Pisces: Cyprinidae) from the upper Zambezi river, Zimbabwe. *Arnoldia (Zimbabwe)* **10**(5): 33-35.
First record of a fish previously unrecorded from the Zambezi.
UZam, Zimbabwe, fish

628. Moll, E.J. and Werger, M.J.A. (1978). Mangrove communities. In: *Biogeography and Ecology of Southern Africa* (edited by Werger, M.J.A.). W. Junk, The Hague, Netherlands. ISBN 90-6193-083-9. pp.1231-1238.
Brief review of knowledge on the mangroves of southern Africa. The east and west coast mangroves form two groups, and each group shows clear vegetation zonation related to water depth.
Mozambique, LZam, Delta, ecology, biogeography, vegetation, plants

629. Monteiro, M.I. (1960). Contribution to the study of the diatomaceae of Lake Nyasa. Estudos, Ensaios e Documentos No. 72. Maputo, Mozambique.
Not seen. Should contain data on the diatoms of Lake Malawi.
Mozambique, LMalawi, phytoplankton

630. Moore, A.E. (1988). Plant distribution and the evolution of the major river systems in southern Africa. *South African Journal of Geology* **91**(3): 346-349.
Account of links between the proto-Upper Zambezi and the Limpopo as shown by distribution of some woody plant species. The palaeo-geomorphology is described.
ZBasin, UZam, plants, biogeography

631. Moreau, J. [editor] (1997). *Advances in the Ecology of Lake Kariba*. University of Zimbabwe Publications, Harare, Zimbabwe. ISBN 0-908307-54-3. 271 pp.
Book comprising 12 detailed chapters on sediments, nitrogen budget, phytoplankton, zooplankton, vegetation, aquatic plants, benthic fauna, crocodiles, birds and energetics.
MZam, Zimbabwe, Kariba, ecology, waterqual, vegetation, reptiles, amphibians, fish, birds, plants, insects, molluscs, crustacea, Oinverts, zooplankton, phytoplankton

632. Morgan-Davies, A.M., Dudley, C.O. and Meredith, H.M. (1984). Additions to the vertebrate fauna of Liwonde National Park, Malawi. *Nyala* **10**(2): 91-98.
List of new records of mammals (1 sp), birds (12 spp), reptiles (24 spp) and amphibians (20 spp) recorded from Liwonde NP, middle Shire valley.
MShire, LZam, checklist, Malawi, Smammals, birds, reptiles, amphibians

633. Mortimer, M.A.E. [editor] (1965). *The Fish and Fisheries of Zambia*. Falcon Press, Ndola, Zambia. 97 pp.
Not seen. Should contain a list of fish species and their distribution in Zambia, perhaps with biological notes.
Zbasin, checklist, Zambia, fish

634. Moss, B. (1979). The Lake Chilwa ecosystem - a limnological overview. In: *Lake Chilwa: Studies of changes in a tropical ecosystem* (edited by Kalk, M., McLachlan, A.J. and Howard-Williams, C.). W.Junk, The Hague, Netherlands. pp.401-415.
Not seen.
Malawi, LChilwa, ecology

635. Moyo, N.A.G. [editor] (1997). *Lake Chivero, a polluted lake*. University of Zimbabwe, Harare, Zimbabwe. 134 pp.
Collection on papers on the eutrophication and pollution of Lake Chivero in the Zambezi catchment. Solutions are presented.
MZam, Chivero, Zimbabwe, water quality, pollution, environmental assessment, human use/impacts, ecology

636. Mphande, J.N.B. (1987). The status of the Nile Crocodile in Malawi. Unpublished report. Department of National Parks and Wildlife, Lilongwe, Malawi.
Results of a survey giving estimates of 4600-15,000 crocodiles in Malawi, of which 45% are in the Elephant Marsh. Results seem much higher than others (e.g. Bruessow 1989).
LZam, survey, Malawi, LShire, reptiles

637. Mulders, R. (1995). Counting exercise: hippopotamus and crocodile, Lower Shire, July 1995. Unpublished report. Wildlife Society of Malawi, Blantyre, Malawi. 7 pp.

Brief report on status of hippo and crocodile along the lower Shire river. Hippo numbers are low and the present extent of suitable feeding areas very restricted owing to extensive cultivation. Poaching is a problem. Numbers seen of each species are given by section of river.
LZam, survey, Malawi, LShire, human use/impact, Lmammals, reptiles

638. Muldoon, G. (1957). *The Trumpeting Herd.* Rupert Hart-Davis, London, UK. 182 pp.
Anecdotal accounts of large mammal populations in S and C Malawi during the 1950s. Massive declines in elephant, other large herbivores and large carnivores are described and documented. This was mainly to allow agricultural development. The first chapter records heavy settlement and cropping along the lower Shire, especially in the Elephant Marsh, in mid 1950s. Also notes that the birdlife in the lower Shire had also declined considerably since the initial descriptions by Livingstone.
LZam, LShire, Malawi, history, human use/impact, birds, Lmammals

639. Muleta, S., Simasiku, P., Kalyocha, G., Kasutu, C., Walusiku, M. and Mwiya, S. (1996). Proposed terms of reference for the preparation of the management plan for Liuwa Plains National Park. Unpublished report. IUCN Upper Zambezi Wetlands Project, Mongu, Zambia. 51 pp.
Report containing detailed information on the Liuwa Plains NP. Ecological characteristics and larger animal species found are given. Seasonality is shown to be an important ecological feature, in particular for wildebeest.
UZam, Barotse, Zambia, ecology, Lmammals

640. Müller, T. and Pope, G. (1982). Vegetation report for the impact assessment of the proposed Mupata and Batoka gorge dams on the Zambezi river. In: *A preliminary assessment of the environmental implications of the proposed Mupata and Batoka hydroelectric schemes (Zambezi river, Zimbabwe)* (edited by Du Toit, R.F.). Natural Resources Board, Harare, Zimbabwe. pp.53-67, 162-165.
Not seen.
MZam, Mana, survey, Zimbabwe, environmental assessment, vegetation, plants

641. Mundy, P.J., Couto, J.T. and Feather, P.J. (1994). Surveys of the Carmine Bee-eater on the lower Zambezi river in Zimbabwe. *Honeyguide* **40**: 214-230.
34 colonies were found with an estimated 11,300 birds.
MZam, Mana, survey, Zimbabwe, birds

642. Munro, J.L. (1966). A limnological survey of Lake McIlwaine, Rhodesia. *Hydrobiologia* **28**(2): 281-308.
General account of Lake Chivero, a man-made dam, with lists of plankton, benthos and fish.
MZam, Mana, survey, Zimbabwe, fish, molluscs, insects, Oinverts, zooplankton

643. Munthali, S.M. (1997). Dwindling food-fish species and fishers' preference: problems of conserving Lake Malawi's biodiversity. *Biodiversity and Conservation* **6**: 253-261.
Survey of fisheries activity on Lake Malawi from a biodiversity conservation viewpoint. The endemic, ornamental cichlids are shown to be at risk now that fish stocks are in decline.
Malawi, LMalawi, environmental assessment, conservation, fisheries, fish

644. Muyanga, E.D. and Chipungu, P.M. (1982). A short review of the Kafue Flats fishery, from 1968 to 1978. In: *Proceedings of the National Seminar on Environment and Change: The Consequences of Hydroelectric Power Development on Utilisation of the Kafue Flats* (edited by Howard, G.W. and Williams, G.J.). Kafue Basin Research Committee, Lusaka, Zambia. pp.105-113.
General description of the fisheries of the Kafue Flats, documenting the changes in relative abundance of some fish species as a result of the Kafue Gorge dam.
UZam, Zambia, Kafue, human use/impact, fisheries, fish

645. Mwenya, A.N. and Kaweche, G.B. (1982). Wildlife conservation in the Kafue Flats in the light of hydroelectric development. In: *Proceedings of the National Seminar on Environment and Change: the Consequences of Hydroelectric Power Development on the Utilization of the Kafue Flats* (edited by Howard, G.W. and Williams, G.J.). Kafue Basin Research Committee, Lusaka, Zambia. pp.129-135.
Account of the history of conservation on the Flats. Estimates of numbers of larger mammals are given (lechwe 100,000).
UZam, Zambia, Kafue, ecology, conservation, Lmammals

646. NEDECO (1960-61). Report on a field survey and an exploratory investigation in connection with the reclamation and utilization of the Elephant Marsh (20,000 ha). Ministry of Agriculture, Lilongwe, Malawi.

Consultants' report on agricultural potential of Elephant Marsh. A soil or landform map (scale 1:50,000) is included, along with hydrological information.
LZam, survey, Malawi, LShire, agriculture, hydrology

647. Nefdt, R.J.C. [compiler] (199?). Kafue Basin Bibliography. Kafue Basin Research Committee, Lusaka, Zambia.
Not seen.
UZam, bibliography, Zambia, Kafue

648. Nefdt, R.J.C. (1996). Reproductive seasonality in Kafue lechwe antelope. *Journal of Zoology, London* **239**: 155-166.
Study on time of mating in lechwe on the Kafue Flats after changes in the time of flooding related to recent hydroelectric schemes. Lechwe primarily mated when water levels were increasing and inundating potential food supplies, although this now takes place at a different time of year from before impoundment. Calving thus occurs when floods are receding and fresh grass becomes available.
UZam, Zambia, Kafue, environmental assessment, Lmammals

649. Newman, K. (1988). *Newman's Birds of Southern Africa.* Southern Book Publishers, Johannesburg, South Africa.
Illustrated guide to the birds of southern Africa.
SAfrica, checklist, birds

650. Newman, K. (1989). *Birds of Botswana.* Southern Book Publishers, Johannesburg, South Africa. ISBN 1-86812-194-1. 344 pp.
Illustrated guide to the birds of Botswana including distribution maps.
UZam, checklist, Botswana, birds

651. Newman, K., Johnston-Stewart, N. and Medland, B. (1992). *Birds of Malawi: a supplement to Newman's Birds of Southern Africa.* Wildlife Society of Malawi, Limbe, Malawi. 110 pp.
Bird species occurring in the Lower Shire and Elephant Marsh are listed.
Zbasin, checklist, Malawi, birds

652. Nkunika, P.O.Y. (1982). The termites of southern Zambia: their distribution in relation to vegetation zones. *Zambia Museums Journal* **6**: 112-117.
Brief account of the termite species of S Zambia in relation to vegetation types. 10 species are listed from grassland and swamps.
Zbasin, checklist, Zambia, insects

653. Nkunika, P.O.Y. (1986). An ecological survey of the termites (Isoptera) of Lochinvar National Park, Zambia. *Journal of the Entomological Society of Southern Africa* **49**(1): 45-53.
Study on the termites and their distribution in Lochinvar NP on the Kafue Flats. 23 species are listed, with species diversity lowest in the floodplain (9 species).
UZam, Zambia, Kafue, ecology, insects

654. Nugent, C. (1990). The Zambezi River: tectonism, climatic change and drainage evolution. *Palaeogeography, Palaeoclimatology, Palaeoecology* **78**: 55-69.
Study suggesting that the proto-Upper Zambezi was captured by the mid-Zambezi through river capture by an overtopping lake. This resulted in cataclysmic floods, evidenced by the stoney ridge near Mana Pools and "ancient alluvium" higher up the river terraces. This is dated to the peak of the last interglacial (end of middle Pleistocene, c.125,000 years BP). The mid Zambezi now shows degradation, not aggradation, owing to rock outcrops along its length stopping further down-cutting. The possibility of repeated switching of drainage around the Chobe/Zambezi confluence and along the Savuti channel, is outlined.
MZam, hydrology, palaeogeography

655. O'Keeffe, J.H., Davies, B.R., King, J.M. and Skelton, P.H. (1989). The conservation status of southern African rivers. In: *Biotic Diversity in Southern Africa: concepts and conservation* (edited by Huntley, B.J.). Oxford University Press, Cape Town, South Africa. ISBN 0-19-570549-1. pp.266-289.
Definition of wetlands and outline of ecological importance and threats. Constraints on availability of freshwater, and thus its development, are emphasised. Although focused on South Africa (with some mention of dambos in Zimbabwe) this paper has wider applications. Comprehensive bibliography.
SAfrica, conservation, hydrology, fish

656. Oates, F. (1971). *Matabeleland and the Victoria Falls.* Heritage Series The Pioneer Head, Harare, Zimbabwe. 383 pp.
Travels through Matabeleland to the Victoria Falls in the 1870s. Although Oates died of fever on the return journey, his meticulous collections were eventually received by the British Museum. Notes include much on natural history of the region, including mammals. Contains detailed reports by scientific officers on his ethnographic, ornithological, herpetological and entomological specimens.
MZam, Zimbabwe, history, Lmammals, birds, insects, reptiles

657. Oatley, T.B. and Prys-Jones, R.P. (1986). A comparative analysis of movements of southern African waterfowl (Anatidae), based on ringing recoveries. *South African Journal of Wildlife Research* **16**: 1-6.
Study on waterfowl movement across southern Africa, covering 2137 recoveries of 9 species. Pochard, Red-billed Teal and Knob-billed Duck move into the Zambezi basin from South Africa.
SAfrica, survey, birds

658. Osborne, T.O. (1975). Notes on the birds of the Liuwa National Park and a preliminary checklist. Unpublished report. National Parks and Wildlife Service, Chilanga, Zambia.
Not seen.
UZam, Barotse, checklist, Zambia, birds

659. Osborne, T.O. (1981). Ecology of the Red-necked Falcon *Falco chicquera* in Zambia. *Ibis* **123**: 289-297.
Studied on the Kafue Flats. Birds, including at least 8 species of waterbird, comprised 98% of the diet.
UZam, Zambia, Kafue, birds

660. Osborne, T.O. and Colebrook-Robjent, J.F.R. (1988). The diurnal raptors of Lochinvar National Park, Zambia, 1970-1980. In: *Proceedings of the Sixth Pan-African Ornithological Congress* (edited by Backhurst, G.C.). Sixth PAOC Organizing Committee, Nairobi, Kenya. pp.223-231.
Account of raptors on the Kafue Flats. The seasonal use, habitats, breeding and density of 49 species are discussed.

UZam, Zambia, Kafue, ecology, birds

661. Owen, R.B., Crossley, R., Johnson, T.C., Tweddle, D., Kornfield, I., Davison, S., Eccles, D.H. and Engstrom, D.E. (1990). Major low levels of Lake Malawi and their implications for speciation rates in cichlid fishes. *Proceedings of the Royal Society of London, B* **240**: 519-553.
Detailed account of the geological features of Lake Malawi with particular reference to changes in water level. The significance of these changes in the evolution of cichlid fishes is discussed.
Malawi, LMalawi, biogeography, palaeogeography, fish

662. Parker, H.W. (1931). A collection of frogs from Portuguese East Africa. *Proceedings of the Zoological Society of London* **1930**: 897-905.
List and brief descriptions of 29 species of frog collected from the lower Zambezi.
LZam, Mozambique, Delta, amphibians

663. Parry, D.C. and Blyther, R. (1991). Changes in the tree canopy cover within the Chobe National Park, the Moremi Game Reserve and the Okavango Delta. Unpublished report. Kalahari Conservation Society, Gaborone, Botswana.
Not seen.
UZam, Botswana, Chobe, Okavango, environmental assessment, vegetation

664. Patterson, G. and Kachinjika, O. (1995). Limnology and phytoplankton ecology. In: *The Fishery Potential and Productivity of the Pelagic Zone of Lake Malawi/Niassa* (edited by Menz, A.). Natural Resources Institute, Chatham, UK. pp.1-67.
Account of the phytoplankton species of Lake Malawi with data on seasonal abundance and distribution. Lists of phytoplankton species collected are given.
checklist, Malawi, LMalawi, ecology, phytoplankton

665. Pedro, J.G. and Barbosa, L.A.G. (1955). A vegetaçâo. *Esboço de Reconhecimento Ecologico-agricola de Moçambique* Memórias e Trabalhos 23. Centro de Investigaçâo Científica Algodeira, Maputo, Mozambique. 67-224 pp.
Main vegetation survey of the country with detailed descriptions. The map (scale 1:2 million) shows 117 vegetation units. The map has been revised slightly for Flora Zambesiaca (Wild & Barbosa 1967).
Zbasin, survey, Mozambique, vegetation

666. Pennington, K.M. (1978). *Pennington's Butterflies of Southern Africa* (edited by Dickson, C.G.C. and Kroon, D.M.). Ad Donker, Johannesburg, South Africa. ISBN 0-949937-487. 670 pp.
Large illustrated identification book on the butterflies of southern Africa covering 781 species, including 16 confined to the Zambezi wetlands. Food plants are mentioned.
SAfrica, checklist, biogeography, insects, ecology

667. Penry, H. (1986). Threatened birds of Botswana - Part 1: the major issues. *Babbler* **11**: 6-8.
Account of conservation categories regarding birds in Botswana based on recent publications. Slaty Egret, Cape Vulture and Wattled Crane are considered at greatest risk of extinction.
UZam, Chobe, Okavango, Botswana, conservation, birds

668. Penry, H. (1994). *Bird Atlas of Botswana*. University of Natal Press, Pietermaritzburg, South Africa. ISBN 0-86980-895-8.
Atlassing was done in the period July 1980 to June 1990, and birds were recorded by half-degree squares. 7 squares cover the Chobe-Linyanti, with numbers of species per square varying from 15 to 405 (Kasane). 12 waterbirds are mapped in this region, and an extra 9 as 'rarities'.
UZam, checklist, biogeography, survey, Botswana, birds

669. Peracca, M.G. (1910). Rettili raccolti nell'alto Zambese (Barotseland) dal Signor Cav. Luigi Jalla. *Bollettino Musei de Zoologia ed Anatomia comparata della R. Università de Torino* **25**(624): 1-6.

Annotated list in Italian of some species of snakes and lizards collected from Barotseland.
UZam, Barotse, Zambia, reptiles

670. Perennou, C. [compiler] (1992). *African Waterfowl Census, 1992*. International Waterfowl Research Bureau, Slimbridge, UK.
A count of 1640 waterfowl was made in the Elephant Marsh (Malawi) in January 1992.
SAfrica, survey, LZam, Malawi, LShire, birds

671. Perera, N.P. (1982). The ecology of wetlands (dambos) of Zambia, and their evaluation for agriculture - a model for the management of wetlands in sub-humid eastern and southern Africa. *International Journal of Ecology and Environmental Sciences* **8**(1): 27-38.
Description of dambos in Zambia, their characteristics, ecology and potential for agricultural use. Dambos cover 5% of Zambia (37,000 km²). Species present are principally determined by the considerable seasonal fluctuations in water level. The main seepage zone is often dominated by the grass Loudetia simplex, the upper wash zone by Hyparrhenia spp., and the lower wash zone by Setaria sphacelata and Typha. Dambos can also be described on the basis of soil pH as sour (4-5.5), intermediate (5.5-7) or sweet (7-8).
Zbasin, Zambia, agriculture, range/livestock

672. Peters, J.L. and Loveridge, A. (1953). Zoological results of a fifth expedition to East Africa. II - Birds from Nyasaland and Tete. *Bulletin of Museum of Comparative Zoology, Harvard* **110**(2): 85-139.
Detailed records of bird collections made during an expedition.
LZam, checklist, Malawi, Mozambique, LShire, birds

673. Peters, W.C.H. (1852). *Naturwissenschaftliche Reise nach Mossambique: Zoologie, 1 - Saugertiere*. Georg Reimer, Berlin, Germany.
Earliest publication on East African mammals with descriptions of new species from coastal Mozambique and report on a collection from Tete. Contains notes on natural history.
Zbasin, checklist, Mozambique, Lmammals, Smammals

674. Phelps, R.J., Toet, M. and Hutton, J.M. (1989). DDT residues in the fat of crocodiles from Lake Kariba, Zimbabwe. *Transactions of the Zimbabwe Scientific Association* **64**: 6-14.
Study shows significant levels of DDT in Lake Kariba crocodiles.
MZam, Zimbabwe, Kariba, pollution, reptiles

675. Pickersgill, M. (1984). Three new *Afrixalus* (Anura: Hyperoliidae) from southeastern Africa. *Durban Museum Novitates* **13**(17): 203-220.
Descriptions of new frog species from the lower Zambezi.
LZam, amphibians

676. Pike, J.G. (1968). The hydrology of Lake Malawi. *Society of Malawi Journal* **21**(2): 20-47.
Review of variation in the levels of Lake Malawi from 1830. There have been many times when the lake was low and the Shire carried little water.
Malawi, LMalawi, hydrology, history

677. Pinhey, E.C.G. (1951). *The Dragonflies of Southern Africa*. Transvaal Museum Memoir No. 5. Transvaal Museum, Pretoria, South Africa.
Comprehensive taxonomic treatment of the dragonfly species known at that time, many from the Zambezi basin.
SAfrica, checklist, insects

678. Pinhey, E.C.G. (1958). Records of dragonflies from the Zambezi and Rhodesia; a revision of the genus Platycypha; a gynandromorph dragonfly from Uganda. *Occasional Papers of the National Museums of Southern Rhodesia* **3**(22B): 97-116.
Brief report on various species of dragonfly collected in the Victoria Falls-Katombora area.
UZam, Zimbabwe, insects

679. Pinhey, E.C.G. (1961). Dragonflies (Odonata) of Central Africa. *Occasional Papers of the Rhodes-Livingstone Museum* **14**: 1-97.
Annotated checklist (with keys) of 226 species of dragonfly from Zambia, including many records from the upper Zambezi.
Zbasin, UZam, biogeography, checklist, Zambia, insects

680. Pinhey, E.C.G. (1962a). *Hawk Moths of Central and Southern Africa*. Thomas Meikle Series, Longman, Cape Town, South Africa. 139 pp.
Identification book on the hawk moths of the region.
SAfrica, insects

681. Pinhey, E.C.G. (1962b). New or little known Lepidoptera from Central Africa. *Occasional Papers of the National Museums of Southern Rhodesia* **26**: 871-891.
Brief report on 57 species of Lepidoptera collected in the Katanga and Mwinilunga areas of N Zambia.
UZam, headwater, Zambia, insects

682. Pinhey, E.C.G. (1962c). New or little known dragonflies (Odonata) of Central and Southern Africa. *Occasional Papers of the National Museums of Southern Rhodesia* **26**: 892-911.
Annotated list (with keys) of 49 species of dragonfly from Zambia and Zimbabwe.
Zbasin, checklist, Zimbabwe, Zambia, insects

683. Pinhey, E.C.G. (1963). A remarkable new primitive dragonfly (Odonata) from the Victoria Falls. *Novos Taxa Entomológicos* **32**: 1-6.
Description of a new species of dragonfly with its closest relations in Madagascar.
UZam, checklist, biogeography, Zimbabwe, insects

684. Pinhey, E.C.G. (1964). Dragonflies (Odonata) of the Angola-Congo borders of Rhodesia. *Publicaçoes Culturais de Companhia de Diamantes de Angola* **63**: 95-129.
Annotated list (with keys) of 56 species of dragonfly collected along the Zambia-Angola border in Mwinilunga District. The species have affinities to the Chobe/Okavango area.
UZam, headwater, checklist, biogeography, Angola, Zambia, insects

685. Pinhey, E.C.G. (1965). *The Butterflies of Southern Africa*. Thomas Meikle Series, Nelson, Cape Town, Johannesburg, South Africa. 139 pp.
Identification book on the butterflies of the region.
SAfrica, insects

686. Pinhey, E.C.G. (1966). Check-list of dragonflies (Odonata) from Malawi, with description of a new *Teinobasis* Kirby. *Arnoldia (Rhodesia)* **2**(33): 1-24.
Detailed listing of the 111 species of dragonflies in Malawi, but little is noted from the lower Shire.
LZam, LShire, checklist, Malawi, insects

687. Pinhey, E.C.G. (1967). Odonata from Ngamiland (1967). *Arnoldia (Rhodesia)* **3**(15): 1-17.
Checklist of 63 dragonfly species recorded from the Okavango region during a wet period. Notes are given on some species.
UZam, checklist, Botswana, Okavango, insects

688. Pinhey, E.C.G. (1968a). An entomologist in N'gamiland. *Botswana Notes and Records* **1**: 31-40.
Popular account of butterfly collecting in N Botswana. Various butterfly and beetle species are mentioned.
UZam, Botswana, Okavango, insects

689. Pinhey, E.C.G. (1968b). Check list of the butterflies (Lepidoptera-Rhapalocera) of Botswana: Part 1. *Botswana Notes and Records* **1**: 85-92.
Brief account of various butterflies, including some from the Chobe area. 41 species are listed.
UZam, Chobe, checklist, Botswana, insects

690. Pinhey, E.C.G. (1971). Check list of the butterflies (Lepidoptera-Rhopalocera) of Botswana: Part 2. *Botswana Notes and Records* **3**: 148-152.
Brief account of various butterflies, including some from the Chobe and Okavango areas. 33 species are listed.
UZam, Chobe, Okavango, checklist, Botswana, insects

691. Pinhey, E.C.G. (1972a). *Emperor Moths of South and South Central Africa*. C. Struik, Cape Town, South Africa. 150 pp.
Identification book on the emperor moths of the region.
SAfrica, insects

692. Pinhey, E.C.G. (1972b). The genus *Aciagrion* Selys (Odonata). *Occasional Papers of the National Museums of Rhodesia* **5**(1): 1-59.
Account of a dragonfly genus with many species recorded from the Zambezi wetlands.
Zbasin, biogeography, insects

693. Pinhey, E.C.G. (1972c). Check list of the butterflies (Lepidoptera, Rhopalocera) of Botswana: Part 3 (with illustrations). *Botswana Notes and Records* **6**: 197-214.
Brief account of various butterflies, including a few from the Chobe and Okavango areas. 30 species are listed.
UZam, Chobe, Okavango, checklist, Botswana, insects

694. Pinhey, E.C.G. (1974a). A revision of the African *Agriocnemis* Selys and *Mortonagrion* Fraser (Odonata: Coenagrionidae). *Occasional Papers of the National Museums of Rhodesia* **5**(4): 171-278.
Account of a dragonfly genus with many species recorded from the Zambezi wetlands.
Zbasin, biogeography, insects

695. Pinhey, E.C.G. (1974b). Checklist of the butterflies (Lepidoptera, Rhopalocera). *Botswana Notes and Records* **8**: 269-288.
Brief account of various butterflies, including a few from the Chobe and Okavango areas. 104 species are listed.
UZam, Chobe, Okavango, checklist, Botswana, insects

696. Pinhey, E.C.G. (1976). Dragonflies (Odonata) of Botswana, with ecological notes. *Occasional Papers of the National Museums and Monuments of Rhodesia* **5**(10): 524-601.
Checklist with keys to the dragonflies of Botswana covering 103 species, the majority in the Okavango swamps.
UZam, checklist, Botswana, Okavango, insects

697. Pinhey, E.C.G. (1978). Odonata. In: *Biogeography and Ecology of Southern Africa* (edited by Werger, M.J.A.). W. Junk, The Hague, Netherlands. ISBN 90-6193-083-9. pp.723-731.
Brief review of knowledge on the dragonflies of southern Africa. The importance of wetlands in distribution is pointed out; many species have wide distribution, but some are very restricted. Areas with high species diversity are the mid Zambezi and the Okavango.
SAfrica, Okavango, biogeography, ecology, insects

698. Pinhey, E.C.G. (1979). Additions and corrections to the 1966 check-list of dragonflies (Odonata) from Malawi. *Arnoldia (Rhodesia)* **8**(38): 1-14.
Additions to Pinhey (1966); very few from the Shire valley.
LZam, LShire, checklist, Malawi, insects

699. Pinhey, E.C.G. (1981). Checklist of the Odonata of Moçambique. *Occasional Papers of the National Museums and Monuments* **6**(8): 557-632.
Illustrated checklist of the dragonflies of Mozambique, including some from the Zambezi delta.
LZam, checklist, Mozambique, Delta, insects

700. Pitman, C.R.S. (1934). Checklist of the Reptilia and Amphibia occurring and believed to occur in Northern Rhodesia. *A report on a faunal survey of Northern Rhodesia with especial reference to game, elephant control and National Parks*. Government of Northern Rhodesia, Livingstone, Zambia. 292-312 pp.
Annotated checklist of reptiles and amphibians with notes on their distribution in Zambia, including species from the Bangweulu swamps.
Zbasin, checklist, Zambia, Bangweulu, reptiles, amphibians

701. Platnick, N.I. and Murphy, J.A. (1987). Studies on Malagasy spiders, 3: the zelotine Gnaphosidae (Araneae, Gnaphosoidea), with a review of the genus *Camillina*. *American Museum Novitates* **2874**: 1-33.
Includes a description of a new species of spider from the Okavango.
UZam, Botswana, Okavango, Oinverts

702. Poynton, J.C. (1985). Nomenclatural revision of southeast African treefrogs of the genus *Leptopelis* (Amphibia: Hyperoliidae). *South African Journal of Science* **81**: 466-468.
Descriptions of some tree frogs found in the lower Zambezi.
LZam, Mozambique, amphibians

703. Poynton, J.C. and Broadley, D.G. (1978). The herpetofauna. In: *Biogeography and Ecology of Southern Africa* (edited by Werger, M.J.A.). W. Junk, The Hague, Netherlands. ISBN 90-6193-083-9. pp.925-948.
Review of knowledge on the reptiles and amphibians of southern Africa. Most species are of tropical affinity, and aspects of zoogeography are discussed. Species are also discussed by broad habitat.
SAfrica, biogeography, ecology, amphibians, reptiles

704. Poynton, J.C. and Broadley, D.G. (1985-88). Amphibia Zambesiaca 1: Scolecomorphidae, Pipidae, Microhylidae, Hemisidae, Arthroleptidae. *Annals of the Natal Museum* **26**(2): 503-553.
Taxonomic revision of 5 groups of amphibians. 4 other taxonomic parts follow (vols. 27, 28, 29).
Zbasin, amphibians

705. Poynton, J.C. and Broadley, D.G. (1991). Amphibia Zambesiaca 5: Zoogeography. *Annals of the Natal Museum* **32**: 221-277.
Distribution maps for 114 species of amphibian in the Zambesiaca area (Botswana, Caprivi, Zambia, Malawi, Mozambique, Zimbabwe). There are considered to be various zoogeographical zones, possibly temperature-determined, with the eastern lowland zone being of particular interest.
survey, Zbasin, biogeography, amphibians

706. Preston, H.B. (1905). Notes on a small collection of shells from Victoria Falls, Zambesi River, with descriptions of new species. *Proceedings of the Malacological Society of London* **6**: 300-301.
Not seen.
UZam, Zimbabwe, molluscs

707. Proctor, D.L.C. (1983). Biological control of the aquatic weed *Salvinia molesta* D.S. Mitchell in Botswana using the weevils *Cyrtobagous singularis* and *Cyrtobagous* sp. nov. *Botswana Notes and Records* **15**: 99-101.
Brief account of biological control of Salvinia in the Kwando-Linyanti-Chobe system.
UZam, Botswana, Chobe, probspp, plants, insects

708. Proctor, J. (1977). Vegetation. In: *Investigation into fish productivity in a shallow freshwater lagoon in Malawi* (edited by Shepherd, C.J.). Ministry of Overseas Development, London, UK. 22-29 pp.
Not seen.
LZam, LShire, Malawi, vegetation

709. Proctor, J. (1981). The macrophytic vegetation of Bangula Lagoon, Malawi. *Kirkia* **12**(1): 141-149.
Description of the aquatic vegetation of Bangula lagoon in the lower Shire. The lagoon is filled seasonally and has the potential for fish production. Its depth varies from 1-3 m, and its extent from 200-1500 ha. The most important floating or submerged plants are Ceratophyllum demersum, Nymphaea petersiana and Pistia stratiotes. The most important sudd or swamp species are Echinochloa pyramidalis, Ludwigia stolonifera, Panicum subalbidum and Phragmites mauritianus. There is a fringing marsh dominated by Cyperus spp.
LZam, survey, Malawi, LShire, water quality, ecology, vegetation, plants

710. Ramberg, L. (1987). Phytoplankton succession in the Sanyati Basin, Lake Kariba. *Hydrobiologia* **153**: 193-202.
Account of the species composition and seasonal variation in phytoplankton in a part of Lake Kariba from 1982-84.

MZam, Zimbabwe, Kariba, phytoplankton

711. Randall, R.D. (1993). Rare birds to look for in the Kasane/north Chobe area. *Babbler* **25**: 23-26.
Includes notes on 7 species of waterbirds, plus map.
UZam, Botswana, Chobe, birds

712. Randall, R.D. (1994a). Important numbers of African Skimmers *Rhynchops flavirostris* on the Chobe River. *Babbler* **26/27**: 31-32.
In November 1993 47 were seen in one flock. In October a flock of 43 consisted of 4 adults and 39 immatures.
UZam, Botswana, Chobe, birds

713. Randall, R.D. (1995). Greater Swamp Warbler *Acrocephalus rufescens* on the Chobe River. *Babbler* **29/30**: 33.
More called up in December 1994.
UZam, Botswana, Chobe, birds

714. Ratcliffe, C. (1972). The fishery of the lower Shire river area. Malawi Fisheries Bulletin No. 3. Fisheries Department, Lilongwe, Malawi. 79 pp.
Not seen.
LZam, Malawi, LShire, fisheries

715. Rattray, J.M. (1960). *The Grass Cover of Africa.* FAO Agricultural Studies No. 49. FAO, Rome, Italy. 168 pp.
Account of the vegetation types of Africa based on grass species composition. Most wetlands are described as undifferentiated types.
SAfrica, vegetation

716. Rattray, J.M. (1962). Vegetation types of Southern Rhodesia. *Kirkia* **2**: 68-93.
Early account of the vegetation of Zimbabwe, based partly on the Yangambi classification system. There are 52 vegetation types described, grouped into 14 physiognomic classes. Many edaphic dambo grasslands are dominated by Loudetia spp. or Alloteropsis semialata.
Zbasin, survey, Zimbabwe, vegetation, plants

717. Rattray, J.M. and Wild, H. (1962). Vegetation map of the Federation of Rhodesia and Nyasaland. *Kirkia* **2**: 94-104.
A vegetation survey of Zimbabwe, Zambia and Malawi, based on the survey of Zimbabwe by Rattray (1962). The map was published separately as part of the Federal Atlas (1960). There are 29 vegetation types, grouped into 6 physiognomic units, basically following the Yangambi system. The wetlands of the Barotse floodplains are mapped as Loudetia grassland (type 3) dominated by L. simplex, replaced by Tristachya in the Siluwana Plains. The smaller and wetter plains of central Barotseland often contain Miscanthidium. The Kafue floodplains are classified as swamp and papyrus sudd (type 5), surrounded by Hyparrhenia grassland with H. rufa and Setaria sp. Sudd normally comprises the grasses/sedges Cyperus papyrus, Vossia cuspidata, Scirpus cubensis, Echinochloa pyramidalis, Pennisetum purpureum, Miscanthidium teretifolium, Eleocharis plantaginea and Echinochloa stagnina. The floodplain of the Shire river is classified as swamp and papyrus sudd.
survey, Zbasin, vegetation, plants

718. Rautenbach, I.L. and Fenton, M.B. (1992). Bats from Mana Pools National Park in Zimbabwe and the first record of *Eptesicus rendalli* from the country. *Zeitschrifte für Säugertierkunde* **57**: 112-115.
Records of bats collected on the Zambezi alluvial floodplain at Mana Pools.
MZam, Mana, checklist, Zimbabwe, Smammals

719. Rees, W.A. (1974). Kafue Flats. *Black Lechwe* **11**(3): 27-35.
Popular report on ecology of the Kafue Flats with emphasis on lechwe. Concern is expressed over hydroelectric developments which will drastically change the hydrological regime.

UZam, Zambia, Kafue, conservation, ecology

720. Rees, W.A. (1976). The ecology of the lechwe, *Kobus leche kafuensis* Haltenorth, in Lochinvar National Park, Zambia, as affected by the Kafue Gorge Hydroelectric Scheme. Herbage digestibility in free-living antelope. *East African Wildlife Journal* **14**(1): 59-66.
Account of digestibility studies on lechwe on the Kafue Flats using collected rumen fluid.
UZam, Zambia, Kafue, Lmammals

721. Rees, W.A. (1978a). The ecology of the Kafue lechwe: soils, water levels and vegetation. *Journal of Applied Ecology* **15**: 163-176.
Account of the physical characteristics, including soils, of Lochinvar NP, Kafue Flats. Fluctuations in flood water levels are given. A vegetation map with 10 units is presented; variation is attributed to hydrological differences. A list of 55 herbaceous plants is included.
UZam, Zambia, Kafue, ecology, vegetation, plants

722. Rees, W.A. (1978b). The ecology of the Kafue lechwe: the food supply. *Journal of Applied Ecology* **15**: 177-191.
Account of the grassland and grasses of Lochinvar NP. Composition and productivity of grazed areas is described, and the effects of heavy grazing noted. Digestibility and nutritive values are given.
UZam, Zambia, Kafue, vegetation, plants, ecology, Lmammals

723. Rees, W.A. (1978c). The ecology of the Kafue lechwe: its nutritional status and herbage intake. *Journal of Applied Ecology* **15**: 193-203.
Account of forage nutritive intake of lechwe in Lochinvar NP. Calcium, phosphorous, sodium, potassium and nitrogen values were looked at. Maintenance requirement for an adult lechwe of 66 kg is 3100 J ME/day.
UZam, Zambia, Kafue, Lmammals

724. Rees, W.A. (1978d). The ecology of the Kafue lechwe: as affected by the Kafue Gorge hydroelectric scheme. *Journal of Applied Ecology* **15**: 205-217.
Account of the effects of the Kafue flood regime on the lechwe at Lochinvar NP. Time, speed and duration of flooding are important factors in lechwe ecology. The Itezhi-tezhi dam will reduce extremes and duration of flooding and the floristic composition of the floodplains. This may cause lechwe mortality owing to reduced appropriate forage.
UZam, Zambia, Kafue, environmental assessment, ecology, Lmammals

725. Rees, W.A. and Zulu, I. (1977). Lechwe ecology at Lochinvar. *Black Lechwe* **12**(4): 6-11.
Account of the ecology of the Kafue Flats regarding lechwe. A vegetation map of Lochinvar is included.
UZam, Zambia, Kafue, vegetation, ecology, Lmammals

726. Regan, C.T. (1921). The cichlid fishes of Lake Nyasa. *Proceedings of the Zoological Society of London* **1921**: 675-727.
Classic account of the cichlids of Lake Malawi, with many original descriptions.
checklist, Malawi, LMalawi, fish

727. Reinthal, P. (1993). Evaluating biodiversity and conserving Lake Malawi's cichlid fish fauna. *Conservation Biology* **7**(3): 712-718.
Account of the rock-dwelling cichlid fish species of Lake Malawi with emphasis on endemism and distribution around the lake. Distribution and diversity are related, and the genus is suggested as the appropriate conservation level.
Malawi, LMalawi, biogeography, conservation, fish

728. Renvoize, S.A. (1996). Survey of plant diversity, 1996. Report on a visit by S.A. Renvoize. Royal Botanic Gardens, Kew/WWF Bangweulu Wetlands Project, London, UK. 23 pp.
Consultant's report on the plants (principally grasses and sedges) of the Bangweulu swamps, with 181 species listed by vegetation type and family.
UZam, Zambia, Bangweulu, ecology, plants

729. Ribbink, A.J. (1991). Distribution and ecology of the cichlids of the African Great Lakes. In: *Cichlid Fishes: Behaviour, Ecology and Evolution* (edited by Keenleyside, M.H.A.). Chapman & Hall, London, UK. pp.36-59.
Review of the reasons for diversity of cichlid fish species in Lakes Malawi, Victoria and Tanganyika. The very high diversity is ascribed to narrow niche specialisation, diversity of niches (seasonality, depth, substrate, oxygen levels) and high investment in few offspring, features which are possible in stable environments. However, this makes the species vulnerable to man-made changes such as mechanised fishing and alien introductions. Chapter contains many references.
Malawi, LMalawi, biogeography, ecology, conservation, fish

730. Ribbink, A.J., Marsh, A.B., Marsh, A.C., Ribbink, A.C. and Sharp, B.J. (1983). A preliminary survey of the cichlid fishes of the rocky habitats in Lake Malawi. *South African Journal of Zoology* **18**: 149-309.
Detailed account of a survey on the 'mbuna' group of cichlids living along the rocky shores of Lake Malawi.
survey, Malawi, LMalawi, fish

731. Ricardo-Bertram, C.K., Borley, H.J.H. and Trewavas, E. (1942). Report on the fish and fisheries of Lake Nyasa. Crown Agents, London, UK. 181 pp.
Considered a classic account on the fish of Lake Malawi with valuable historical data.
Malawi, LMalawi, fisheries, fish

732. Richards, E.V. (1954). The Shire Valley project. *Nyasaland Journal* **7**(1): 7-18.
An early, general account of the lower Shire area. Water levels were very low earlier this century, the river ceasing to flow in 1915, and swamp areas were under cultivation.
LZam, Malawi, LShire, hydrology, history

733. Robarts, R.D., Thornton, J.A. and Watts, C.J. (1982). Phytoplankton, primary production and nutrient limitation. In: *Lake McIlwaine: the eutrophication and recovery of a tropical African lake* (edited by Thornton, J.A.). W. Junk, The Hague, Netherlands. ISBN 90-6193-102-9. pp.106-133.
Study of phytoplankton found in Lake Chivero, with an account of its productivity and the importance of nutrient limitation. Variation in composition is seen through the year. An appendix gives a partial list of 13 species.
MZam, Chivero, Zimbabwe, ecology, water quality, phytoplankton

734. Robertson, I. (1995). Recent reports. *Bulletin of the African Bird Club* **2**: 123-127.
Up to 1068 Wattled Cranes were seen in February 1995 at Blue Lagoon, Kafue Flats.
UZam, Zambia, Kafue, birds

735. Robinette, W.L. and Child, G. (1964). Notes on biology of the lechwe (*Kobus leche*). *The Puku* **2**: 84-117.
Study of the Kafue lechwe on Lochinvar Ranch covering reproduction, weights and measurements, and diseases/parasites.
UZam, Zambia, Kafue, ecology, Lmammals

736. Rodwell, T.C., Tagg, J. and Grobler, M. (1995). Wildlife resources in the Caprivi, Namibia: the results of an aerial census in 1994 and comparisons with past surveys. Research Discussion Paper No. 9. Department of Environmental Affairs, Windhoek, Namibia. 29 pp.
Survey of large mammals in the Caprivi. The Mamili swamps between the Kwando and Linyanti rivers, is now a National Park and the largest protected wetland in Namibia (360 km²). Up to 80% is flooded during high floods. Transect counts of large mammals showed 640 elephant (density c.1.8/km²), a small but stable population of buffalo (1170), and lechwe (1033), hippo (470), kudu (30), reedbuck (40), and some goats.
UZam, survey, Namibia, Chobe, Lmammals

737. Roodt, V. (1993?). *The Shell Field Guide to the Common Trees of the Okavango Delta and Moremi Game Reserve.* Shell Botswana, Gaborone, Botswana. 112 pp.
Illustrated identification guide to some trees of the Okavango, with notes on ecology, uses and history.
UZam, checklist, Botswana, Okavango, ecology, plants

738. Roux, J. (1907). Sur quelques reptiles Sud-Africains. *Revue Suisse Zool.* **15**: 75-86.
Brief annotated list in French of various reptile species found in Barotseland.
UZam, Zambia, Barotse, reptiles

739. Rowan, M.K. (1963). The Yellowbilled Duck *Anas undulata* Dubois in southern Africa. *Ostrich Supplement* **5**: 56 pp.
Second report of the African Wildfowl Enquiry. Occurs in Barotseland and the eastern Caprivi.
UZam, Namibia, Chobe, Barotse, birds

740. Russell-Smith, A. (1976). Preliminary observations on the effects of insecticide application on the aquatic fauna of the Okavango Delta. In: *The Okavango Delta and its Future Utilisation* (edited by Botswana Society). Botswana Society, Gaborone, Botswana. pp.153-160.
General account of the effects of DDT and endosulfan application on the aquatic ecology of the Okavango delta. Preliminary results suggest effects are not too serious.
UZam, Botswana, Okavango, pollution, fish, Oinverts

741. Russell-Smith, A. (1981). Seasonal activity and diversity of ground-living spiders in two African savanna habitats. *Bulletin of the British Arachnological Society* **5**(4): 145-154.
Study on diversity of spiders in two habitats (floodplain grassland and mopane woodland) in the Okavango delta. 135 species are listed.
UZam, survey, Botswana, Okavango, ecology, Oinverts

742. Russell-Smith, A. and Ruckert, E. (1981). The effects of aerial spraying of endosulfan for tsetse fly control on aquatic invertebrates in the Okavango Swamps, Botswana. *Environmental Pollution (series A)* **24**: 57-73.
Not seen.
UZam, Botswana, Okavango, pollution, Oinverts

743. Saket, M., Taquidir, M.A. and Banze, C.J.A. (1995). Methodology and results of the forestry vegetation mapping at 1:250,000. National Directorate of Forests and Wildlife/FAO, Maputo, Mozambique. 24 pp.
Report and maps for a national forest inventory based on satellite imagery and airphotos. Woody vegetation covers 67% of the country.
Mozambique, survey, vegetation, agriculture

744. Santos, S. and Soto, B. (1992). Mangroves: their ecology, status and utilisation. In: *Wetlands Conservation Conference for Southern Africa: Proceedings of the Southern African Development Coordination Conference held in Gaborone, Botswana, 3-5 June 1991* (edited by Matiza, T. and Chabwela, H.N.). IUCN Wetlands Programme No. 4. IUCN, Gland, Switzerland. ISBN 2-8317-0125-2. pp.149-156.
Brief account of mangroves in Mozambique. There are six species of mangroves; the extent of mangrove forest is 850 km².
LZam, Mozambique, Delta, vegetation

745. Sanyanga, R.A. (1995). Management of the Lake Kariba inshore fishery and some thoughts on biodiversity and conservation issues. *Environmental Conservation* **22**(2): 111-116.
General discussion on the biodiversity and conservation of fish stocks in Lake Kariba, including aspects such as regulation, over-fishing and the introduction of exotic species. A list of fish species is given.
MZam, Zimbabwe, Kariba, human use/impact, conservation, fisheries, fish

746. Sanyanga, R.A. and Feresu, F. (1994). First catches of the African pike *Hepstus odoe* (Bloch, 1794) (Pisces: Hepsetidae) in Lake Kariba, Zimbabwe. *Revue d'Hydrobiologie Tropicale* **27**(1): 39-42.
First account of this species being found in the mid-Zambezi system, although it is known from the upper Zambezi.

MZam, Zimbabwe, Kariba, fish

747. Sanyanga, R.A., Machena, C. and Kautsky, N. (1995). Abundance and distribution of inshore fish in fished and protected areas in Lake Kariba, Zimbabwe. *Hydrobiologia* **306**: 67-78.
Account of the effects of fishing on fish populations. Some differences were noted but data are equivocal.
MZam, Zimbabwe, Kariba, human use/impact, fisheries, fish

748. Satellitbild (1993). Land Cover Map of Malawi. Satellitbild/Malawi Forestry Department, Lilongwe, Malawi.
Series of 10 land cover maps at scale 1:250,000. The Nsanje sheet covers the lower Shire wetlands. Type of vegetation cover is shown with particular detail in plantation and agricultural categories. The lower Shire wetlands are all mapped as Marshy Area or Swamp, surrounded by Agriculture in Mainly Grass Area.
survey, Malawi, agriculture

749. Sayer, J.A. and Van Lavieren, L.P. (1975). The ecology of the Kafue lechwe population of Zambia before the operation of hydro-electric dams on the Kafue river. *East African Wildlife Journal* **13**(1): 9-37.
Account of the numbers and status of Kafue lechwe from 1953 to 1972. A stable population of 94,000 is suggested for the early 1970s. Analysis of the age structure of the population suggests that it will decline under an altered flooding regime.
UZam, survey, Zambia, Kafue, ecology, Lmammals

750. Schelpe, E.A.C.L.E. (1961). The ecology of *Salvinia auriculata* and associated vegetation on Kariba lake. *Journal of South African Botany* **27**: 181-187.
Account of the invasion of Salvinia on Lake Kariba.
MZam, Zimbabwe, Kariba, probspp, ecology, plants

751. Schiøtz, A. (1975). *The Treefrogs of Eastern Africa.* Steenstrupia, Copenhagen, Denmark. ISBN 87-87519-03-8.
Illustrated account of the tree frogs of E Africa, including parts of the Zambezi basin.
SAfrica, amphibians

752. Schlettwein, C.H.G. (1985). Distribution and densities of *Cyrtobagous singularis* Hustache (Coleoptera: Curculionidae) on *Salvinia molesta* Mitchell in the Eastern Caprivi Zipfel. *Madoqua* **14**(3): 291-293.
Brief report on the occurrence of the introduced biological control beetle Cyrtobagous on Salvinia in E Caprivi. It was shown to be widespread and established, but population densities are low.
UZam, Namibia, Chobe, probspp, insects

753. Schlettwein, C.H.G. and Bethune, S. (1992). Aquatic weeds and their management in southern Africa: biological control of *Salvinia molesta* in the Eastern Caprivi. In: *Wetlands Conservation Conference for Southern Africa: Proceedings of the Southern African Development Coordination Conference held in Gaborone, Botswana, 3-5 June 1991* (edited by Matiza, T. and Chabwela, H.N.). IUCN Wetlands Programme No. 4. IUCN, Gland, Switzerland. ISBN 2-8317-0125-2. pp.173-187.
Account of the problem with the aquatic weed Salvinia molesta in the E Caprivi and the methods used to control it. Details are given on growth rates.
UZam, Namibia, Chobe, probspp, plants

754. Schlettwein, C.H.G. and Koch, H.W.R. (1983). Growth and mortality rates of *Salvinia molesta* in the eastern Caprivi Zipfel. In: *Proceedings of the 20th Annual Congress of the Limnological Society of Southern Africa*. South Africa. 20 pp.
Study of growth rates of Salvinia on Lake Liambezi and on the Chobe river. Doubling times on the Chobe were 8.6-15.8 days (4.4-8.5% per day), but much lower on Lake Liambezi, possibly owing to a deficiency of nitrogen.
UZam, Namibia, Chobe, probspp, plants

755. Schlettwein, C.H.G., Simmons, R.E., MacDonald, A. and Grobler, H.J.W. (1991). Flora, fauna and conservation of East Caprivi wetlands. *Madoqua* **17**(2): 67-76.
Account of the largest of Namibia's wetlands, covering 5000 km². The E Caprivi wetlands are divided into 5 zones - upper Kwando river, lower Kwando and Linyanti swamp, Lake Liambezi, Chobe marsh, Zambezi and Chobe floodplains. In wet years they all join up. Conservation concerns include invasion (now controlled) by Salvinia, poaching, large cattle populations and overfishing. Wildlife (sitatunga, lechwe) are about 10% of their 1980 numbers. An appendix of 90 species of aquatic and marsh plants is given.
UZam, survey, Namibia, Chobe, hydrology, probspp, conservation, plants, birds, Lmammals

756. Schmidt, I. (1997). The Zambezi Delta: diagnostic overview of its socio-economic characteristics. Research Consultancy Services/IUCN, Beira, Mozambique. 54 pp.
Detailed consultants' report with much information on socio-economics and history, but nothing on biodiversity.
LZam, bibliography, Mozambique, Delta, history, human use/impact

757. Schmidt, K.P. and Inger, R.F. (1959). Amphibians. Exploration du Parc National de l'Upemba: Mission G.F. De Witte No. 56. 264 pp.
Accounts of various amphibian species from S Zaire.
UZam, amphibians

758. Schulten, G.G. (1974). The food of some duck species occurring at Lake Chilwa, Malawi. *Ostrich* **45**: 224-226.
Account of a study on the gut contents of 7 species of duck from Lake Chilwa. Most food items were seeds; also some leaves, algae and insects.
Malawi, LChilwa, plants, ecology, birds

759. Schuster, R.H. (1976). Reproductive social organisation of Kafue lechwe: implications for management and survival. In: *Proceedings of the Fourth Regional Wildlife Conference for Eastern and Central Africa*. Zambia Printing Company, Lusaka, Zambia. pp 163-183.
Describes social behaviour and the lek mating system of Kafue lechwe in Lochinvar NP, and identifies threats should wetland habitat be changed. Priorities for management are noted.
UZam, Zambia, Kafue, ecology, environmental assessment, conservation, Lmammals

760. Schuster, R.H. (1977). Social organisation of Kafue lechwe. *Black Lechwe* **12**(3): 40-51.
Account of ecology and reproductive behaviour in lechwe on the Kafue Flats.
UZam, Zambia, Kafue, ecology, Lmammals

761. Schuster, R.H. (1980). Will the Kafue lechwe survive the Kafue dams? *Oryx* **15**(5): 476-489.
Not seen.
UZam, Zambia, Kafue, environmental assessment, conservation, Lmammals

762. Schuurman, G. and Dangerfield, J.M. (1997). Dispersion and abundance of *Macrotermes michaelsenii* colonies: a limited role for intraspecific competition. *Journal of Tropical Ecology* **13**(1): 39-49.
Study on the distribution of termitaria in various habitats within Moremi, Okavango. The highest density was found on floodplain grassland. It is suggested that distribution is not regular, and not density-dependent.
UZam, Botswana, Okavango, ecology, insects

763. Scott, A.J. (1993). A revised and annotated check-list of the birds of the Luangwa Valley National Parks and adjacent areas. Occasional Paper No. 3. Zambian Ornithological Society, Lusaka, Zambia. 52 pp. Second edition.
A comprehensive checklist of birds, primarily from the South Luangwa and Luambe NPs below the 900 m contour. Brief notes of habitats are given. 731 species are listed with brief notes on abundance and distribution. A bibliography and gazetteer are included.
MZam, Luangwa, checklist, Zambia, birds

764. Scott, D.A. and Rose, P.M. (1996). *Atlas of Anatidae Populations in Africa and Western Eurasia.* Wetlands International Publication No. 41. Wetlands International, Wageningen, Netherlands. ISBN 1-900442-09-4. 336 pp.
Detailed account of the distribution and status of swans, geese and ducks in Africa. 14 species of duck in the Zambezi basin are included, each with a full map. Also indicates 3 categories of 'key sites' where 1%-2%, 2%-10%, and >10% of the 'flyway' population has been counted. Only one such site (Kafue Flats) is listed in our area. (Three palaearctic migrants plus Maccoa Duck are said not to occur).
SAfrica, biogeography, survey, birds

765. Scott, K.M.F. (1974). New and interesting Trichoptera collected by Dr. H. Bertrand in Southern Africa in 1959. *Annals of the Cape Provincial Museums (Natural History)* **9**(14): 237-248.
Account including a description of a new species of caddis fly from the Zambezi above Victoria Falls.
UZam, Zimbabwe, insects

766. Scott, K.M.F. (1983). On the Hydropsychidae (Trichoptera) of southern Africa with keys to African genera of imagos, larvae and pupae and species lists. *Annals of the Cape Provincial Museums (Natural History)* **14**(8): 299-422.
Account of southern African caddis flies, including from the Zambezi river.
SAfrica, checklist, insects

767. Scudder, T., Manley, R.E., Coley, R.W., Davis, R.K., Green, J., Howard, G.W., Lawry, S.W., Martz, D., Rogers, P.P., Taylor, A.R.D., Turner, S.D., White, G.F. and Wright, E.P. [editors] (1993). *The IUCN Review of the Southern Okavango Integrated Water Development Project.* IUCN Wetlands Programme No. 6. IUCN, Gland, Switzerland. ISBN 2-8317-0114-7. 544 pp.
Authoritative and detailed account of the proposed Southern Okavango Integrated Water Development Project, which resulted in the Botswana government abandoning the controversial proposal. The report principally covers hydrology and water resources, and social and economic considerations, and offers suitable development alternatives. Although the Okavango is not directly part of the Zambezi basin, the report is a good model of studies that could be carried out, and addresses similar issues to those found in the Zambezi.
UZam, survey, Botswana, Okavango, hydrology, ecology, vegetation, environmental assessment, human use/impact, agriculture, fisheries, range/livestock, history, waterqual, fish

768. Seagrief, S.C. (1962). The Lukanga swamps of Northern Rhodesia. *Journal of South African Botany* **28**: 3-7.
Brief account of the Lukanga swamps on the upper Kafue. A few plant species are mentioned; Phragmites reed is the most common species.
UZam, Zambia, Kafue, plants

769. Seaman, M.T., Scott, W.E., Walmsley, R.D., van der Waal, B.C.W. and Toerien, D.F. (1978). A limnological investigation of Lake Liambezi, Caprivi. *Journal of the Limnological Society of Southern Africa* **4**(2): 129-144.
Account of a survey of the lake from the early-mid 1970s. It is 101 km² in extent, shallow and reed-fringed. The water was clear an oxygenated, and slightly alkaline. Fishery potential is good, but threatened by Salvinia encroachment. Data on water temperature, oxygen levels and chemical analyses are presented. A list of phytoplankton species is given, along with some data on zooplankton and fish.
UZam, survey, Namibia, Chobe, ecology, water quality, fish, phytoplankton, zooplankton, Oinverts

770. Shaw, P.A. (1984). A historical note on the outflows of the Okavango Delta system. *Botswana Notes and Records* **16**: 127-130.
Not seen.
UZam, Botswana, Okavango, palaeogeography, hydrology, history

771. Shaw, P.A. (1985). Late Quaternary landforms and environmental change in northwest Botswana: the evidence of Lake Ngami and the Mababe depression. *Transactions of the Institute of British Geographers (new series)* **10**: 333-340.
Not seen.
UZam, Botswana, Okavango, Chobe, palaeogeography, history, hydrology

772. Shaw, P.A. (1988). After the Flood: the fluvio-lacustrine landforms of northern Botswana. *Earth-Science Reviews* **25**: 449-456.
Review paper of recent work on palaeo-landforms. Lakes palaeo-Makgadikgadi and Thamalakane are described, the former is tectonic in origin and last existed c.35,000 BP while the latter has persisted until more recently. Lake Thamalakane was fed by increased inflow from higher rainfall in the past.
UZam, Botswana, Okavango, hydrology, palaeogeography

773. Shaw, P.A. and Cooke, H.J. (1986). Geomorphic evidence for the late Quaternary palaeoclimates of the middle Kalahari of northern Botswana. *Catena* **13**: 349-359.
Account of geomorphological evidence from N Botswana indicating dry conditions around 25,000 years BP, humid conditions from 16,000 to 13,000 BP, and rainfall peaks around 6,000 and 2,000 BP.
UZam, Botswana, palaeogeography

774. Shaw, P.A. and Thomas, D.S.G. (1988). Lake Caprivi: a late Quaternary link between the Zambezi and middle Kalahari drainage systems. *Zeitschrift für Geomorphologie N.F.* **32**(3): 329-337.
Account of the suggested existence of a late Quaternary palaeolake, Lake Caprivi (about 2000 km² in extent), linking the Okavango to the Zambezi via the Chobe river. The lake was formed by ponding behind the Mambova Falls at the Chobe-Zambezi confluence. Carbon 14 dating suggests an age of 15,000 years BP, with another high-water period around 2-3,000 BP. Capture of Zambezi river near Victoria Falls has been placed between Pliocene and mid-Pleistocene (4-1 million years ago).
UZam, Botswana, Chobe, Namibia, palaeogeography, hydrology

775. Sheppe, W.A. (1973). Notes on Zambian mammals and shrews. *The Puku* **7**: 167-190.
Report on nearly 2000 specimens of 30 species collected in various parts of Zambia between 1966 and 1970. Wetland habitats from which specimens were collected include Kafue Flats, Kafue Gorge, Kafue NP and South Luangwa NP.

Zbasin, Kafue, Luangwa, Zambia, Smammals

776. Sheppe, W. and Haas, P. (1976). Large mammal populations of the lower Chobe river, Botswana. *Mammalia* **40**: 223-243.
Survey of mammals along the Chobe river. 16 ungulate, 2 primate and 4 carnivore species were noted, with details given on distribution and habitat. Numbers of animals declined at the beginning of the rains as migratory species left. There may have been changes in species composition since 1969.
UZam, survey, Botswana, Chobe, ecology, Lmammals

777. Sheppe, W. and Haas, P. (1981). The annual cycle of small mammal populations along the Chobe river, Botswana. *Mammalia* **45**(2): 157-176.
Account contrasting small mammal populations, principally rodents, on the Chobe floodplains and Kafue Flats. Total populations were higher on the floodplain than on the surrounding high round, perhaps owing to higher grass productivity.
UZam, Botswana, Chobe, ecology, Smammals

778. Sheppe, W. and Osborne, T. (1971). Patterns of use of a floodplain by Zambian mammals. *Ecological Monographs* **41**(3): 179-205.
Description of the Kafue Flats and its vegetation. The utilisation by mammals (especially rodents), birds and other animals (including ants and termites) is described. Lechwe are the principal users, perhaps because of lack of suitable habitat and food for other species.
UZam, Kafue, Zambia, ecology, Lmammals, Smammals, insects

779. Sherry, B. and Sherry, I. (1984). *Guide to Lengwe National Park*. Montfort Press, Limbe, Malawi.
Contains natural history data on many vertebrates.
LZam, Malawi, LShire, ecology

780. Silva, C. (1989). História da pescaria de camarâo de águas pouco profundas no Banco de Sofala. *Revista de Investigaçâo Pesquiera, Maputo* **18**: 47-60.
Account in Portuguese of the shrimp fishing industry off the Sofala Bank, Mozambique, mostly focussing on Penaeus indicus. Figures on yield and catch per unit effort are given, along with a discussion on the relation between stock and recruitment. Yields decreased between 1974 and 1986 owing to decreased stock.
LZam, Mozambique, Delta, fisheries, crustacea

781. Simbotwe, M.P. and Patterson, J.W. (1983). Ecological notes and provisional checklist of amphibians and reptiles collected from Lochinvar National Park, Zambia. *Black Lechwe (new series)* **4**: 17-22.
Checklist of 38 species of reptile and 26 amphibians collected in Lochinvar NP on the Kafue Flats, with indications of habitat.
UZam, checklist, Zambia, Kafue, reptiles, amphibians

782. Simmons, R.E. (1996). Population declines, viable breeding areas, and management options for flamingos in Southern Africa. *Conservation Biology* **10**(2): 504-514.
Account of breeding (considered non-viable) of both species of flamingo on Etosha Pan, Namibia. The only other breeding site in southern Africa, Makgadikgadi Pans in Botswana, is under threat and not formally protected. Breeding success has been declining since the 1970s owing to drought. Various management interventions to reduce chick deaths from drought are suggested.
Namibia, conservation, ecology, birds

783. Simmons, R.E., Brown, C.J. and Griffin, M. (1991). The status and conservation of wetlands in Namibia. Special Wetlands Edition. *Madoqua* **17**(2): 55-254.
24 papers on Namibian wetlands. One on E. Caprivi. Others on biota and issues.
Namibia, Chobe, UZam, ecology, conservation, vegetation, plants, Lmammals, Smammals, fish, birds, insects, molluscs, reptiles, amphibians

784. Simons, H.W., Roger, P.M., Bhima, R., Chiwona, E.A. and Banda, H.M. (1991). Mammal inventory, Malawi 1991. MLW/87/010 Field Document No. 9. FAO Wildlife Management and Crop Protection Project/Department of National Parks and Wildlife, Lilongwe, Malawi.
Report containing counts of hippo in Elephant Marsh and the lower Shire valley showing 2601 animals.
LZam, LShire, survey, Malawi, human use/impact, Lmammals

785. Simpson, C.D. (1974). Food studies on the Chobe bushbuck, *Tragelaphus scriptus ornatus* Pocock, 1900. *Arnoldia (Rhodesia)* **6**(32): 1-6.
Study on feeding behaviour of bushbuck along the Chobe waterfront, Botswana. 83 plant species were utilized, but it is suggested bushbuck are selective feeders under optimum conditions.
UZam, Botswana, Chobe, ecology, plants, Lmammals

786. Simpson, C.D. (1974). Habitat reference and seasonal movement in the Chobe bushbuck, *Tragelaphus scriptus ornatus* Pocock, 1900. *Arnoldia (Rhodesia)* **6**(31): 1-7.
Account of bushbuck habitat along the Chobe river in Botswana. Bushbuck have wide habitat preference, which varies somewhat through the year. They particularly favour the riparian forest fringe (av. 4.4 head/acre). Surface water is probably the major factor influencing concentration.
UZam, Botswana, Chobe, Lmammals, vegetation, ecology

787. Simpson, C.D. (1974). *Population ecology of the Zambezi bushbuck (*Tragelaphus scriptus ornatus *Pocock).* PhD thesis, Texas A & M University. USA. 274 pp.
Not seen.
UZam, Botswana, Chobe, ecology, Lmammals

788. Simpson, C.D. (1975). A detailed vegetation study on the Chobe river in north-east Botswana. *Kirkia* **10**(1): 185-227.
Vegetation survey of the area for 32 km along the Chobe river in Botswana W of Kasane for a study on bushbuck. 8 vegetation types are described. The floodplain grassland covers much of the Caprivi Strip on the other bank, and comprises mostly sedges and grasses. Fringing the higher banks Syzygium guineense trees are found. The riparian forest fringe varies considerably from closed-canopy forest to bushland. Dominant species are Faidherbia albida, Garcinia livingstonei, Combretum imberbe and Diospyros mespiliformis. Other common species are mentioned.
UZam, survey, Botswana, Chobe, vegetation, ecology, plants

789. Singini, P.J.T. (1996). The Marromeu complex of the Zambezi Delta: Mozambique's unique wetland. In: *Proceedings of 1993 African Crane and Wetland Training Workshop* (edited by Beilfuss, R.D., Tarboton, W.R. and Gichuki, N.N.). International Crane Foundation, Baraboo, WI, USA. pp.341-343.
Brief account of Marromeu (c.360 km²). It is an important habitat for Wattled Cranes and other waterfowl and is perhaps the most important coastal wetland in southern Africa. It should be recognised as a World Heritage Site and a Ramsar site. A massive reduction in large mammals has been noted since 1979, and the effects of Cabora Bassa dam are considered severe.
LZam, Mozambique, Delta, environmental assessment, conservation, birds

790. Skarpe, C. (1997). Ecology of the vegetation in the draw-down zone of Lake Kariba. In: *Advances in the Ecology of Lake Kariba* (edited by Moreau, J.). University of Zimbabwe Publications, Harare, Zimbabwe. ISBN 0-908307-54-3. pp.120-138.
Account of classification of the littoral vegetation on the Zimbabwe side of Lake Kariba. The vegetation is described and mapped under 5 types. Panicum repens appears to be particularly important.
MZam, Zimbabwe, Kariba, ecology, vegetation, plants

791. Skelton, P. (1993). *A Complete Guide to the Freshwater Fishes of Southern Africa.* Southern Book Publishers, Halfway House, South Africa. ISBN 1-86812-493-2. 388 pp.
Illustrated guide to all the fishes of southern Africa including the Zambezi basin, lower Shire and Kafue rivers. Descriptions, distributions, biological notes and keys are given.
SAfrica, checklist, biogeography, fish

792. Skelton. P. (1994). Diversity and distribution of freshwater fishes in east and southern Africa. *Annales de Musée Royal de l'Afrique Centrale, Zoologie* **275**: 95-131.
Account of the origin and dispersal of freshwater fishes, including in the Zambezi basin but excluding Lake Malawi. General patterns of distribution are explained. Lists of species from the Zambezi basin, by sub-basin, are given. The similarity between the upper Zambezi and Okavango sub-basins, and dissimilarity between the upper and mid/lower Zambezi is highlighted. An hypothesised outline of drainage history since the early Tertiary is given.
SAfrica, checklist, biogeography, fish

793. Skinner, J.D. and Smithers, R.H.N. (1991). *Mammals of the Southern African Subregion*. University of Pretoria, Pretoria, South Africa.
Detailed review of behaviour, ecology, distribution and status of all mammal species occurring south of the Zambezi and Cunene rivers: includes some new data and references after Smithers (1983). Distribution maps are provided for the entire range of most species. Detailed bibliography which includes studies of many species in their ranges in Angola, Malawi, N Mozambique and Zambia.
SAfrica, checklist, biogeography, Smammals, Lmammals

794. Smith, P.A. (1969). Report on (1) a search for the aquatic weed *Salvinia auriculata* Aubl. in the Kwando, Linyanti and Savuti rivers and the Selinda Spillway and (2) a herbicide spraying experiment and other measures to control the *Salvinia* infestation at Shaile on the Linyanti river in north-western Botswana, January-May 1969. Unpublished report, Department of Veterinary Services and Tsetse Control, Maun, Botswana. 18 pp.
One of the first detailed reports on the distribution and ecology of Salvinia in the Kwando-Linyanti-Chobe system. Reviews current findings. Also includes early results on control, including herbicide spraying and physical methods.

UZam, survey, Botswana, Chobe, ecology, environmental assessment, probspp, plants

795. Smith, P.A. (1976). An outline of the vegetation of the Okavango drainage system. In: *The Okavango Delta and its Future Utilisation* (edited by Botswana Society). Botswana Society, Gaborone, Botswana. pp.93-112.
Detailed account of the vegetation of the Okavango delta and river, with particular emphasis on the delta. Perennial swamp, seasonal swamp, floodplains, watercourses, open water and islands are described separately. A list of plant species is included, grouped by growth form (woody, grass, herb) and habitat.
UZam, survey, Botswana, Okavango, ecology, vegetation, plants

796. Smith, P.A. (1984). A preliminary list of aquatic, semi-aquatic and other wetland, vascular plants of Botswana. Unpublished report, Maun, Botswana. 21 pp.
Comprehensive list of plants derived from herbarium specimens (including Kew, Pretoria, Harare), literature and observation. 680 species are listed (excluding varieties), 248 from the Chobe-Linyanti area, with brief notes on habit and distribution in Botswana.
UZam, checklist, Botswana, Okavango, Chobe, plants

797. Smith, P.A. (1985). The distribution and ecology of *Salvinia* in Botswana. In: *Proceedings of the Second Conservation Seminar for District Authorities* Department of Wildlife and National Parks, Gaborone, Botswana. pp.72-78.
Basic account of the biology of Salvinia, its history and distribution in Botswana.
UZam, Botswana, Chobe, probspp, plants

798. Smith, P.A. (1991). Vegetation. *Okavango Ecozoning report* Snowy Mountains Consultants, Maun, Botswana. 53-76, 205-211 pp.
Detailed account of the vegetation of the Okavango swamps, with classification by habitat. Plants and vegetation types considered important for conservation are described. The international conservation importance of the Okavango area is brought out.
UZam, survey, Botswana, Okavango, vegetation, conservation, plants

799. Smith, P.A. (1993). Control of floating water weeds in Botswana. In: *Control of Africa's Floating Water Weeds* (edited by Greathead, A. and De Groot, P.). Report CSC(93)AGR-18 PR295 Commonwealth Science Council/Biomass Users Network/CAB International, UK. pp.31-42.
Detailed review of the Botswana experience with control of water weeds, focussing on Salvinia and Pistia.
UZam, Botswana, Chobe, probspp, plants

800. Smith, P.A. (1997). Checklist of Poaceae from the Okavango. Unpublished report, Maun, Botswana. 10 pp.
List of 195 grass species from the Okavango, including the 'panhandle' and delta.
UZam, checklist, Botswana, Okavango, plants

801. Smith, P.P. (1997). A preliminary checklist of the vascular plants in the North Luangwa National Park, Zambia. *Kirkia* **16**(2): 205-245.
Checklist of flowering plants of the N Luangwa valley, with an account of the vegetation. 924 species are listed by family. Two of the 13 vegetation types can be considered wetlands.
MZam, Luangwa, checklist, Zambia, vegetation, plants

802. Smithers, R.H.N. (1964). *A check list of the birds of the Bechuanaland Protectorate and the Caprivi Strip.* Trustees of the National Museums of Southern Rhodesia, Harare, Zimbabwe. 188 pp.
Descriptive listing of all birds found in Botswana and Caprivi including an account of the habitats. Some species are illustrated or have distribution maps.
UZam, checklist, Botswana, Namibia, Chobe, vegetation, birds

803. Smithers, R.H.N. (1971). *Mammals of Botswana.* Museum Memoir No. 1. National Museums of Rhodesia, Harare, Zimbabwe. 340 pp.
Remains the most comprehensive detailed review of the distributions of all Botswana mammals. Includes gazetteer. 119 species are recorded from the Chobe and Okavango.
UZam, checklist, Botswana, biogeography, Lmammals, Smammals

804. Smithers, R.H.N. (1983). *Mammals of the Southern African Subregion.* University of Pretoria, Pretoria, South Africa.

Detailed review of behaviour, ecology, distribution and status of all mammal species occurring south of the Zambezi and Cunene Rivers. Distribution maps are provided for the entire range of most species. Detailed bibliography which includes studies of many species in their ranges in Angola, Malawi, N Mozambique and Zambia.
SAfrica, checklist, biogeography, Lmammals, Smammals

805. Smithers, R.H.N. and Tello, J.L.P.L. (1976). *Check list and atlas of the mammals of Moçambique.* Museum Memoir No. 8. National Museums and Monuments of Rhodesia, Harare, Zimbabwe. 184 pp.
Comprehensive and detailed descriptive account of all Mozambique mammals. Distributions are given, and the main habitat/vegetation types outlined.
Zbasin, checklist, biogeography, Mozambique, vegetation, Lmammals, Smammals

806. Smithers, R.H.N. and Wilson, V.J. (1979). *Checklist and atlas of the mammals of Zimbabwe Rhodesia.* Museum Memoir No. 9. National Museums and Monuments of Rhodesia, Harare, Zimbabwe. 193 pp.
Remains the most comprehensive detailed review of the distributions of all Zimbabwe mammals. Many of the small mammal accounts (especially bats) have been supplemented by new data.
Zbasin, biogeography, checklist, Zimbabwe, Lmammals, Smammals

807. Sommerlatte, M.W.L. (1976). A survey of elephant populations in north-eastern Botswana. Field Document 2. FAO/Department of Wildlife, National Parks and Tourism, Gaborone, Botswana. 100 pp.
Study on elephant distribution in relation to vegetation and availability of surface water, looked at seasonally in 1973-75. Estimated total elephant population was 5746, with a mean density of 0.5 elephants/km². In an exceptional dry season a concentration of 4.6/km² was reached along the Chobe waterfront. The Chobe NP is a wet season dispersal area. Favoured vegetation types for elephant are the Terminalia/Burkea and Baikiaea woodlands, while Acacia woodlands are used more in the dry season. Mopane woodland is intermediate, and grasslands are of minor importance. The Linyanti, Chobe, Savuti and Shinamba areas suffer high tree mortality from elephant, coupled with the effects of fire. Recommendations include reduction in elephant population sizes and encouragement of regeneration of some Acacia woodlands. The report includes a simple vegetation map. The edaphic grasslands of the Chobe floodplain are said to be important for lechwe and puku, but there is also some elephant utilization. The perennial swamps along the Linyanti river are little used except by sitatunga and lechwe, which inhabit the islands.

UZam, Botswana, Chobe, ecology, Lmammals

808. Spinage, C.A. (1994). First discoveries of new antelopes in Botswana. *Botswana Notes & Records* **26**: 109-113.
Reports on discovery of four antelopes in Botswana in the 19th century. All are associated with riparian and wetland habitats.
UZam, Botswana, history, Lmammals

809. Stead, D. and Dudley, C.O. (1977). Liwonde National Park, Part II - The mammals. *Nyala* **3**: 29-38.
Descriptive list of mammals sighted in Liwonde NP, middle Shire valley. 52 species are mentioned.
LZam, MShire, checklist, Malawi, Lmammals, Smammals

810. Stevens, R.A. (1973). A report on the lowland viper, *Atheris superciliaris* (Peters), from the Lake Chilwa floodplain of Malawi. *Arnoldia (Rhodesia)* **6**(22): 1-22.
Account of the biology of a snake found in the lower Shire, lower Zambezi and Zambezi delta areas.
Malawi, LShire, LChilwa, LZam, Delta, reptiles

811. Stevens, R.A. (1974). An annotated checklist of the amphibians and reptiles known to occur in southeastern Malawi. *Arnoldia (Rhodesia)* **6**(30): 1-22.
Annotated list of 159 species, including many from the lower Shire. Around 12 species are recorded from the Elephant Marsh.
LZam, checklist, Malawi, LShire, reptiles, amphibians

812. Stewart, M.M. (1967). *Amphibians of Malawi.* State University of New York Press, New York, USA. 163 pp.
57 species of amphibian are recorded from Malawi, of which about 22 are recorded from the lower Shire. Notes on biology are given along with identification keys.
LZam, LShire, checklist, Malawi, amphibians

813. Stobbs, A.R. (1971). Malawi: Natural Regions and Areas. Sheet 3 - Southern Malawi. Directorate of Overseas Surveys, UK.
Map at 1:500,000 scale to accompany report "The physical environment of Southern Malawi, with special reference to soils and agriculture", Ministry of Agriculture and Natural Resources, Malawi/Overseas Development Administration. Detailed survey of environmental conditions and agriculture for southern Malawi. The legend shows natural region, natural area, altitude, mean annual temperature, mean annual rainfall, soil parent material, landforms, vegetation, soils, present land use, area under cultivation and agricultural potential. 29 map units are depicted, most of them subdivided.
LZam, survey, Malawi, LShire, agriculture, vegetation

814. Stowe, R.J. and Becker, D. (1992). Status and conservation of Corncrakes *Crex crex* outside the breeding grounds. *Tauraco* **2**: 1-23.
A detailed country-by-country report with a map. Many are recorded from Zambia and Malawi.
Zbasin, conservation, birds

815. Stuart, C. and Stuart, T. (1996). *Africa's Vanishing Wildlife*. Southern Book Publishers, Halfway House, South Africa. ISBN 1-86812-521-1. 198 pp.
Popular pictorial account of endangered species in Africa. Includes brief descriptions on lechwe (only 8000 red lechwe remain (1000 in the E Caprivi) and 30,000 black lechwe), Wattled Crane, Shoebill, Saddlebilled Stork, White Stork, Slaty Egret, and Black-cheeked Lovebird, each with a map and some vital statistics.
SAfrica, conservation, Lmammals, birds

816. Stuart, S.N. and Collar, N.J. (1988). Birds at risk in Africa and related islands: the causes of their rarity and decline. In: *Proceedings of the Sixth Pan-African Ornithological Congress* (edited by Backhurst, G.C.). Sixth PAOC Organizing Committee, Nairobi, Kenya. pp.1-25.
Account of biogeography and ecology of 297 threatened bird species. For inland water species, the Slaty Egret and White-winged Flufftail are listed as threatened, and the Shoebill and Wattled Crane as near-threatened. Man-induced habitat alteration is cited as a threat for all 4 species. Human disturbance/persecution in one way or another is cited as a threat for the Shoebill and Wattled Crane.
SAfrica, conservation, birds

817. Stutterheim, I.M. and Panagis, K. (1985). The status and distribution of oxpeckers (Aves: Passeriformes: Buphagidae) in Kavango and Caprivi, South West Africa/Namibia. *South African Journal of Zoology* **20**(1): 10-14.
Study on two oxpecker species in N Namibia. In E Caprivi the Yellowbilled Oxpecker predominates, associated with domestic cattle along water courses and floodplains.
UZam, survey, Namibia, Chobe, birds

818. SVADP (1975). *An atlas of the Lower Shire Valley, Malawi* Department of Surveys, Blantyre, Malawi. 46 pp.
Set of maps from the Shire Valley Agricultural Development Project covering both the physical background of the area and development work.
LZam, survey, Malawi, LShire, agriculture

819. Swedeplan (1989). Programme for the planning of resource utilisation in the Okavango Delta region. Vol. 1: Natural resource and utilisation inventory. Swedeplan/Ministry of Local Government and Lands, Gaborone, Botswana. 434 pp.
Consultants' report on the natural resources and environmental issues of much of N Botswana, including the Chobe/Linyanti area. Includes geology, soil and vegetation maps.
UZam, Botswana, Okavango, agriculture, vegetation, ecology, fisheries, environmental assessment

820. Sweeney, R.C.H. (1959). *A preliminary checklist of the mammals of Nyasaland.* Nyasaland Society/Hetherwick Press, Blantyre, Malawi. 71 pp.
Collection records and notes on mammals of Malawi. Around 15 are noted from the lower Shire.
Zbasin, LShire, checklist, Malawi, Smammals

821. Sweeney, R.C.H. (1960). The Chelonia of Nyasaland Protectorate. *The Nyasaland Journal* **13**(1): 35-50.
An annotated list, with key, to the six species of tortoise, terrapin and turtle in Malawi. Species found in the lower Shire are mentioned.
Zbasin, LShire, checklist, Malawi, reptiles

822. Sweeney, R.C.H. (1961). *Snakes of Nyasaland.* Nyasaland Society, Zomba, Malawi. 200 pp.
Collection records and notes on snakes of Malawi. Around 17 are noted from the lower Shire.
Zbasin, LShire, checklist, Malawi, reptiles

823. Sweeney, R.C.H. (1970a). *Animal Life of Malawi. Vol. 1, Vertebrates* I.P.T., Belgrade, Yugoslavia. 213 pp.
Reference book on all vertebrates known in Malawi. Many biological and anecdotal records are given.
Zbasin, checklist, Malawi, Lmammals, Smammals, birds, fish, reptiles, amphibians

824. Sweeney, R.C.H. (1970b). *Animal Life of Malawi. Vol. 2, Invertebrates* I.P.T., Belgrade, Yugoslavia. 236 pp.
Reference book on all invertebrates known in Malawi. Many biological and anecdotal records are given.
Zbasin, checklist, Malawi, insects, molluscs, Oinverts

825. Sweeney, R.C.H. (1971). *Snakes of Nyasaland: with new added corrigenda and addenda.* A. Asher & Co., Amsterdam, Netherlands. 200 pp.
Additions to collection records and notes on snakes of Malawi.
Zbasin, checklist, Malawi, reptiles

826. Tabler, E.C. [editor] (1963). *The Zambezi Papers of Richard Thornton. Vol. 1 (1858-1860) and Vol. 2 (1860-1863)*. Chatto & Windus, London, UK.
Two volumes giving a detailed account of Livingstone's Zambezi expedition focussing on observations from the lower Zambezi and Luangwa rivers. After leaving Livingstone's expedition, Thornton travelled alone as far west as Chikwenya islands at the Sapi-Zambezi confluence, and as far north as Fundo on the Luangwa. He also mapped part of the lower Shire. Detailed records on natural history and geography of the region are given.
Zbasin, Malawi, Mozambique, Zambia, LShire, Luangwa, Zimbabwe, history

827. Taylor, P.B. (1979). Palaearctic and intra-African migrant birds in Zambia: a report for the period May 1971 to December 1976. Occasional Paper No. 1. Zambian Ornithological Society, Lusaka, Zambia. 169 pp.
Includes data on 37 and 27 species of waterbirds, respectively.
Zbasin, Zambia, birds

828. Taylor, R.D. (1985). *The response of buffalo,* Syncerus caffer, *to the Kariba lakeshore grassland (*Panicum repens *L.) in Matusadona National Park*. PhD thesis, University of Zimbabwe. Harare, Zimbabwe. 514 pp.
Study of buffalo on the Kariba floodplain grassland. It looks at behaviour, nutritional requirements and reproductive ecology related to forage supply. On the floodplains forage was available into the dry season, and was thus a key resource.
MZam, Zimbabwe, Kariba, ecology, vegetation, Lmammals

829. Taylor, R.D. (1987). 'Mystery' buffalo deaths explained. *Zimbabwe Wildlife* **50**: 19-21.
Report on decline in buffalo occurring along the Kariba shoreline.
MZam, Zimbabwe, Kariba, Lmammals

830. Taylor, V. [compiler] (1993). *African Waterfowl Census, 1993*. International Waterfowl Research Bureau, Slimbridge, UK.
Counts were made on the Chobe river in Botswana (955 birds of 23 spp) in January 1993, the Elephant Marsh in Malawi in July 1992 (422 birds of 36 spp) and January 1993 (402 birds of 27 spp), and the Kafue Flats in Zambia in January 1993 (estimated 132,900 birds of 87 spp).
SAfrica, survey, Chobe, LShire, Kafue, birds

831. Taylor, V. and Rose, P. [compilers] (1994). *African Waterfowl Census, 1994*. International Waterfowl Research Bureau, Slimbridge, UK.
Counts were made on the Chobe river in Botswana (4935 birds of 41? spp) in July 1993, the Elephant Marsh in Malawi in July 1993 (2849 birds of 34 spp), on the Kafue Flats in Zambia in July 1993 (73,975 birds of 63 spp) and in January 1994 (129,477 birds of 83 spp).
Zbasin, survey, LShire, Chobe, Kafue, birds

832. Teede, J. and Teede, F. (1990). *The Zambezi: River of the Gods*. Russel Friedman Books, Halfway House, South Africa. ISBN 0-620-15214-1.
Has brief text from the source to the delta. 24 photos feature waterbirds.
Zbasin

833. Teixeira, J.B. (1968). Angola. In: *Conservation of Vegetation in Africa South of the Sahara. Proceedings of a symposium held at the 6th AETFAT Congress, Uppsala, September 1966* (edited by Hedberg, I. and Hedberg, O.). Acta Phytogeographica Suecia No. 54. Almqvist & Wiksells, Uppsala, Sweden. pp.193-197.
Brief account of the vegetation of Angola. Two conservation areas in the upper Zambezi area are very briefly described - Cameia NP and Lóvua Forest Reserve.
Angola, UZam, vegetation, conservation

834. Tello, J.L.P.L. (1986). Wildlife cropping in the Zambezi Delta, Mocambique. In: *Proceedings of Working Party on Wildlife Management and National Parks of the African Forestry Commission.* pp.323-385.
Not seen.
LZam, Mozambique, Delta, Lmammals

835. Tello, J.L.P.L. and Dutton, P. (1979). Programa de Operaçâo Bufalo. Unpublished report. Departamento do Fauna Bravia, Maputo, Mozambique.
Not seen.
LZam, Mozambique, Delta, human use/impact, Lmammals

836. Tembo, A. and Saiwana, L. (1991). Aerial survey results of Liuwa National Park. Unpublished report. National Parks and Wildlife Service, Lusaka, Zambia.
Not seen.
UZam, Barotse, survey, Zambia, Lmammals

837. Thirgood, S.J., Nefdt, R.J.C., Jeffery, R.C.V. and Kamweneshe, B. (1994). Population trends and current status of black lechwe (*Kobus*: Bovidae) in Zambia. *African Journal of Ecology* **32**: 1-8.
Account of black lechwe in the Bangweulu swamps. There was a major decline until 1970, followed by a rise in numbers to c.30,000. Illegal hunting now accounts for c.3000/year.
UZam, survey, Zambia, Bangweulu, conservation, Lmammals

838. Thirgood, S.J., Robertson, A., Jarvis, A.M., Belbin, S.V., Robertson, D., Nefdt, R.J. and Kamweneshe, B. (1992). Mating system and the ecology of black lechwe (*Kobus*: Bovidae) in Zambia. *Journal of Zoology, London* **228**: 155-172.
Account of the reproductive biology of black lechwe in the Bangweulu swamps. Seasonal movements are outlined.

UZam, Zambia, Bangweulu, ecology, Lmammals

839. Thomas, D.S.G. and Shaw, P.A. (1988). Late Cainozoic drainage evolution in the Zambezi basin: geomorphological evidence from the Kalahari rim. *Journal of African Earth Sciences* **7**(4): 611-618.
Review article on the Zambezi drainage system describing progressive capture of the proto-Upper Zambezi during the late Tertiary. Present course of Zambezi is young, dating from 4-1 million years ago. It has evolved through drainage capture and tectonic activity. The Luangwa river was originally part of the upper Zambezi, but was captured by mid Zambezi around Pliocene-early Pleistocene. The Kafue river, also part of the proto-Upper Zambezi, was captured later. The fish of the upper Kafue form part of the Upper Zambezi Okavangian faunal element, distinct from that of the mid Zambezi. They are also ecologically separated in that there is little slow water habitat in the mid Zambezi. The west-flowing tributaries of the Gwayi river were possibly tributaries of the proto-Upper Zambezi.
Zbasin, UZam, Kafue, hydrology, palaeogeography

840. Thomas, D.S.G. and Shaw, P.A. (1991). *The Kalahari Environment.* Cambridge University Press, Cambridge, UK. ISBN 0-521-37080-9. 284 pp.
Detailed account of the geography and palaeogeography of the Kalahari, with particular reference to Botswana.
UZam, Botswana, palaeogeography

841. Thomas, O. and Wroughton, R.C. (1907). The Rudd Exploration of South Africa: VIII - List of mammals obtained by Mr Grant at Beira. *Proceedings of Zoological Society of London* **1907**
Not seen.
LZam, Mozambique, Smammals

842. Thomas, O. and Wroughton, R.C. (1908). The Rudd Exploration of South Africa: X - List of mammals obtained by Mr Grant near Tette, Zambezia. *Proceedings of Zoological Society of London* **1908**: 535-552.
Not seen.
MZam, Mozambique, Smammals

843. Thomas, P.I. (1970). A Chitonga-botanical dictionary of some species occurring in the vicinity of the Mwenda estuary, Lake Kariba, Rhodesia. *Kirkia* **7**(2): 269-284.
A list of Tonga vernacular names of 400 plant species from the Mwenda river area, Binga on Lake Kariba. An alphabetical list of Tonga names with botanical equivalent is also included.
MZam, checklist, Zimbabwe, Kariba, plants

844. Thomasson, K. (1955). Notes on the plankton of Lake Bangweulu. *Nova Acta Societas Scientiae Uppsalaensis* **4**: 3-18.
Not seen.
UZam, Zambia, Bangweulu, phytoplankton

845. Thomasson, K. (1965). Notes on the algal vegetation of Lake Kariba. *Nova Acta Societas Scientiae Uppsalaensis (Series 4)* **19**: 1-34.
Illustrated account of phytoplankton collected from Lake Kariba in 1959.
MZam, Zimbabwe, Zambia, Kariba, phytoplankton

846. Thomasson, K. (1980). Plankton of Lake Kariba re-examined. *Acta Phytogeographica Suecia* **68**: 157-162.
Account with lists of phytoplankton collected from Lake Kariba in 1968-70.
MZam, checklist, Zimbabwe, Zambia, Kariba, phytoplankton

847. Thompson, B.R. (1969). Some bird records from Sesheke District. *The Puku* **5**: 235-236.
Brief notes on 21 bird species from SW Zambia, including some associated with wetlands.
UZam, Zambia, checklist, birds

848. Thompson, K. (1976). The Okavango Delta and its future utilisation: an attempt at a synthesis of the proceedings. In: *The Okavango Delta and its Future Utilisation* (edited by Botswana Society). Botswana Society, Gaborone, Botswana. pp.3-12.

Synthesis of the proceedings of the Okavango symposium. The potentials for economic development and conservation are outlined, as are the limitations and problems. The Okavango is discussed in context of similar environments elsewhere in the world.
UZam, Botswana, Okavango, agriculture, fisheries, human use/impact, ecology

849. Thompson, K. (1976). Primary productivity of African wetlands, with particular reference to the Okavango Delta. In: *The Okavango Delta and its Future Utilisation* (edited by Botswana Society). Botswana Society, Gaborone, Botswana. pp.67-79.
Review article on wetland plant productivity, with particular reference to papyrus. Papyrus has an annual net productivity around 50-60 t DM/ha/year, even under low nutrient conditions; it shows tight nutrient cycling. Burning reduces nutrient levels, hence growth rates. An estimate of primary productivity of submerged macrophytes is 10-12 t DM/ha/year, and for phytoplankton 0.5 t DM/ha/year.
UZam, Botswana, Okavango, ecology, vegetation, plants

850. Thompson, K., Howard-Williams, C. and Mitchell, D. (1985). A cross-indexed bibliography of African wetland plants and vegetation. In: *The Ecology and Management of African Wetland Vegetation: a botanical account of African swamps and shallow waterbodies* (edited by Denny, P.). Geobotany Vol. 6. W. Junk, Dordrecht, Netherlands. ISBN 90-6193-509-1. pp.237-316.
Comprehensive bibliography of 794 references with keywords indicating country, subject and species (if appropriate). The references are also indexed with a comprehensive series of index words. Most of the references are to vegetation description or aquatic weeds and their control, and rather few are to ecology or ecological processes. The literature from South Africa is the most comprehensive.
SAfrica, bibliography, ecology, vegetation, probspp, plants

851. Thornton, J.A. [editor] (1982). *Lake McIlwaine: the eutrophication and recovery of a tropical African lake*. W. Junk, The Hague, Netherlands. ISBN 90-6193-102-9. 251 pp.
Compiled book containing 22 papers on various aspects of the geography, hydrology, water chemistry, biology, utilisation and management of Lake Chivero (formerly McIlwaine) near Harare. A comprehensive bibliography is included.
MZam, Chivero, Zimbabwe, human use/impact, ecology, water quality, fisheries, probspp, plants, phytoplankton, zooplankton, Oinverts, fish, birds

852. Thornton, J.A. and Taussig, H.J. (1982). Zooplankton and secondary production. In: *Lake McIlwaine: the eutrophication and recovery of a tropical African lake* (edited by Thornton, J.A.). W. Junk, The Hague, Netherlands. ISBN 90-6193-102-9. pp.133-137.
Account of zooplankton found in Lake Chivero, with brief notes on potential productivity. An appendix gives a list of 27 species found.
MZam, Chivero, Zimbabwe, Oinverts

853. Thys van den Audenaerde, D.F.E. (1994). Introduction of aquatic species into Zambian waters, and their importance for aquaculture and fisheries. ALCOM Field Document No. 24. FAO, Harare, Zimbabwe. 29 pp.
General review of fish introduction in Zambia. The successful establishment of Nile Tilapia in the Kafue river is of particular concern.
Zbasin, Zambia, Kafue, probspp, fish

854. Timberlake, J.R. (1996). Sites of interest for botanical conservation in the communal lands of the Zambezi Valley, Zimbabwe. Zambezi Society/Biodiversity Foundation for Africa, Harare, Zimbabwe. 52 pp.
Consultants' report with account and descriptions of relatively small sites of interest for botanical conservation in the communal lands of the Zambezi valley in Zimbabwe. Some riparian sites on recent alluvium are described from along tributaries of the Zambezi. The only wetland described is a saline spring with Cyperus laevigatus and Sporobolus consimilis at Kanyemba.
MZam, Mana, Zimbabwe, vegetation, environmental assessment, conservation, plants

855. Timberlake, J.R. and Mapaure, I. (1992). Vegetation and its conservation in the eastern mid-Zambezi Valley, Zimbabwe. *Transactions of the Zimbabwe Scientific Association* **66**: 1-14.
Account of the vegetation of the communal lands of the mid-Zambezi valley in Zimbabwe. 12 vegetation types are described, only one of which is on recent alluvium (type 5, alluvial floodplains and riverine woodland). Flanking the larger rivers Faidherbia albida is common. Phragmites mauritianus reeds occur on some sandbanks. Areas suitable for botanical conservation are mapped and described.
MZam, Mana, survey, Zimbabwe, vegetation, ecology, conservation, plants

856. Timberlake, J.R., Nobanda, N. and Mapaure, I. (1993). Vegetation survey of the communal lands - north and west Zimbabwe. *Kirkia* **14**(2): 171-270.
Account and map (scale 1:500,000) of the vegetation of the communal lands over much of the Zambezi catchment within Zimbabwe, using a phytosociological approach and satellite imagery. 37 vegetation types are described, grouped into 8 physiognomic/floristic classes. The floodplains of the Zambezi tributaries are mostly described under mixed riparian woodland (type B2) or Faidherbia riparian woodland (type B3). Dambo grasslands at lower altitudes are classified as Cynodon-Eragrostis grasslands on sands (type J2) or Panicum repens lakeshore grassland (type J4) on Lake Kariba. Relationships to soils and other environmental factors are discussed.
MZam, Mana, survey, Zimbabwe, vegetation, ecology, plants

857. Tinley, K.L. (1969). A first air count of the buffalo of Marromeu. *Veterinária Moçambicana* **1**(2): 155-170.
Account of aerial survey of buffalo and other large mammals in Marromeu and adjacent areas in 1968. Distribution maps are given. Results show over 16,000 buffalo and 4000 waterbuck, but only 257 elephant. The potentials for sustained management and tourism are pointed out.
LZam, survey, Mozambique, Delta, Lmammals

858. Tinley, K.L. (1971). Determinants of coastal conservation: diversity and dynamics of the environment as exemplified by the Moçambique Coast. In: *Nature Conservation as a form of land use: Proceedings of SARCUSS Symposium* SARCUSS, Pretoria, South Africa. pp.124-153.
Detailed account of the geomorphology, ecology and dynamics of the Mozambique coast. The Zambezi delta is briefly mentioned.
LZam, Mozambique, Delta, ecology, conservation, vegetation

859. Tinley, K.L. (1973). *An Ecological Reconnaissance of the Moremi Wildlife Reserve, Northern Okovango Swamps, Botswana*. Okovango Wildlife Society, Johannesburg, South Africa. 146 pp.
Detailed ecological account of the Moremi area, part of the Okavango, with sections on geography, soils, climate, vegetation, large mammals and biogeography. Species lists of plants, birds and mammals are given.
UZam, survey, Botswana, Okavango, vegetation, conservation, ecology, Lmammals, birds, plants

860. Tinley, K.L. (1975). Marromeu: wrecked by the big dams. *African Wildlife* **29**(2): 22-25.
Popular account of the environmental consequences of Cabora Bassa dam on the Marromeu wetlands and buffalo populations. The great tourist potential of the area is pointed out.
LZam, Mozambique, Delta, Cabora, environmental assessment, conservation

861. Tinley, K.L. (1977). *Framework of the Gorongosa Ecosystem.* DSc thesis, University of Pretoria. Pretoria, South Africa. 184 pp.
Detailed and authoritative account of the Gorongosa ecosystem in the rift valley of central Mozambique, including part of the Zambezi delta and its hinterland. A holistic, landscape-guided, evolutionary approach is used, and the vegetation, large mammal populations and land use are described in this context. The vegetation is described in detail. Conservation of the ecosystem and its large mammals is discussed.
LZam, survey, Mozambique, Delta, vegetation, conservation, ecology, human use/impact, Lmammals, plants

862. Tinley, K.L. (1994). Ecological profile of the region (form, content, process). In: *Description of Gorongosa-Marromeu Natural Resource Management Area* IUCN ROSA, Harare, Zimbabwe. 25 pp.
Account of the geography and geomorphology of the Marromeu-Gorongosa area. The vegetation of the different landscapes is described; and the conservation importance of the whole area is outlined.
LZam, survey, Delta, Mozambique, vegetation, conservation, ecology

863. Tinley, K.L., Rosinha, A.J., Tello, J.L.P.L. and Dutton, T.P. (1976). Wildlife and wild places in Mozambique. *Oryx* **13**(4): 344-350.
Not seen.
Zbasin, Mozambique, conservation

864. Tinley, K.L. and Sousa Dias, A.H.G.d. (1973). Wildlife reconnaissance of the mid-Zambezi Valley in Moçambique before formation of the CaboraBassa dam. *Veterinária Moçambicana* **6**(2): 103-131.
Detailed account of the ecology, large mammals and conservation potential of the mid-Zambezi river between Zumbo and the proposed Cabora Bassa dam. Mammal populations were low, partly due to excessive hunting. The main animals were impala and kudu.
MZam, survey, Mozambique, Cabora, conservation, ecology, vegetation, Lmammals, fish

865. Toews, D. (1975). Limnology of Lake Bangweulu. FI: DP/SAM/681511/7 Report FAO, Rome, Italy. 7 pp.
Not seen.
UZam, Zambia, Bangweulu

866. Toms, R.B. and Otte, D. (1988). New genera, species and records of East and Southern African tree crickets (Orthoptera: Gryllidae: Oecanthinae). *Annals of the Transvaal Museum* **34**(20): 469-521.
Account of a number of new species of tree crickets, including one only recorded from the Okavango/Chobe area.

SAfrica, checklist, insects

867. Toots, H. (1970). Exotic fishes in Rhodesia. *Rhodesia Agriculture Journal* **67**: 83-88.
Account of exotic fish species introduced into rivers and dams in Zimbabwe, including those in the Zambezi basin.

Zbasin, Zimbabwe, fish

868. Trapnell, C.G. and Clothier, J.N. (1937). *The soils, vegetation and agricultural systems of North-Western Rhodesia*. Government Printer, Lusaka, Zambia. 81 pp.

Account of soils, climate and vegetation types of much of Zambia. There are 7 Kalahari Sand vegetation types in Barotseland, each very briefly described. A map is included. There is a later revised edition (1957).
UZam, Barotse, Zambia, vegetation, agriculture

869. Trapnell, C.G., Martin, J.D. and Allan, W. (1950). *Vegetation-soil map of Northern Rhodesia*. Government Printer, Lusaka, Zambia.
Not seen.
UZam, Zambia, agriculture, vegetation

870. Traylor, M.A. (1963). Check-list of Angolan birds. *Publicaçoes Culturais de Compania de Diamantes de Angola* **61**: 1-250.
Not seen.
checklist, UZam, Angola, birds

871. Traylor, M.A. (1965). A collection of birds from Barotseland and Bechuanaland. *Ibis* **107**: 137-172.
Not seen.
UZam, Barotse, checklist, Botswana, Chobe, Zambia, birds

872. Traylor, M.A. and Hart, R.C. (1965). Some interesting birds from Barotseland. *The Puku* **3**: 133-141.

Annotated checklist of 49 bird species from Kalabo, W Zambia, including 14 waterbirds.
UZam, Barotse, Zambia, checklist, birds

873. Tree, A.J. (1969). The status of Ethiopian waders in Zambia. *The Puku* **5**: 181-205.
Account of 15 waterbirds which breed in Zambia with detailed breeding notes and maps.
Zbasin, Zambia, birds

874. Trendall, J. (1988). The distribution and dispersal of introduced fish at Thumbi West Island in Lake Malawi, Africa. *Journal of Fish Biology* **33**: 357-369.
Account of the changes that occurred amongst a community of rock-dwelling cichlid fish living around an island in Lake Malawi when fish from other islands were introduced. The conclusions have important implications for the conservation of biodiversity in the lake.
Malawi, LMalawi, environmental assessment, conservation, fish

875. Trewavas, E. (1983). *Tilapiine Fishes of the Genera* Sarotherodon, Oreochromis *and* Danakilia. British Museum (Natural History), London, UK.
Taxonomic description of all species from these 3 genera, including species from the Zambezi basin and Lake Malawi.

checklist, biogeography, Zbasin, LMalawi, fish

876. Turner, B. (1983). *Bibliography of the Kafue Flats*. Kafue Basin Research Committee, University of Zambia, Lusaka, Zambia. 88 pp.
Extensive bibliography containing published/unpublished references, maps, list of events and an index of place names.
UZam, bibliography, Zambia, Kafue, history

877. Turner, G.F. (1995). Management, conservation and species changes of exploited fish stocks in Lake Malawi. In: *The Impact of Species Changes in African Lakes* (edited by Pitcher, T.J. and Hart, P.J.B.). Fish and Fisheries Series No. 18. Chapman & Hall, London, UK. ISBN 0-412-55050-4. pp.365-395.
Review of the fisheries industry of Lake Malawi. Prior to 1986 endemic tilapia (chambo) fishing dominated, but the various fishing methods have resulted in over-exploitation. Endemic haplochromine fish now dominate the catch. Species changes are ascribed to changes in fishing methods used. Species introductions will not increase productivity.
Malawi, LMalawi, fisheries, human use/impact, fish

878. Turner, G.F., Tweddle, D. and Makwinja, R.D. (1995). Changes in demersal cichlid communities as a result of trawling in southern Lake Malawi. In: *The Impact of Species Changes in African Lakes* (edited by Pitcher, T.J. and Hart, P.J.B.). Fish and Fisheries Series No. 18. Chapman & Hall, London, UK. ISBN 0-412-55050-4. pp.398-412.
Study of the impact of commercial trawling on species composition and community structure of haplochromine cichlids. Populations are declining and recommendations are given for conservation measures.
Malawi, LMalawi, fisheries, human use/impact, fish

879. Turner, J.L. (1977a). Changes in the size structure of cichlid populations in Lake Malawi resulting from bottom trawling. *Journal of the Fisheries Research Board of Canada* **34**: 232-238.
Account of changes in the size structure of cichlid fishes in Lake Malawi as a result of bottom-trawling, which may have implications for their conservation.
Malawi, LMalawi, human use/impact, fisheries, fish

880. Turner, J.L. (1977b). Some effects of demersal trawling in Lake Malawi (Lake Nyasa) from 1968 to 1974. *Journal of Fish Biology* **10**: 261-271.

Account of changes in the size structure of cichlid fishes in Lake Malawi as a result of bottom-trawling, including data on changes in species composition. Results may have implications in fish conservation.
Malawi, LMalawi, human use/impact, fisheries, fish

881. Turner, J.L. (1982). Lake flies, water fleas and sardines. *Fishery Expansion Project, Malawi: Biological studies on the pelagic ecosystem of Lake Malawi.* FI:DP/MLW/75/019 Technical Report No. 1. FAO, Rome, Italy. 165-182 pp.
Report on the possible interactions between lake flies, water fleas (Cladocera) and pelagic fish such as kapenta, comparing Lakes Malawi, Kariba and Tanganyika. Lake Malawi has high numbers of lake flies and Cladocera, but few pelagic fish. This is compared to Lake Tanganyika which has high populations of pelagic fish (kapenta) but few Cladocera or lake flies. It is suggested the lake flies are an important food source for pelagic fish, and that Lake Malawi could support a high pelagic fish population.
Malawi, LMalawi, fisheries, ecology, environmental assessment, fish, insects, crustacea

882. Tvedten, I., Girvan, L.A., Masdoorp, M., Pomuti, A. and van Rooy, G. (1994). Freshwater fisheries and fish management in Namibia: a socio-economic background study. Unpublished report. Multi-Disciplinary Research Centre, University of Namibia, Windhoek, Namibia.
Study on freshwater fisheries in Namibia. A good map of floodplains and swamps in the E Caprivi is provided. An overview of the hydrology and fisheries potential of the Kwando, Linyanti, Lake Liambezi, Chobe and Zambezi is given.
UZam, Namibia, Chobe, hydrology, fisheries, fish

883. Tweddle, D. (n.d.). An introduction to the angling fishes of Malawi. Unpublished booklet, Blantyre, Malawi. 47 pp.
Basic identification booklet to all larger fish species of the Shire river and Lake Malawi (except Cichlidae). 43 indigenous species are described, of which 29 are found in the lower Shire.
LZam, LMalawi, LShire, checklist, Malawi, fish

884. Tweddle, D. (1992). Conservation and threats to the resources of Lake Malawi. *Mitt. International Verein. Limnology* **23**: 17-24.
Not seen.
Malawi, LMalawi, conservation, fish

885. Tweddle, D. (1995?). Malawi fish taxonomy, speciation and evolution bibliography (includes selected other groups such as aquatic molluscs). Unpublished typescript, Blantyre, Malawi. 21 pp.
Detailed bibliography (citation only, no annotations), possibly an expanded version of Tweddle & Mkoko 1986, covering fish, crustacea, midges, gastropods, nematodes, dragonflies, etc. On file at the Wildlife Society of Malawi, Limbe. Most references are related to Lakes Malawi and Chilwa.
LZam, LMalawi, LChilwa, bibliography, Malawi, biogeography, fish, insects, Oinverts

886. Tweddle, D., Hastings, R.E. and Jones, T. (1977). The development of a floodplain fishery: Elephant Marsh, Malawi. In: *Symposium on River and Floodplain Fisheries* FAO, Rome, Italy. pp.15.
Not seen. Paper FIPL CIFA/77/Symp. 9.
LZam, Malawi, LShire, fisheries

887. Tweddle, D., Lewis, D.S.C. and Willoughby, N.G. (1979). The nature of the barrier separating the Lake Malawi and Zambezi fish faunas. *Ichthyological Bulletin of the J.L.B. Smith Institute of Ichthyology, Rhodes University* **39**: 1-9.
Account of the differences in fish fauna above and below Kapichira Falls on the Shire river. The falls are an ecological barrier to downstream movement of Lake Malawi fish. Lists of fish species are given.
LZam, survey, biogeography, checklist, Malawi, LShire, fish

888. Tweddle, D. and Mkoko, B.J. (1986). Limnological bibliography of Malawi. CIFA Occasional Paper 13. FAO Fisheries Department, Rome, Italy. 75 pp.
Large bibliography of 1101 references, covering a varied published and unpublished literature on fish, fisheries, aquatic birds and allied subjects. Entries are also cross-referenced by subject.
Zbasin, bibliography, Malawi, fisheries, fish

889. Tweddle, D., Turner, G.F. and Seisay, M.B.D. (1995). Changes in species composition and abundance as a consequence of fishing in Lake Malombe, Malawi. In: *The Impact of Species Changes in African Lakes* (edited by Pitcher, T.J. and Hart, P.J.B.). Fish and Fisheries Series No. 18. Chapman & Hall, London, UK. ISBN 0-412-55050-4. pp.413-412.
Study of changes in cichlid fish populations from a lake fed by Lake Malawi and the Shire river. Chambo numbers have decreased, and appear to be separate from the Lake Malawi population. This has been replaced by kambuzi, of lesser value. The fisheries industry is in imminent danger of collapse.
Malawi, LMalawi, environmental assessment, human use/impact, fisheries, fish

890. Tweddle, D. and Willoughby, N.G. (1976). Dry season fish populations in the Shire Valley game reserves. *Nyala* **2**(1): 3-16.
Not seen.

LZam, Malawi, LShire, fish

891. Tweddle, D. and Willoughby, N.G. (1979a). An annotated checklist of the fish fauna of the river Shire south of the Kapichira Falls, Malawi. *Ichthyological Bulletin of the J.L.B. Smith Institute of Ichthyology, Rhodes University* **39**: 11-22.
Gives a list of 61 species of fish from the Shire river below the waterfalls that mark the boundary of the lower and upper Shire. The species are essentially those found in the lower Zambezi.
LZam, survey, checklist, biogeography, Malawi, LShire, fish

892. Tweddle, D. and Willoughby, N.G. (1979b). An annotated checklist of the fish fauna of the river Shire south of Kapichira Falls. *Nyala* **5**(2): 75-91.
List of 61 species from the Shire river below the waterfalls that mark the boundary of the lower and upper Shire. Abbreviated version of Tweddle & Willoughby 1979.
LZam, biogeography, checklist, Malawi, LShire, fish

893. University of Idaho (1971). Ecology of fishes in the Kafue River. Report prepared for FAO/UNDP. FI: SF/SAM 11, Technical Report 2. University of Idaho, Moscow, Idaho, USA. 66 pp.
Not seen. Possibly contains lists of fish species from the Kafue river.
UZam, Zambia, Kafue, ecology, fish

894. University of Michigan (1971). The fisheries of the Kafue river flats, Zambia in relation to the Kafue Gorge dam. Report prepared for FAO/UNDP. FI: SF/SAM 11, Technical Report 1. University of Michigan, Ann Arbor, Michigan, USA. 161 pp.
Not seen. Probably includes list of commercially important species in the Kafue river and an assessment of changes due to dam closure.
UZam, Zambia, Kafue, environmental assessment, fisheries, fish

895. Urban, E.K. (1988). Status of cranes in Africa. In: *Proceedings of the Sixth Pan-African Ornithological Congress* (edited by Backhurst, G.C.). Sixth PAOC Organizing Committee, Nairobi, Kenya. pp.315-329.
Account of conservation status of crane species across Africa. Wattled Cranes populations are estimated for 11 countries. The species occurs in 2 E Provinces of Angola, Chobe/Linyanti rivers and Savuti Marsh, Marromeu, E Caprivi with up to 11,000 birds in Zambia, particularly on the Kafue Flats and Liuwa Plain. Several thousand Grey Crowned Cranes also occur in Zambia.
Zbasin, conservation, birds

896. Van Bruggen, A.C. (1966). Notes on non-marine molluscs from Mozambique and Bechuanaland, with a checklist of Bechuanaland species. *Annals of the Transvaal Museum* **25**: 99-111.
Not seen.
UZam, LZam, checklist, Mozambique, Botswana, molluscs

897. Van Bruggen, A.C. (1970). A contribution to the knowledge of non-marine mollusca of South West Africa. *Zool. Meded. Leiden* **45**: 43-73.
Not seen.
Namibia, molluscs

898. Van Bruggen, A.C. (1980). A note on some molluscs from the Caprivi Strip, South West Africa (Namibia). *Basteria* **44**: 81-84.
Not seen.
UZam, Namibia, Chobe, molluscs

899. Van der Lingen, M.I. (1973). Lake Kariba: early history and south shore. In: *Man-made Lakes: Their Problems and Environmental Effects* (edited by Ackermann, W.C., White, G.F. and Worthington, E.B.). Geophysical Monograph Series Vol. 17. American Geophysical Union, Washington DC, USA. pp.132-142.

Not seen.
MZam, Zimbabwe, Kariba

900. Van der Waal, B.C.W. (1976). *'n Visekologiese Studie van die Liambezimeer in die Oos-Caprivi met verwysing na visontginning deur die Bantoebevolking*. DSc thesis, Rand Afrikaans University. Johannesburg, South Africa. 192 pp.
Study in Afrikaans on the fish and fisheries of Lake Liambezi in the E Caprivi.
UZam, Namibia, Chobe, fisheries, ecology, fish

901. Van der Waal, B.C.W. (1980). Aspects of the fisheries of Lake Liambezi, Caprivi. *Journal of Limnological Society of Southern Africa* **6**(1): 19-31.
The lake contains 43 fish species, and production estimates are 74-157 kg/ha. Fish catches depend on net type and size. Data are presented on catch sizes. A small commercial fishery is operating, mostly for cichlids. Recommendations for improving the fishery industry are given.
UZam, Namibia, Chobe, human use/impact, fisheries, fish

902. Van der Waal, B.C.W. (1985). Aspects of the biology of larger fish species of Lake Liambezi, Caprivi, South West Africa. *Madoqua* **14**(2): 101-144.
Account of the fish species found in the lake; 43 species are listed and an account of the biology of 27 species is given, including age and growth, reproduction and feeding habits. The lake ecology is based on the gradual decomposition of organic material from the surrounding swamps.
UZam, Namibia, Chobe, ecology, fish

903. Van der Waal, B.C.W. (1990). Aspects of the fishery of the Eastern Caprivi, Namibia. *Madoqua* **17**(1): 1-16.
Account of the small-scale fishing industry of Lake Liambezi and the Caprivi floodplains and swamps. Gill nets mostly caught cichlids and catfish, with an annual total of 700,000 kg. Data from experimental catches with different gill sizes are given. The need for management and control of the industry to avoid over-harvesting are pointed out.
UZam, Namibia, Chobe, fisheries, human use/impact, fish

904. Van der Waal, B.C.W. (1991). A survey of the fisheries in Kavango, Namibia. *Madoqua* **17**(2): 113-122.
Account of small-scale fishing along the Kavango river in N Namibia. Total annual catch was estimated at 840,000 kg. Much of the fishing gear in use catches small fish and is relatively non-selective. The importance of measures to control habitat destruction is stressed. Lists of fish species caught by different methods are given.
UZam, Namibia, Okavango, fisheries, conservation, human use/impact, fish

905. Van der Waal, B.C.W. and Skelton, P.H. (1984). Check list of fishes of Caprivi. *Madoqua* **13**(4): 303-320.
List of 76 species of freshwater fish collected from the Caprivi over 4 years. The Kwando-Linyanti system contains two species not found in the Zambezi, and the Zambezi contains 14 species not in the Kwando. Habitat preferences are given.
UZam, checklist, biogeography, Namibia, Chobe, ecology, fish

906. Van der Walt, M.M., Cowan, G.L., Erasmus, A. and Marneweck, G.C. (1995). Listing of wetland references for South Africa: draft. Department of Environmental Affairs and Tourism, Pretoria, South Africa.
Listing from a computerised database of 4091 references concerning or relevant to wetlands in southern Africa, with particular reference to South Africa.
SAfrica

907. Van Gils, H. (1988). *Environmental profile: Western Province, Zambia*. ITC, Enschede, Netherlands. 37 pp.
Overview of the environmental attributes and issues of Western Province. Climate, land systems, broad vegetation types and wildlife resources are outlined.
UZam, Barotse, survey, Zambia, agriculture, range/livestock, fisheries, vegetation, human use, environmental assessment

908. Van Hille, J.C. (1985). Anthicidae (Coleoptera heteromera) collected in Botswana, 1982-83. *Botswana Notes and Records* **17**: 149-162.
List of species of beetle collected in Botswana, including a number of species from the Okavango area.
UZam, Okavango, checklist, Botswana, insects

909. Van Oosten, C. (1989). An analytical bibliography of the Western Province of Zambia. International Agricultural Centre, Wageningen, Netherlands. 241 pp.
A comprehensive and thematic listing of published references on many aspects of Western Province, including agriculture, fisheries and forestry. A description of the area is given. All entries are annotated.
UZam, Barotse, bibliography, Zambia, history, agriculture, range/livestock

910. Van Rensburg, H.J. (1968). The ecology of the Kafue Flats. In: *Multipurpose survey of the Kafue river basin. Final Report.* SF: 35/ZAM, Report Vol. 4(1). FAO, Rome, Italy. 138 pp.
Not seen.
UZam, Zambia, Kafue, vegetation, ecology, plants

911. Van Rensburg, H.J. (1968). List of plant species. In: *Multipurpose survey of the Kafue river basin. Final Report.* SF: 35/ZAM, Report Vol. 4(2). FAO, Rome, Italy. 178 pp.
Annotated list of plant species.
UZam, checklist, Zambia, Kafue, plants

912. Van Rensburg, H.J. (1972). Fire: its effect on grasslands, including swamps - southern, central and eastern Africa. In: *Proceedings of the Tall Timbers Fire Ecology Conference, 11.* Tall Timbers Research Station, Florida, USA. pp.175-199.
Superficial review paper on the effects of fire on grasslands. Wetlands mentioned are the Okavango, Lake Ngami and the Kafue Flats. Time of burning is shown to be important, and fire can have a beneficial effect for grazers.
Zbasin, Zambia, Botswana, Kafue, Okavango, vegetation, ecology, range/livestock

913. Van Son, G. (1949). The butterflies of southern Africa. Part 1- Papilionidae and Pieridae. *Memoirs of the Transvaal Museum* **3**
First of 4 volumes (Nos. 3, 8, 14, 22) containing keys, descriptions, life histories, distributions and habits of 6 groups of butterfly.
SAfrica, insects, ecology

914. Vaughan-Kirby, F. (1896). *In Haunts of Wild Game: A hunter naturalist's wanderings from Kahlamba to Libombo.* Blackwood & Sons, London, UK.
Not seen.
LZam, Mozambique, history

915. Vaughan-Kirby, F. (1899). *Sport in East Central Africa: Being an account of hunting trips in Portuguese and other districts of east central Africa.* Rowland Ward, London, UK. 340 pp.
Detailed account of a trip up the Zambezi from Chinde to Chiromo and then to Zomba. Decline of hippo in lower Zambezi noted. Detailed account of observations of large mammals in Tete Province. Includes natural history notes on large and medium sized mammal species.
LZam, MZam, Mozambique, history

916. Venema, J.H. (1991). Land resources appraisal of Ngabu Agricultural Development Division, Malawi. Field Document No. 21, AG:DP/MLW/85/011. Land Resources Evaluation Project, FAO/Ministry of Agriculture, Lilongwe, Malawi. 200 pp.
Report on the agricultural potential of part of the lower Shire, principally the upland areas and not the marshes. Contains maps at 1:250,000 scale on soils/physiography, agro-climatic zones, land units, present land use and vegetation (from 1989).
LZam, survey, Malawi, LShire, agriculture, vegetation

917. Verboom, W.C. (1965). The Barotseland ecological survey, 1964. Unpublished report. Department of Agriculture, Lusaka, Zambia.
Not seen.
UZam, Barotse, survey, Zambia, vegetation

918. Verboom, W.C. (1966). The grassland communities of Barotseland. *Journal of Tropical Agriculture (Trinidad)* **43**(2): 107-115.
Not seen.
UZam, Barotse, Zambia, vegetation

919. Verboom, W.C. (1970). The grasses and other fodder resources of the Western Province of Zambia: annotated list of grasses, sedges and legumes. Unpublished report. Department of Agriculture, Lusaka, Zambia.
Not seen.
UZam, Barotse, checklist, Zambia, plants

920. Verboom, W.C. (1975). List of plant species in the main vegetation types of the Bangweulu Basin. In: *Black Lechwe Research Project, Final Report* (edited by Grimsdell, J.J.R. and Bell, R.H.V.). Animal Production Research Report ARI-NCSR/TR 31. Lusaka, Zambia.
Not seen.
UZam, checklist, Zambia, Bangweulu, vegetation, plants

921. Verboom, W.C. (1981a). Animal protein-producing area of Zambia. Vol. 1 - The grasslands of the cattle-keeping people. National Council for Scientific Research, Zambia/International Institute for Aerial Survey and Earth Sciences, Enschede, Netherlands. 245 pp.
Botanical and ecological account of the rangelands of Zambia, with particular reference to grasslands, which are divided into plateau grasslands and floodplain grasslands. A description and listing of the grass, sedge and legume species of the Barotse floodplains is given, with accompanying ecological notes, based on collections by Verboom in 1964. The Barotse sand grasslands are said to be fire climax open woodland developed on nutrient-poor Kalahari sands. The floodplain grasslands of Western Province occur on the Bulozi Plain, the Matabele-Mulonga Plain and the Siloana Plain. Seasonal shallow flooding occurs from December to May. The grass, sedge and herbs present depend on land unit.
UZam, Barotse, survey, checklist, Zambia, range/livestock, vegetation, ecology, plants

922. Verboom, W.C. (1981b). Animal protein-producing area of Zambia. Vol. 2 - The flood plains. National Council for Scientific Research, Zambia/International Institute for Aerial Survey and Earth Sciences, Enschede, Netherlands.
Botanical and ecological account of the rangelands of Zambia, with particular reference to grasslands, which are divided into plateau grasslands and floodplain grasslands.
UZam, Barotse, survey, checklist, Zambia, vegetation, ecology, range/livestock, plants

923. Verboom, W.C. and Brunt, M.A. (1970a). An ecological survey of Western Province, Zambia, with special reference to the fodder resources. Vol. 1 - The environment. Land Resource Study 8. Land Resources Division, Directorate of Overseas Surveys, Surrey, UK. 95 pp.
Detailed account of the land units, climate, hydrology, soils, vegetation and wildlife of Western Province. The vegetation is described under 15 types. Maps of the area and of the Matabele Plain are given.

UZam, Barotse, survey, Zambia, agriculture, vegetation, Lmammals, plants

924. Verboom, W.C. and Brunt, M.A. (1970b). An ecological survey of Western Province, Zambia, with special reference to the fodder resources. Vol. 2 - The grasslands and their development. Land Resource Study 8. Land Resources Division, Directorate of Overseas Surveys, Surrey, UK. 133 pp.
Continuation of Vol. 1 with sections on fodder resources and utilisation, species lists and fodder analyses. The vegetation types of Western Province based on Trapnell et al. and Fanshawe are described, and many species listed. Notes on forage value and palatability are given.
UZam, Barotse, survey, Zambia, range/livestock, vegetation, plants

925. Vesey-Fitzgerald, D.F. (1956). The black lechwe and modern methods of wild life preservation. *Black Lechwe* **1**(1): 10-14.
Popular article on the black lechwe and its conservation in the Bangweulu swamps. Gives details of the floodplain ecology and the aerial census method aimed at permitting sustainable offtake by local communities based on accurate population census.
UZam, Zambia, Bangweulu, conservation, Lmammals

926. Vesey-Fitzgerald, D.F. (1961). The black lechwe and modern methods of wild life preservation. *The Northern Rhodesia Journal* **2**(6): 25-32.
Popular article on the black lechwe and its conservation. Reprint of Vesey-Fitzgerald (1956).
UZam, Zambia, Bangweulu, conservation, Lmammals

927. Vesey-Fitzgerald, D.F. (1965). Lechwe pastures. *The Puku* **3**: 143-147.
Details on the vegetation and physical characteristics of floodplains inhabited by lechwe in Zambia. Grass species and phenology is described.
UZam, Zambia, ecology, vegetation, Lmammals

928. Vesey-Fitzgerald, D.F. (1972). Black lechwe. *Black Lechwe* (1): 9-11.
Popular article on the black lechwe.
UZam, Zambia, Bangweulu, Lmammals

929. Von Richter, W. and Osterberg, R. (1977). The nutritive values of some major food plants of lechwe, puku and waterbuck along the Chobe river, Botswana. *East African Wildlife Journal* **15**: 91-97.
Study comparing nutritive values of various grasses and herbs, and grazing selection, by 3 antelope species on floodplain grassland in N Botswana.
UZam, Botswana, Chobe, ecology, Lmammals, plants

930. Von Richter, W. and Passineau, J. (1979). Endangered wildlife species in Botswana. *Botswana Notes & Records* **11**: 21-125.
Summarises status of threatened populations of birds and mammals in Botswana. 20 species are mentioned, 4 of which are closely associated with wetlands.
UZam, Botswana, conservation, Lmammals

931. Vostradovsky, J. (1984). Fishery investigations on Cahora Bassa reservoir (March 1983-May 1984). FAO/GCP/MOZ/006/SWE Field Document No.11. FAO, Rome, Italy. 30 pp.
Consultants' report on fish biology in Lake Cabora Bassa. Particular reference is given to kapenta.
MZam, Mozambique, Cabora, fisheries, water quality, fish

932. Vostradovsky, J. (1986). On the ichthyofauna and possibilities of fishery utilisation of the Cahora Bassa reservoir on the Zambezi river (1983-1984 period). *Prace VURH Vodnany* **15**: 3-20.
Lists the fish species caught in Cabora Bassa 8-9 years after its creation, with some data on their relative abundance.

MZam, Mozambique, Cabora, fisheries, fish

933. Wackernagel, A. (1993). *Elephants and vegetation: severity, scale and patchiness of elephant impact along the Linyanti River, Chobe District, Botswana*. MSc thesis, University of Witwatersrand. Johannesburg, South Africa.
Not seen.
UZam, Botswana, Chobe, vegetation, environmental assessment, ecology, Lmammals

934. Weare, P.R. and Yalala, A. (1971). Provisional vegetation map of Botswana. *Botswana Notes and Records* **3**: 131-147.
A revised vegetation map (at scale 1:3 million) of Botswana compiled from previous surveys. There are 29 vegetation types, grouped into 9 physiognomic classes. The Chobe/Linyanti area, including the riparian strips, is described as swamp grassland (type 6b), with dense stands of Phragmites communis, Cyperus haspan and C. papyrus. Hyphaene and Ficus verruculosa can be found on islands.
UZam, Botswana, vegetation

935. Weis, G.F. (1970). Report to the Government of Zambia in fishery development in the central Barotse floodplain. FAO/UNDP Report T.A. 2816. Rome, Italy. 19 pp.
Not seen.

UZam, Barotse, Zambia, fisheries

936. Wellington, J.H. (1954). The significance of the middle courses of the Zambesi and Limpopo rivers and their relations with the Moçambique plain. *South African Journal of Science* **50**(7): 182-185.
Not seen.
Zbasin, palaeogeography

937. Welsh, H. (1965). A contribution to our knowledge of the blue-green algae of South West Africa and Bechuanaland. *Nova Hedwigia* **9**: 131-162.
Not seen.
UZam, Namibia, Botswana, phytoplankton

938. Werger, M.J.A. and Coetzee, B.J. (1978). The Sudano-Zambezian region. In: *Biogeography and Ecology of Southern Africa* (edited by Werger, M.J.A.). W. Junk, The Hague, Netherlands. ISBN 90-6193-083-9. pp.301-462.
Comprehensive review of vegetation and ecology of a significant part of the Zambezi basin. Various factors affecting plant and vegetation distribution are discussed. Brief descriptions are given of the vegetation of the Zambezi floodplain and dambo grasslands, and also of the Zambezi and Luangwa valleys, the central African plateau, and the Zambezi delta.
Zbasin, biogeography, ecology, vegetation, plants

939. Wessels, C.L., Tannock, J., Balke, D. and Phelps, R.J. (1977). Chlorinated hydrocarbon insecticide residues in *Crocodilus niloticus* Laurente eggs from Lake Kariba. *Transactions of the Zimbabwe Scientific Association* **60**(3): 11-17.
Study shows persistent pesticide residues in the eggs of Lake Kariba crocodiles at a level normally associated with reproductive failure.
MZam, Zimbabwe, Kariba, pollution, reptiles

940. Whellan, J.A. (1975). The Acridoidea of Malawi: an annotated check list. *Acrida* **4**(2): 105-122.
Checklist of 135 species of grasshopper from Malawi. Only a few records are from the lower Shire.
Zbasin, checklist, Malawi, insects

941. White, C.M.N. (1956). Northern Rhodesian butterflies. *Northern Rhodesia Journal* **3**: 14-21.
Briefly annotated list of some butterflies collected in Zambia, with many from the upper Zambezi area. 48 species are listed.
Zbasin, UZam, checklist, Zambia, insects

942. White, C.M.N. and Ansell, W.F.H. (1966). A list of Luvale and Lunda mammal names. *The Puku* **4**: 181-185.
Local names for 93 medium and large size mammal species from North Western Province, Zambia.
UZam, Barotse, survey, Zambia, Lmammals, Smammals

943. White, F. (1962). *Forest Flora of Northern Rhodesia*. Oxford University Press, Oxford, UK.
Descriptive account with keys of all the 1525 woody plant species of Zambia.
Zbasin, checklist, Zambia, plants

944. White, F. (1965). The savanna woodlands of the Zambezian and Sudanian domains: an ecological and phytogeographical comparison. *Webbia* **19**: 651-681.
An important attempt to determine phytogeographical relations in the Zambezian region. Within the Zambezian Domain (covering the complete Zambezi Basin) a Barotse centre (characterised by Baikiaea plurijuga) and a Kariban centre (characterised by Triplochiton) are recognised. A Katangan centre (characterised by Diospyros mweroensis) is recognised at the headwaters of the Zambezi. Other characteristic species of these centres are listed. Within the Zambian woody flora, 61 species are confined the Zambezi valley or its major tributaries.
UZam, survey, Zbasin, biogeography, vegetation, plants

945. White, F. (1968). Zambia. In: *Conservation of Vegetation in Africa South of the Sahara. Proceedings of a symposium held at the 6th AETFAT Congress, Uppsala, September 12-16 1966* (edited by Hedberg, I. and Hedberg, O.). Acta Phytogeographica Suecia No. 54. Almqvist & Wiksells, Uppsala, Sweden. pp.208-215.
Brief account of the vegetation of Zambia, including the Zambezi wetlands.
Zbasin, Zambia, vegetation, conservation, plants

946. White, F. (1976). The underground forests of Africa: a preliminary review. *Gardens' Bulletin, Singapore* **29**: 57-71.
Account of the group of geoxylic suffrutex plants with massive woody underground stems that are characteristic of the poorly drained grasslands of the Zambezian floral region, particularly on the Kalahari sands in Barotseland. A list of species and their tree/shrub relatives is given. These species are typically found on dambo margins. The importance of these species and how they evolved is discussed. Fire and frost are not thought to be major factors.

UZam, checklist, Zbasin, biogeography, vegetation, plants

947. White, F. (1983). *The Vegetation of Africa: a descriptive memoir to accompany the UNESCO/AETFAT/UNSO vegetation map.* Natural Resources Research 20. UNESCO, Paris, France. ISBN 92-3-101955-4. 356 pp.
Definitive account of the vegetation of Africa. Contains detailed accounts of the vegetation and plant species composition of various vegetation types. Wetland vegetation, which is often too small to be adequately mapped, is described under mangroves, herbaceous freshwater swamp and aquatic vegetation. The Barotse plains are mapped as edaphic grassland mosaic with semi-aquatic vegetation (type 64). The Busango, Kafue and Lukanga swamps are also mapped as edaphic grassland mosaic with semi-aquatic vegetation, but with the addition of herbaceous swamp and aquatic vegetation (type 75) in the centre of the Lukango swamps, and a mosaic of dry deciduous forest and secondary grassland (type 22) in the centre of the Kafue Flats. The Zambezi delta is mapped as Zanzibar-Inhambane East African coastal mosaic (type 16a), with mangroves (type 77) on the coast.
SAfrica, survey, vegetation, biogeography, ecology, plants

948. Wild, H. and Barbosa, L.A.G. (1967). Vegetation map of the Flora Zambesiaca region. M.O. Collins, Harare, Zimbabwe. 71 pp. Supplement to Flora Zambesiaca, plus 2 maps.
Descriptions of vegetation types of Zambia, Botswana, Zimbabwe, Malawi and Mozambique with accompanying colour map at 1:2.5 million scale, based on previous surveys. There are 74 vegetation types, grouped into 9 physiognomic types. The Chobe/Linyanti swamps are classified as Loudetia grassland on Kalahari sands (type 65), with small unmapped areas of papyrus sudd (type 64), as are the Barotse floodplains. Loudetia simplex is the main grass, replaced by Tristachya on the Silowana Plains. Vetiveria nigritana marks the alluvial banks. The upper Kafue Flats are classified as Loudetia grassland, while the lower swamps are described as edaphic or secondary plateau grassland with Hyparrhenia (type 67). On the Chambeshi floodplain the major grasses are Hyparrhenia gazensis, Paspalum commersonii, Digitaria scalarum, Loudetia simplex and Themeda triandra. On other floodplains Acroceras macrum, Echinochloa haploclada, Sacciolepis and Estolasia imbricata are dominant. The Lukanga swamps are described as papyrus sudd (type 64) surrounded by Hyparrhenia grassland (67). The swamps of the lower Shire valley in Malawi are described as papyrus sudd (64), but formations on alluvium (type 54) in Mozambique. Sudd consists of Cyperus papyrus, other Cyperus spp. and Phragmites reed beds. In the Shire valley Vossia cuspidata and Echinochloa pyramidalis are important. The Zambezi delta is described as formations on alluvium (54) with inclusions of coastal thicket of Mimusops caffra (type 14b) on the dunes at the coast and fringing Rhizophora mangroves (type 14a). Type 54 is quite varied, and is difficult to typify. The delta near Quelimane has extensive groves of coconut.

survey, Zbasin, vegetation, plants

949. Williams, A.J. (n.d.). Popular checklist of the birds of South West Africa/Namibia. Unpublished report. Department of Agriculture & Nature Conservation, Windhoek, Namibia.
Lists 617 bird species from Namibia.
Zbasin, checklist, Namibia, birds

950. Williams, A.J. (1991). Wetland birds and conservation in Namibia: an overview. *Madoqua* **17**(2): 245-248.
Review of birds associated with Namibian wetlands. Of 620 birds found in the country, 167 (27%) are wholly dependent on wetlands. A high proportion of these are endangered owing to habitat destruction. Of particular concern are the Slaty Egret (a near-endemic) and the Wattled Crane.
Zbasin, Namibia, conservation, birds

951. Williams, G.D., Coppinger, M.P. and Maclean, G.L. (1989). Distribution and breeding of the Rock Pratincole on the upper and middle Zambezi river. *Ostrich* **60**: 55-64.
Study on the Rock Pratincole from the Zambezi source to the Luangwa confluence. Distribution is related to suitable breeding (rocky) habitat. A total of 1938 were seen, principally in lower Barotseland, Kazungula to Kariba, and Kariba to Kanyemba.
UZam, MZam, survey, birds

952. Williams, G.J. and Howard, G.W. [editors] (1977). *Development and Ecology in the Lower Kafue Basin in the Nineteen Seventies. Proceedings of a National Seminar on Environment and Change.* Kafue Basin Research Committee, Lusaka, Zambia.
Not seen.
UZam, Zambia, Kafue, environmental assessment, ecology

953. Williams, J. (1987). Wattled Crane survey in Caprivi. *Quagga* **18**: 22-23.
Only 11 were estimated by aerial sampling in the Linyanti swamp in July 1986. In the Lupala-Nkasa Island section in June 1986, 25 adults were seen.
UZam, survey, Namibia, Chobe, birds

954. Williams, R.E. (1971). Fish ecology of the Kafue river and flood plain environment. *Fisheries Research Bulletin, Zambia* **5**: 305-330.
Study on the fish and fish ecology of the Kafue basin. The importance of seasonal flooding is stressed, and this will be greatly modified by proposed dams. Fish migrate from the river to the floodplain when the waters rise, and their life cycle and breeding is closely related to this. The effects on fisheries are discussed. Lists of 53 fish species and 25 fish-eating birds are given.
UZam, checklist, Zambia, Kafue, fisheries, ecology, environmental assessment, birds, fish

955. Williamson, D.T. (1979). *An outline of the ecology and behaviour of red lechwe (*Kobus leche leche *Gray 1850)*. PhD thesis, University of Natal. Pietermaritzburg, South Africa.
Not seen.
UZam, Botswana, Chobe, ecology, Lmammals

956. Williamson, D.T. (1981). The status of red lechwe in the Linyanti swamp. *Botswana Notes & Records* **13**: 101-105.
Brief account of the population structure and status of red lechwe, indicating a declining population.
UZam, Botswana, Chobe, conservation, ecology, Lmammals

957. Williamson, D.T. (1986). Notes on the sitatunga in the Linyanti Swamp, Botswana. *African Journal of Ecology* **24**: 293-297.
Brief account of sitatunga - habitat, locomotion, activity, group size and behaviour.
UZam, Botswana, Chobe, ecology, Lmammals

958. Williamson, D.T. (1990). Habitat selection by red lechwe (*Kobus leche leche* Gray, 1950). *African Journal of Ecology* **28**: 89-101.
Account of habitat use by red lechwe in the Linyanti swamp, Botswana. Selection of feeding sites was probably related to grass quality.
UZam, Botswana, Chobe, ecology, Lmammals

959. Williamson, D.T. (1994). Social behaviour and organization of red lechwe in the Linyanti Swamp. *African Journal of Ecology* **32**: 130-141.
Account of behaviour of red lechwe in the Chobe area. Mating systems of Kafue and red lechwe differ.
UZam, Botswana, Chobe, ecology, Lmammals

960. Willoughby, N.G. (1979). The development and management of the Shire Valley fishery, Malawi, southern Africa. In: *Proceedings of the International Conference on Kainji Lake and River Basin Development in Africa, Ibadan, Nigeria, December 1977*. Kainji Lake Research Institute, New Bussa, Nigeria. pp.278-287.
Not seen. May contain data on fishes of the lower Shire river and marshes.
LZam, Malawi, LShire, fisheries, fish

961. Willoughby, N.G. and Tweddle, D. (1977). The fish and fisheries of the R. Mwanza, Malawi. Unpublished report. Fisheries Department, Lilongwe, Malawi. 5 pp.
Not seen.
LZam, Malawi, LShire, fisheries, fish

962. Willoughby, N.G. and Tweddle, D. (1978). The ecology of the catfish *Clarias gariepinus* and *Clarias ngamensis* in the Shire Valley, Malawi. *Journal of Zoology* **186**: 507-534.
Study of two commercially important fish species in the Elephant Marsh, Malawi. Abundance, distribution and movements were investigated, and growth rates determined. Breeding seasons, length and age at maturity and fecundity are given. Comparison of stomach contents provides data on feeding preferences.
LZam, Malawi, LShire, ecology, fish

963. Willoughby, N.G. and Tweddle, D. (1978). The ecology of the commercially important species in the Shire Valley fishery, Malawi. CIFA Technical Paper No. 5. FAO, Rome, Italy. pp.137-152.
Review of the biology of the major 5 economically-important fish species found in the lower Shire, focussing on Elephant Marsh. Most of the life cycle is subject to seasonal drying of swamps; breeding occurs during high water.

LZam, Malawi, LShire, ecology, fisheries, fish

964. Willoughby, N.G. and Walker, R.S. (1977). The traditional fishery of the lower Shire valley, Malawi. CIFA Technical Paper No.5. FAO, Rome, Italy. pp.288-295.
Not seen.
LZam, Malawi, LShire, fisheries, fish

965. Wilson, J.G.M. and van Zegeren, K. (n.d.). Birds of Lake Chilwa: a systematic annotated checklist. Unpublished report, Zomba, Malawi.
Not seen.
checklist, Malawi, LChilwa, birds

966. Winemiller, K.O. (1991). Comparative ecology of *Serranochromis* species (Teleostei: Cichlidae) in the Upper Zambezi River floodplain. *Journal of Fish Biology* **39**: 617-639.
Account of 9 species of cichlid fish in the upper Zambezi, covering size distribution within populations, habitat preferences, breeding seasons, fecundity, growth and feeding habits.
UZam, Barotse, Zambia, ecology, fish

967. Winemiller, K.O. and Kelso-Winemiller, L.C. (1993). Description of a new *Neolebias* species (Pisces, Distichodontidae) from the upper Zambezi drainage of Zambia. *Copeia* **1993**: 112-116.

Describes a recently discovered fish species.
Zambia, UZam, Barotse, fish

968. Winemiller, K.O. and Kelso-Winemiller, L.C. (1994). Comparative ecology of the African pike, *Hepsetus odoe*, and tigerfish, *Hydrocynus forskahlii*, in the Zambezi River floodplain. *Journal of Fish Biology* **45**: 211-225.
Account of 2 species of predatory fish in the upper Zambezi, covering population structure, habitat preferences and feeding habits.
Zambia, UZam, Barotse, ecology, fish

969. Winemiller, K.O. and Kelso-Winemiller, L.C. (1996). Comparative ecology of catfishes of the Upper Zambezi River floodplain. *Journal of Fish Biology* **49**: 1043-1061.
Account of 16 species of catfish from the Barotse floodplain. Species fell into four feeding guilds - large carnivores, medium-sized carnivores, medium-sized omnivores and small omnivores. Two species may have declined through over-exploitation.
Zambia, UZam, Barotse, human use/impact, ecology, fish

970. Winterbottom, J.M. (1942). A contribution to the ornithology of Barotseland. *Ibis (14th series)* **6**: 18-27, 337-389.
Account of the Barotseland area, including a brief zoogeographical analysis, followed by an annotated checklist of 264 bird species including 69 waterbirds.
checklist, UZam, Barotse, Zambia, biogeography, birds

971. Winterbottom, J.M. (1943). On the avifauna of the Barotse plain. *Ostrich* **14**: 78-88.
Account of the birds of the Barotse floodplain from Lukulu to Senanga. Bird groups are discussed on the basis of 123 lists made (not presented).
UZam, Barotse, Zambia, birds

972. Winterbottom, J.M. (1954). An expedition to western Shesheke. *Bokmakierie* **6**(2): 39.
Not seen.
UZam, Zambia, Barotse, birds

973. Winterbottom, J.M. (1971). A preliminary check list of the birds of South West Africa. SWA Scientific Society, Windhoek, Namibia.
Lists 576 bird species from Namibia.
Zbasin, checklist, Namibia, birds

974. Wood, P.A. and Tree, A.J. (1992). Zambezi River survey, 1991. *Honeyguide* **38**: 54-63.
Survey down the Zambezi from Kariba to Kanyemba on the Zimbabwe side including data on 5 species of waterbirds.

MZam, Mana, survey, Zimbabwe, birds

975. Worsley, S. (1988). Vegetation survey of the Matetsi complex. Unpublished manuscript + map. Department of National Parks, Harare, Zimbabwe.
Account of the vegetation of much of the NW corner of Zimbabwe.
UZam, survey, Zimbabwe, vegetation

976. Wright, P.J. (1966). A note on the Wattled Crane (*Grus carunculatus*). *The Puku* **4**: 196-198.
Brief note on behaviour of Wattled Crane in the N Kafue NP, Zambia.
UZam, Kafue, Zambia, birds

977. Young, E.D. (1868). *The Search After Livingstone*. Letts, Son & Co., London, UK. 262 pp.
Includes reports of teeming wildlife along the lower Shire valley, but little in Elephant Marsh. Human populations were large.
LZam, Malawi, LShire, history

978. Young, E.D. (1877). *Nyassa: a journal of adventures whilst exploring Lake Nyassa, Central Africa, and establishing the settlement of Livingstonia.* John Murray, London, UK. 239 pp.
8 years after Young (1868), going through the same area, he refers to increased settlement and little wildlife. This could be due to cessation of warring activities by the advent of the British.
LZam, Malawi, LShire, LMalawi, history

979. Zaranyika, M., Mambo, F. and Makhubalo, E. (1994). Organochlorine pesticide residues in the sediments of selected river bays in Lake Kariba, Zimbabwe. *Scient. Tot. Environment* **142**: 221-226.
Study shows the presence of organochlorine residues in inshore sediments associated with river draining.
MZam, Zimbabwe, Kariba, pollution