The IUCN Species Survival Commission

The Status and Distribution of Freshwater Biodiversity in Eastern Africa

Compiled by W. Darwall, K. Smith, T. Lowe and J.-C. Vié

Occasional Paper of the IUCN Species Survival Commission No. 31

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Dedication

We would like to dedicate this work to the memory of Dr. Luc De Vos who sadly passed away shortly after the beginning of the project. Luc (Tuur) was employed by the project as one of Africa's foremost ichthyologists. His passing is a great loss to the field of ichthyology and he will be missed by many.

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Executive Summary

Biodiversity within inland water ecosystems in Eastern Africa is both highly diverse and of great regional importance to livelihoods and economies. However, development activities are not always compatible with the conservation of this diversity and it is poorly represented in the development planning process. One of the main reasons for inadequate representation of biodiversity is cited as a lack of readily available information on the status and distribution of inland water taxa. In a response to this need for information, the IUCN/SSC Freshwater Biodiversity Assessment Programme conducted a regional assessment of over 1,600 taxa of freshwater fishes, molluscs, odonates and crabs from Burundi, Kenya, Malawi, Rwanda, Tanzania and Uganda. In the process of the study, which is based on the collation and analysis of existing information, regional experts from five of these countries were trained in biodiversity assessment methods and, where appropriate, in field assessment and taxonomy. Distribution ranges have been mapped for the majority of species so providing an important tool for application to the conservation and development planning process. The full dataset is to be made freely available through the internet and through distribution on CD-ROM.

Levels of regional endemism are notably high with 82% of fish and 74% of molluscs restricted to the region. Species diversity is also high and the major centres of diversity are the African Great Lakes of Malawi/Nyassa/Niassa, Tanganyika and Victoria, and in the Eastern Arc Mountain Range (for Odonata).

Major threats are identified as loss and degradation of habitat, in particular from sedimentation due to deforestation and eutrophication, and the introduction of alien species. The centres of threatened species are the African Great Lakes and a number of East Coast river drainages. A major concern for the future is the potential impact of water resource developments such as for improved water supply, irrigation and provision of hydro-electric power.

A gaps analysis found that inland waters are poorly protected within the existing Protected Areas network which is largely focused on terrestrial ecosystems. Forest Reserves were, however, observed to provide effective protection of watersheds at the headwaters of some river systems; it is recommended that their legal status be raised to provide a greater incentive for their effective management and for increasing the potential for attracting funds.

Finally, it is most important that the data from this study are made available to the relevant decision makers and stakeholders in a format that can be easily understood and readily integrated within the decision making process. With this in mind a second major project has been initiated to extend the work to the rest of Africa and to develop a series of "Best Practice Guidelines" for the integration of biodiversity information within the development process.

Chapter 1

Background

The goods and services derived from inland waters have an estimated global value of several trillion US$ and include essential products such as food and drinking water in addition to providing less measurable services such as water filtration and flood control (Postel and Carpenter 1997). Despite their clear economic value many inland water ecosystems, especially wetlands, have long been considered a wasteful use of land and are rarely protected. Lack of recognition for the value of these systems has already led to the loss many of the world's wetlands and rates of species loss have, in some cases, been estimated at five times greater than those seen in other ecosystems (e.g., Myers 1997; Ricciardi and Rasmussen 1999).

With global development objectives firmly focused to deal with the world's freshwater supply crisis, and with the Millennium Development Goals (MDGs) set to halve the number of people without access to safe drinking water and sanitation by the year 2015 (see http://www.un.org/milleniumgoals/), the stage is set for a potential large-scale impact to freshwater biodiversity. In Africa access to water supply needs to be extended to an additional 350 million people and sanitation to an additional 363 million people (Yahaya 2004). An immediate initiative is required to assess the status of freshwater biodiversity and to integrate that information within the water development planning process. Without this baseline information it will be difficult to avoid a significant impact to freshwater biodiversity, the potential loss of livelihoods, and a decline in those national economies dependant on biodiversity goods and services. The outputs of the project presented here are a major step towards fulfilling that requirement for Eastern Africa, a region with great problems of water scarcity and lack of supply, huge dependence on freshwater biodiversity products, and widely dispersed, largely inaccessible, information on freshwater biological diversity.

1.1 Global status of freshwater biodiversity

1.1.1 Species diversity

Recent estimates place 44,000 of the world's 1,868,000 described species as coming from freshwater ecosystems (Reaka-Kudla 1997). This figure may seem small compared to other ecosystems but considering that these ecosystems occupy only 0.8% of the Earth's surface it translates into an incredibly species-rich group of habitats. An estimated 12% of all animal species live in freshwater, representing approximately 42% of the world's fishes and 25% of the world's molluscs (McAllister *et al.* 1997; Froese and Pauly 2004). With the continuing description and discovery of more freshwater fish each year it is now estimated that there are over 12,000 primary freshwater species and a

J.-C. Vié

A major cause of wetland loss has been through conversion to agriculture, such as for rice farming.

further 2,680 brackish or diadromous species (Froese and Pauly 2004). Endemism is also unusually high in some habitats with, for example, in Eastern Africa 632 endemic animal species recorded in Lake Tanganyika, and in South America an estimated 1,800 species of fish endemic to the Amazon River basin (Darwall and Revenga in press).

1.1.2 Major threats to freshwater species

A number of reviews have shown that habitat loss and degradation, water withdrawal, overexploitation and pollution, and the introduction of non-native species are the leading causes of freshwater species decline and ecosystem degradation (e.g., Abramovitz 1996; McAllister *et al.* 1997; Groombridge and Jenkins 1998; Revenga *et al.* 2000; Revenga and Kura 2003; Ellison 2004). Rarely, however, do these threats occur singly; with most threatened species subjected to multiple interacting stresses (Miller *et al.* 1989; Harrison and Stiassny 1999; Malmqvist and Rundle 2002). The major drivers for these threats stem from the ever increasing demand for water by the human population, be it for irrigation, production of hydro-electric power, or domestic or industrial water supply. Globally, it has been estimated that such activities have led to a 50% loss in wetland habitats in the last century (e.g., Duggan 1990). This figure still needs supporting evidence but it is clear that such high rates of wetland loss are even exceeded in some countries such as the USA where the scale of loss between 1986 and 1997 has been estimated at 80% (Dahl 2000). Should these development activities proceed without integration of biodiversity considerations within the planning process the livelihoods of the very same people targeted to benefit from such actions may be damaged as freshwater biodiversity resources are simultaneously lost through degradation of wetland ecosystems.

1.1.3 Species threatened status

The change in status of threatened species is one of the most widely used indicators for assessing the condition of ecosystems and their biodiversity, and has been identified for immediate testing by the Convention on Biological Diversity (CBD) as one of the main indicators for monitoring progress towards the 2010 targets for reduction of biodiversity loss. It also provides an important tool in priority setting exercises for species conservation. At the global level the best source of information on the threatened status of plants and animals is the *IUCN Red List of Threatened Species* (IUCN – The World Conservation Union 2004) (hereafter cited as the IUCN Red List). The IUCN Red List provides information on a species taxonomy, habitat preferences, conservation priorities, distributions, threats and threatened status, as assessed using the *IUCN Red List Categories and Criteria: Version 3.1* (IUCN 2001). This system is designed to determine the relative risk of extinction, with the main purpose of cataloguing and highlighting those taxa that are facing a higher risk of global extinction (i.e., those listed as Critically Endangered, Endangered or Vulnerable).

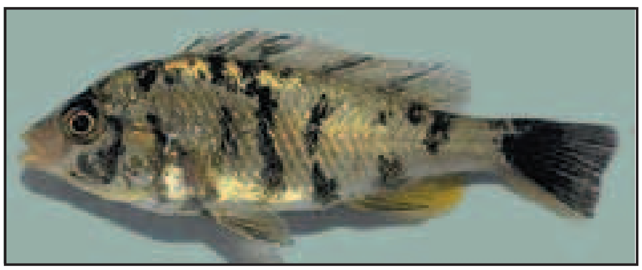
For inland waters the coverage of species assessed for the IUCN Red List is still very poor. Nonetheless, it is clear that of those species that have been assessed a disproportionately high number are threatened with extinction. In 1998 an average of 17% of freshwater fish species in the 20 countries for which assessments were

N. Roettcher

Traditional swamp fishery in Southern Sudan.

Table 1.1. Estimated numbers of extant inland water dependent species and the number of these that are at risk of extinction according to the 2003 IUCN Red List. Only birds and mammals have been fully assessed. Only a small proportion of other taxa have been assessed. DD = Data Deficient and refers to the number of species assessed for which there were insufficient data to assign a threat category (Revenga and Kura 2003; Groombridge and Jenkins 1998; with assistance from Wetlands International, and the IUCN Red List Programme; see also http://www.globalamphibians.org).

Taxon	Estimated total number of inland water-dependent species or subspecies	Estimated percentage assessed for the 2003 IUCN Red List	Number of species assessed as threatened (2003 IUCN Red List)
Plants	??	<0.1%	16 (DD: 0)
Insects	>125,000	<0.1%	126 (DD: 12)
Molluscs	>6,000	<15%	421 (DD: 96)
Crustaceans	>4,000	<12%	409 (DD: 32)
Fishes	>14,000	<10%	610 (DD: 231)
Reptiles	169	<64%	109 (DD: 11)
Amphibians	3,908	<10%	143 (DD: 74)
Waterbirds	868	100%	79 (DD: 1)
Mammals	c.135	100%	42 (DD: 11)



Haplochromis Ecology Survey Team

Haplochromis (*Paralabidochromis*) *chromogynos*, a haplochromine cichlid endemic to Lake Victoria.

most complete were classified by IUCN as threatened (Groombridge and Jenkins 1998). Fifty-four percent of freshwater fishes endemic to Madagascar are threatened, representing the highest level of threat to any taxonomic group in the 2004 IUCN Red List. Table 1.1 provides an estimate of the percentage of all inland water taxa assessed for the 2003 IUCN Red List and the number of species classified as threatened. Table 1.2 demonstrates the small proportion of Eastern African species assessed and the unusually high level of threat to those species. It is clear, however, that the apparent high levels of threat are partly due to past bias in selecting those species already known to be threatened, such as the endemic haplochromine cichlids in Lake Victoria. A more comprehensive assessment was required to determine the true regional levels of threat to these taxa.

Table 1.2. Estimated numbers of inland water-dependent species in Eastern Africa assessed for the 2003 IUCN Red List and the percentage assessed as threatened or Extinct. DD = Data Deficient which refers to the number of species assessed for which there were insufficient data to assign a threat category (IUCN 2003).

Taxon	Number species assessed	Percentage threatened or Extinct
Plants	0	–
Insects	2	100%
Molluscs	58	90% (plus 2% DD)
Crustaceans	11	55% (plus 45% DD)
Fish	100	87%
Reptiles	7	29% (plus 14% DD)
Amphibians	1	100% (Extinct)
Waterbirds	6	33%
Mammals	19	21% (plus 10% DD)

The global scale of threat to inland water species is further highlighted by a reported population decline in almost all of the 200 freshwater, wetland, and water margin vertebrate species examined in a study by UNEP-WCMC (Groombridge and Jenkins 1998). The *Living Planet Report 2004* (WWF 2004) Freshwater Species Population Index, based on trend information for 323 vertebrate species populations, showed that these populations declined by about 50% between 1970 and 2000 – the most rapid decline of the three ecosystems assessed. As a final example from a better known taxonomic group, 35% of the 297 taxa of freshwater mussels in North America have been listed under the United States Endangered Species Act as Extinct or Endangered, or were candidates for listing as Endangered (Kay 1995).

1.2 Situation analysis for Eastern Africa

The inland waters of Eastern Africa are internationally recognised for their high levels of species richness and endemism, particularly within the Rift Valley lakes. The freshwater fisheries supported by this diversity are almost entirely artisanal, providing income and food security to a large portion of the poorer communities. The following examples help to demonstrate this high level of regional dependence. In Malawi it is frequently stated, (e.g. FAO 1996), that 70% of dietary animal protein is derived

W. Darwall

The sub-littoral habitat typical of Lake Tanganyika which is home to many endemic fish and mollusc species.

T. Twongo

Nile perch, *Lates niloticus*, introduced to Lake Victoria.

W. Darwall

Chiramila fishing nets, Lake Malawi.

from fish, and the fishery sector is thought to constitute a major source of income and livelihood for more than 300,000 people. Over one million people are dependent upon the fisheries from Lake Tanganyika (see http://www.ltbp.org/) and Lake Victoria's fisheries provide protein for the eight million people along the lake's shore and support over 100,000 fishermen (see http://www.lvemp.org/). Disruption of the fisheries in Lakes Tanganyika and Victoria through loss of biodiversity attributed to overfishing, eutrophication, and the introduction of alien species has already led to significant loss of jobs, livelihoods and food security (Abila 2000; West 2001). In the river basins and flood plains of the Lower Rufiji and Kilombero Rivers in Tanzania an estimated 50,000 men participate in capture fisheries (Mwalyosi 1990) which may be threatened by the 22 potential major hydro-electric power sites already identified in the Rufiji Basin. Information on the associated biodiversity must be integrated into the planning process if these impacts are to be avoided or minimised. However, as for the rest of Eastern Africa, existing information on aquatic biodiversity is widely dispersed, disorganised, and is largely inaccessible to decision makers and for effective integration within expanding water development plans.

In addition to direct impacts such as from fishing and introduced species a potential threat to freshwater biodiversity in Eastern Africa is the indirect impact of the increasing numbers of projects designed to increase access to safe drinking water and sanitation. For example, in Eastern Africa the demand for water is expected to increase dramatically in the immediate future as populations rise and countries work towards meeting the MDGs. Population growth projections for Eastern Africa are particularly high (Table 1.3) with all countries having growth rates of at least 1.4% rising to a maximum of 2.4% in Uganda. These growth rate projections are all higher than the global average of 1%. Eastern African countries have made considerable progress since 1990 in improving access to safe drinking water (Table 1.4). For example, by 2002 73% of people in Tanzania had access to safe drinking water, a 92% increase in access over the period 1990 to 2002. However, the region still has more than 50% of the population without improved sanitation (World Health Organisation and United Nations Children's Fund 2004). Water requirements for irrigation are also likely to increase as countries step up their agricultural production in an effort to reduce the levels of poverty within the region.

Table 1.3. Projected population growth rates (World Bank 2004).

	Total population (millions)		Average annual population growth (%)
	2002	2015	2002–2015
Global	6,198.5	7,090.7	1.0
Burundi	7.1	8.8	1.7
Kenya	31.3	37.5	1.4
Malawi	10.7	13.6	1.8
Tanzania	35.2	43.9	1.7
Uganda	24.6	33.6	2.4

Table 1.4. Percentages of populations with access to safe drinking water (World Health Organisation and United Nations Children's Fund 2004).

	Access to safe drinking water (%)		Increase (%)
Country	1990	2002	1990–2002
Burundi	69	79	14
Kenya	45	62	38
Malawi	41	67	63
Tanzania	38	73	92
Uganda	44	56	27

Fragmentation of habitats and diversion of water resources for development of hydro-electric power presents an additional threat to freshwater biodiversity. Eastern Africa is already heavily reliant upon hydro-electricity. In 2001 57% of electricity for the region was hydro-electric power (see http://www.eia.doe.gov/emeu/ca/eafrica). This high dependence upon hydro-electric power, which relies upon rainfall and is affected by drought, has led to an erratic power supply. Even though the region is trying to reduce its reliance upon hydro-electric power by diversifying sources of energy to include gas and geothermal power plants and through linking up national grids there are still recommendations to expand developments in this sector (World Energy Council 2001) and the potential is huge. For example, it is estimated that the potential power to be generated through hydro-electric projects is 3,000 megawatts (MW) in Uganda, 3,800 MW in Tanzania (see http://www.mbendi.co.za), and 2000 MW in Kenya (see http://www.small-hydro.com). In Uganda there is a controversial private hydro-electric power project (290 MW) planned at Bujagali, which would be East Africa's largest foreign direct investment project. A selection of the many other proposed hydro-electric power projects are in listed in Table 1.5.

In summary, without careful planning development of watercourses for provision of drinking water, sanitation, irrigation and hydro-electric power will impact upon the

Table 1.5. Proposed hydro-electric power projects in Eastern Africa (see http://www.small-hydro.com and http://www.mbendi.co.za). * = Site identified but with no definite development plans; MW = megawatts.

Country	Proposed hydro-electric power projects
Burundi	10 MW Mpanda project 20 MW Kabu 16 project
Kenya	Expand storage capacity of the Masinga Dam Two 30 MW stations at Olkaria Government considering a station in the Lake Victoria area.
Malawi	128 MW Kapichira project 365 MW at various sites including Lower Rufu on the South Rukuru/North Rumphi Rivers.
Tanzania	358 MW Ruhudji project 222 MW Rumakali project 80 MW Masigira project * 160 MW Mpanga project * 1,400 MW Stiglers Gorge project * 180 MW Rusumo Falls project * 40 MW Upper Kihansi project *
Uganda	290 MW Bujagali project 180 MW Karuma Falls project 12 MW Muzizi project

integrity of the dependant wetland ecosystems and their associated biodiversity. Planning to minimise or mitigate for these potential impacts requires integration of reliable information on the distribution, ecology and threatened status of that biodiversity.

1.2.1 Regional value of wetlands and their biodiversity

A key element in promoting the protection of inland waters is the valuation of the goods and services that they provide. As outlined above, freshwater ecosystems provide immense benefits to local and national economies and provide the basis for the livelihoods of many of the worlds poor. Until these benefits are realised, in dollar values, it will remain extremely difficult to convince development planners and politicians of their value and the need to account for biodiversity conservation within the development planning process. It is difficult to quantify, in economic terms, the value of, or the reliance on, wetland goods and services by local communities; many products are consumed within rural households and never enter formal markets. Furthermore, as many of the dependent local communities are among the poorest in the world dollar values for goods and services, when placed in an international economic system, would appear low and would mask the social and even survival benefits they may provide (Emerton *et al*. 1999). In response to this need an increasing number of methodologies and studies have attempted to value wetland biodiversity in Eastern Africa (e.g. Emerton 1998; Turpie and van Zyl 2002; Turpie *et al*. 2003; Turpie *et al*. 2005). For example, the economic costs arising from flood loss and resulting downstream ecosystem degradation by the proposed construction of the Mutonga-Grand Falls Dam on the Tana River in Kenya have been quantified (IUCN Water and Nature Initiative 2003). In this case it was shown that the construction of a single dam would lead to a predicted loss of US$ 19.13 million affecting over 1 million people within the Tana River catchment. The methodology has also been applied in Uganda where economic valuation of the Nakivubo Swamp showed that the wastewater purification and nutrient retention services of the swamp have an economic value of between US$ 1 million and 1.75 million a year (IUCN Water and Nature Initiative 2003). Finally, economic valuation of the wetland biodiversity in the Pangani Basin shows that households derive from US$ 2 in the highlands to US$ 800 per year at the estuary from harvesting wetland products (mostly mangroves, palms and fisheries in the estuary) (Turpie *et al*. 2003; Turpie *et al*. 2005). In the lower delta, harvesting wetland products accounts for much of the annual household income. The wetland valuation methodology employed in these studies would, however, benefit from a more comprehensive source of biodiversity information.

1.3 The precautionary approach to species conservation

Even when the economic value of a wetland and its associated biodiversity has been determined as high in many cases it remains a difficult task to justify the need to conserve all species. This is particularly true where the diversity is already exceptionally high such as in the freshwater fish communities of many of the African lakes. In such cases fishery managers may argue that it would be easier to manage a fishery of just a few fast-growing and commercially valuable species than to manage the multi-species fisheries typical of these lakes. This argument may seem logical but a vivid example for demonstrating the potential value in conserving all species comes from Lake Victoria where the impact of species loss on local livelihoods is clear. Here, introduction of the Nile perch (*Lates niloticus*) and Nile tilapia (*Oreochromis niloticus*) has contributed to the probable extinction or decline of an estimated 200 species of fish that formerly provided the main source of income and protein to many lakeside communities (Witte *et al*. 1992). Clearly the loss of so many species is a disaster but, in studying the patterns of recovery for some species, it has also become more apparent as to why we should take a precautionary approach to species conservation. Research is starting to show that in some cases formerly rare species, once poorly represented in fishery catches, are the species best adapted to the degraded environmental conditions now prevailing in the lake (Witte *et al*. in prep.). A few of these species are starting to dominate in the fish community and may ultimately form the basis for future fisheries. If these species had been lost, having been considered "redundant" and not worthy of conservation, then it is possible that the remaining species would be unable to survive the degraded conditions now prevalent throughout the lake and future fisheries might be lost. The message given here is to adopt the precautionary approach where it is assumed that all species are important and may one day be key components of fisheries or their supporting foodwebs.

1.4 Objectives of the study

IUCN initiated a programme in 2001 to build capacity to conserve and sustainably manage inland water biodiversity resources throughout Eastern Africa (Figure 1.1). Lack of basic information on species distributions and threatened status in these systems has long been a key obstacle facing freshwater ecosystem managers in the region. Specifically, the project aimed to:

i) Provide the required biodiversity information through establishing a regional network of experts and training them in biodiversity assessment tools;
ii) Collate information for assessments of conservation

T. Lowe

Workshop participants, Uganda.

status and distributions of biodiversity throughout the inland waters of Burundi, Kenya, Malawi, Tanzania, Uganda and, for some taxa, Rwanda in Eastern Africa (this pilot study was restricted to those countries for which the aquatic biodiversity was known to be high and for which local dependence on wetland products is also high); and

iii) Store, manage, analyse and make widely available that biodiversity information within the IUCN Species Survival Commission (SSC) data management system, the Species Information Service (SIS), and throughout the region and global presence of the IUCN.

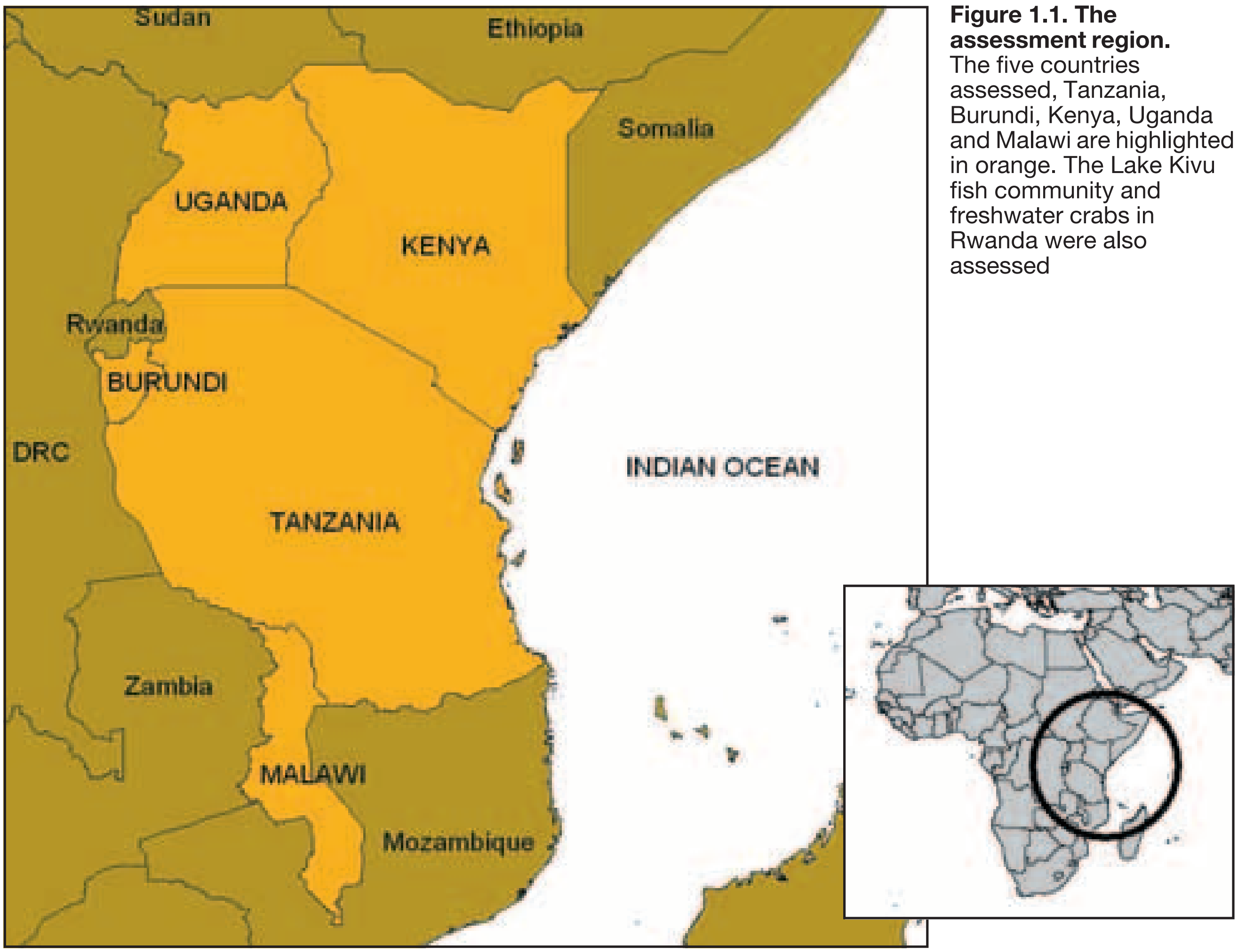


Figure 1.1. The assessment region. The five countries assessed, Tanzania, Burundi, Kenya, Uganda and Malawi are highlighted in orange. The Lake Kivu fish community and freshwater crabs in Rwanda were also assessed

Chapter 2

Assessment Methodology

2.1 Selection of priority taxa

In the majority of cases large-scale biodiversity assessments have focused on a limited range of taxonomic groups most often including those groups that provide obvious benefits to humans through direct consumption, or the more charismatic groups such as the mammals and birds. In the case of aquatic systems it is the wetland birds and fish that have received most attention. It is, however, important that we take a more holistic approach through also collating information to conserve those other components of the foodweb essential to the maintenance of healthy functioning wetland ecosystems, even if they are neither charismatic nor often noticed (especially submerged species). Clearly, it is not practical to assess all species so a number of priority taxonomic groups were selected to represent a range of trophic levels within the foodwebs that underlie and support wetland ecosystems. Priority groups were selected to include those taxa for which there was thought to be a reasonable level of pre-existing information. The taxonomic groups selected were: fin fishes; molluscs; odonates (dragonflies and damselflies); and crabs. Additional work on aquatic plants remains ongoing. Although fishes provide a clear benefit to the livelihoods of millions of people throughout the region, either as a source of income or as a valuable food source, benefits provided by the other taxa may be indirect and poorly appreciated but nonetheless are most important. In all cases these taxa provide essential components of the foodweb supporting the fisheries. Given the wide range of trophic levels and ecological roles encompassed within these four taxonomic groups, it is proposed that information on their distributions and conservation status, when combined, will provide a useful indication of the overall health of the associated wetland ecosystems.

Research diver, Lake Tanganyika.

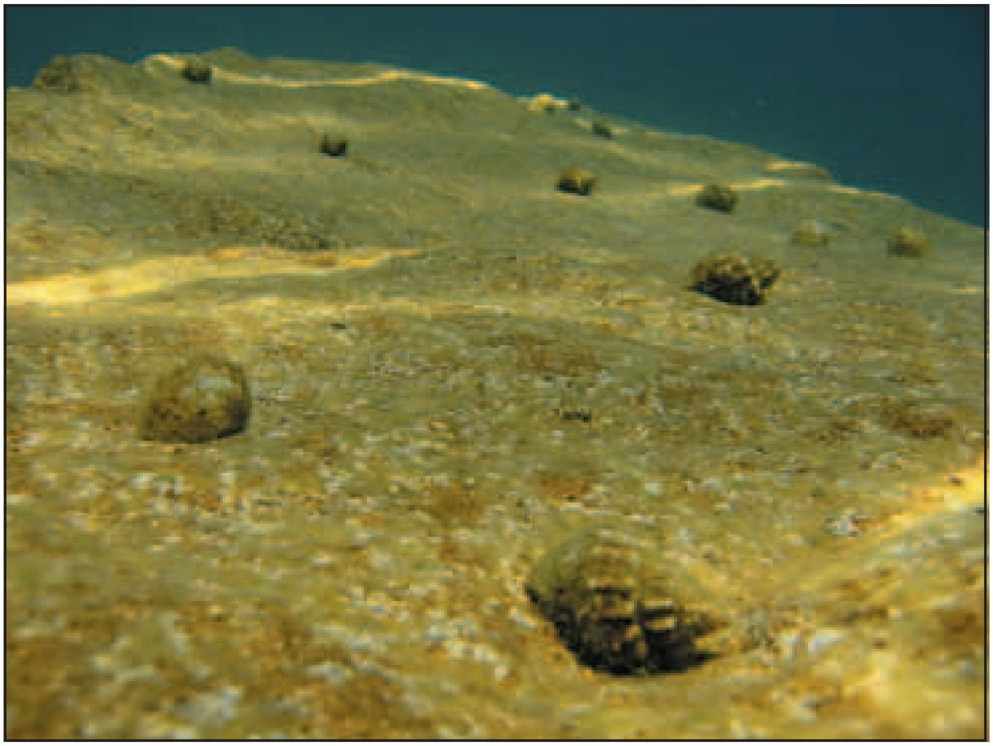
W. Darwall

2.1.1 Fishes

Arguably fishes form the most important wetland product on a global scale providing the primary source of protein for nearly 1 billion people (FAO 2002) and food security for many more (Coates 1995). Some 92% of the recorded inland fisheries catch comes from developing countries and the importance of inland fisheries in Eastern Africa should not be underestimated (e.g. Kamukala and Crafter 1993).

2.1.2 Molluscs

Freshwater molluscs are one of the most threatened groups of freshwater taxa (Kay 1995). They remain fairly unobtrusive, and are not normally considered as being charismatic creatures so rarely attract the attention of the popular media. This is unfortunate as they are essential to the maintenance of wetland ecosystems, primarily through their control of water quality and nutrient balance through filter-feeding and algal-grazing and, to a lesser degree, as a food source for predators including a number of fish species. There are an estimated 7,000 freshwater molluscs for which valid descriptions exist, in addition to a possible additional 10,000 undescribed species. Of these species, only a small number have had their conservation status assessed (less than 15% of freshwater molluscs were assessed for the 2003 IUCN Red List) and their value to wetland ecosystems is poorly appreciated. The impact of developments such as dams has not been adequately addressed and few are aware of the complex life histories of some groups such as unionid mussels that rely on the maintenance of migratory fish runs to carry their parasitic larvae to the river headwaters. For example, the construction of dams has been documented as playing a major role in the extinction of



Lavigeria cornuta grazing algae, Lake Tanganyika.

many of the North American mussels within the last 100 years. Many species are also restricted to microhabitats such as the riffles (areas of fast current velocity, shallow depth, and broken water surface) between pools and runs (areas of rapid non-turbulent flow). The introduction of alien species, wetland drainage and river channelisation, pollution, sedimentation and siltation also impact heavily on unionid mussels.

2.1.3 Odonates

An estimated 500 species of odonates are known from the wider Eastern Africa, ranging from Somalia and Ethiopia in the north, southwards to Mozambique and Zimbabwe, and westwards to the eastern Democratic Republic of Congo and Botswana (Clausnitzer and Jodicke 2004). Although the habitat selection of adult dragonflies strongly depends on the terrestrial vegetation type their larvae develop in water where they play a critical role in regard to water quality, nutrient cycling, and aquatic habitat structure. A full array of ecological types are represented within the group which, as such, has been widely used as an indicator for wetland quality in Europe, Japan, the USA and Australia. A baseline dataset is needed for Eastern Africa to facilitate development of similar long-term monitoring schemes.

Endangered *Platycypha auripes* from the Eastern Arc Mountains of Tanzania.

S. Marijnissen

Platythelphusa tuberculata, endemic to Lake Tanganyika.

2.1.4 Crabs

There are around 100 species of freshwater crab currently recognised from Africa (Dobson 2004) of which over one third are found in Eastern Africa. Most species are associated with flowing water although Lake Tanganyika also supports a number of endemic species (West *et al.* 1991, 2003). Density estimates are highly variable, but they consistently show that crabs make up a very significant proportion of the invertebrate fauna in terms of overall biomass. For example, in the Eastern Usambara Mountains of Tanzania Abdallah *et al.* (2004) estimated overall biomass of crabs to be 88% of the total invertebrate biomass, rising to 94% in debris dams. The overwhelming importance of detritus in the diet of most species suggests that they are key shredders in African rivers. The detritus-shredding guild, apparently almost completely absent from most tropical systems, may be taken up in a large part by crabs in African river systems. This, combined with their general abundance and high biomass, makes them potentially very important to the dynamics of nutrient recycling in African rivers. Crabs also provide a valued food source for a wide range of predators and occasionally form the basis of small-scale fisheries such as in Lakes Malawi/Nyasa/Niassa (hereafter referred to as Lake Malawi) and Tanganyika.

Typical crab habitat. The Lukusi River in Kakemega Forest, Kenya.

M. Dobson

2.2 Species mapping and data analysis

Digitised species distribution maps were initially constructed using the mapping component of the IUCN SSC Species Information Service Data Entry Module. All maps were then edited and standardised within the ArcView GIS software. Additional digital information layers were employed to show river basin boundaries, wetland areas, protected areas, rivers, and locations of major dams. In the case of fishes and molluscs species distribution ranges were mapped to the boundaries of the river basins in which they were recorded. For the lake-dwelling species, where depth related data were available, distributions were mapped to bathymetric (depth) layers. It is recognised that species ranges may not extend throughout a river basin but until this finer spatial detail is provided each species is assumed to have a basin-wide distribution. The available information on crab distributions, largely obtained from museum collections, was limited to point localities.

2.3 Assessment of species threatened status

The risk of extinction for each species was assessed according to the *IUCN Red List Categories and Criteria: Version 3.1* (IUCN 2001). Extinction is a chance process. Thus, a listing in a higher extinction risk category implies a higher expectation of extinction, and over the time-frames specified in the guidelines more taxa listed in a higher category are expected to go extinct than those in a lower one (without effective conservation action). All taxa listed as Critically Endangered, Endangered or Vulnerable are described as threatened. The *IUCN Red List Categories and Criteria: Version 3.1* and the *Guidelines for Application of IUCN Red List Criteria at Regional Levels: Version 3.0* can be downloaded from http://www.iucnredlist.org.

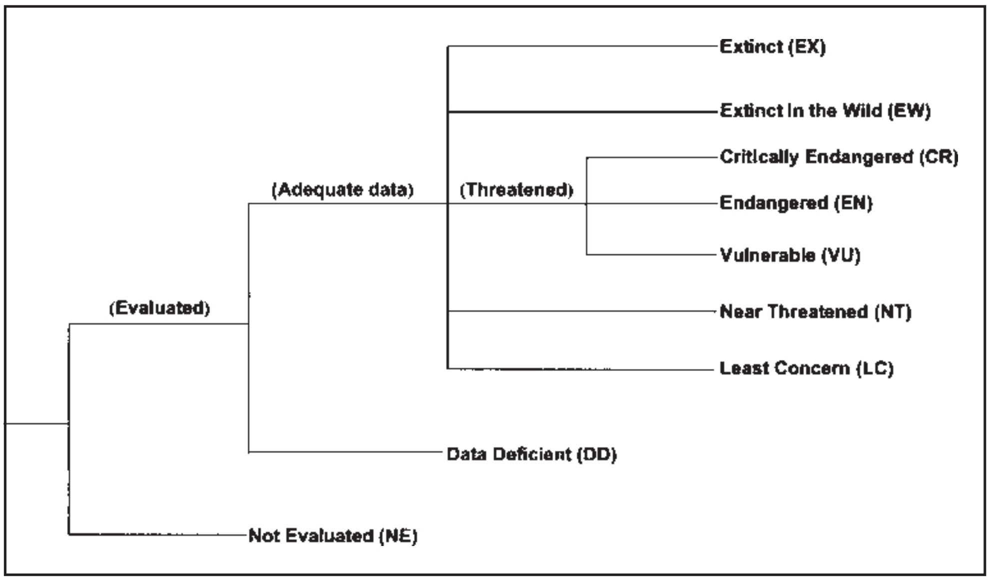


Figure 2.1. Breakdown of the *IUCN Red List Categories and Criteria: Version 3.1*.

Chapter 3

Results

The resulting baseline dataset (available on the accompanying CD) is the most comprehensive yet for Eastern Africa with more than 1,600 taxa assessed and evaluated to date (Tables 3.1 and 3.2). This is the first time the majority of these taxa have been assessed for their Red List threatened status. The dataset is thought to include all known odonates and crabs within the region but may be missing some of the less well-known molluscs and is missing a number of fish species within the family Cichlidae, many of which are still to be described and for which the taxonomy is not yet stable. The number of fish species yet to be described, particularly in the African Great Lakes, is large and most recent suggestions are that there may be up to 1,000 species in Lake Malawi, and more than 500 species in Lake Victoria (prior to the Nile perch introduction) (Snoeks 2000). Species were assessed for both their global and regional Red List status where possible. Regional assessments could not, however, be completed for many of the odonates and some of the crabs as data were not available to evaluate the potential influence of any sub-populations existing beyond the boundaries of the region. Conversely, sufficient information was not obtained to assess the global status of a number of the more widespread fish and a few mollusc species.

3.1 Species threatened status

The breakdown of the Red List threatened status is given for each taxonomic group in Table 3.3. Twenty-eight percent of fishes, 16% of molluscs, 7% of odonates and 54% of crabs are assessed as globally threatened (Figure 3.1).

Table 3.1. Numbers of species assessed within each taxonomic group.

Taxon	Orders	Families	Genera	Species
Fishes	27	41	230	1,090
Molluscs	5	17	65	230
Odonates	1	13	78	304
Crabs	1	3	3	37

Table 3.2. Numbers of species recorded in each country. N/A = not assessed. * In Rwanda only the freshwater crabs and the fish community in Lake Kivu were assessed.

Taxon	Burundi	Kenya	Malawi	Rwanda*	Tanzania	Uganda
Fishes	251	211	419	43	633	125
Molluscs	68	96	40	N/A	145	87
Odonates	4	172	153	N/A	169	229
Crabs	5	13	4	6	23	11
Combined	328	492	616	N/A	970	452

Table 3.3. Summary of Global and Regional assessments of threatened status for each taxonomic group (2001 IUCN Red List Categories and Criteria). The categories are abbreviated as: EX = Extinct; CR = Critically Endangered; VU = Vulnerable; NT = Near Threatened; LC = Least Concern; DD = Data Deficient.

Global Threatened Status (IUCN Red List)

			Threatened species					
Taxonomic group	**Totals**	**EX**	**CR**	**EN**	**VU**	**NT**	**LC**	**DD**
Fishes	901	2	38	37	175	12	564	73
Molluscs	215	0	5	17	13	19	90	90
Odonates	295	0	9	8	4	20	233	21
Crabs	37	0	0	6	14	1	16	0

Regional Threatened Status (IUCN Red List)

			Threatened species					
Taxonomic group	**Totals**	**EX**	**CR**	**EN**	**VU**	**NT**	**LC**	**DD**
Fishes	1,060	2	38	41	204	17	677	81
Molluscs	215	0	5	17	18	22	65	88
Odonates	47	0	9	5	3	10	6	14
Crabs	28	0	0	6	12	1	9	0

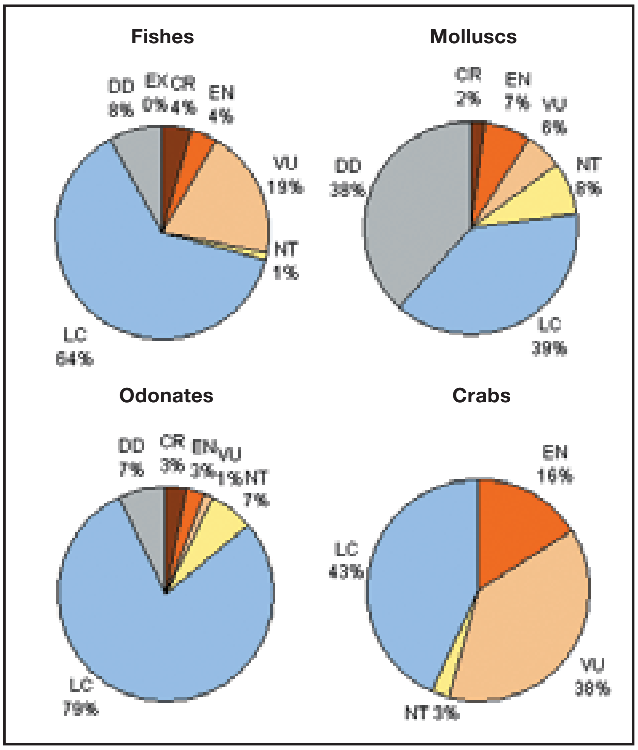


Figure 3.1. Breakdown of the proportions of taxa within each category of globally threatened status (*2001 IUCN Red List Categories and Criteria*). The categories are abbreviated as: EX = Extinct; CR = Critically Endangered; EN = Endangered; VU = Vulnerable; NT = Near Threatened; LC = Least Concern; DD = Data Deficient. The orange to red segments are the threatened species (CR, EN, VU).

3.2 Levels of regional endemism

A notably high proportion of species assessed are endemic to the region (Table 3.4). Such high levels of endemism indicate a significant degree of adaptation to the environmental conditions within the region. It therefore follows that, should these species be lost, alternative replacement species may not be as well adapted to the local conditions.

Table 3.4. Numbers of species endemic to the Eastern African region.

	Total recorded	Endemic	% endemic
Fishes	1,090	890	82
Molluscs	230	171	74
Odonates	304	47	15
Crabs	37	28	76

3.3 Species distributions

Species distribution ranges have been mapped according to the best available information but are largely extrapolated from patchy records for point localities. Electronic copies of all individual species distribution maps are included in the accompanying CD as jpeg and GIS Shape files. They can also be viewed within the *Species Summary Documents* on the CD.

Centres of species richness, threatened species, and restricted range species are displayed using GIS grid overlays for each taxon. For fishes and molluscs, which are restricted to river and lake systems, additional maps are presented to show their distribution among river catchments. River catchment boundaries are based on the Hydro1K river basin GIS layer provided by the U.S. Geological Survey, in cooperation with UNEP/GRID Sioux Falls. The river basin layer includes six levels of detail. The highest level (Level 6) shows small sub-basins within a river system whereas the lowest level (Level 1) shows only the major river basins. Level 3 resolution (Figure 3.2) was employed in the analysis as it was considered to provide the best visual clarity for these data and to represent an appropriate scale for application to river basin management.

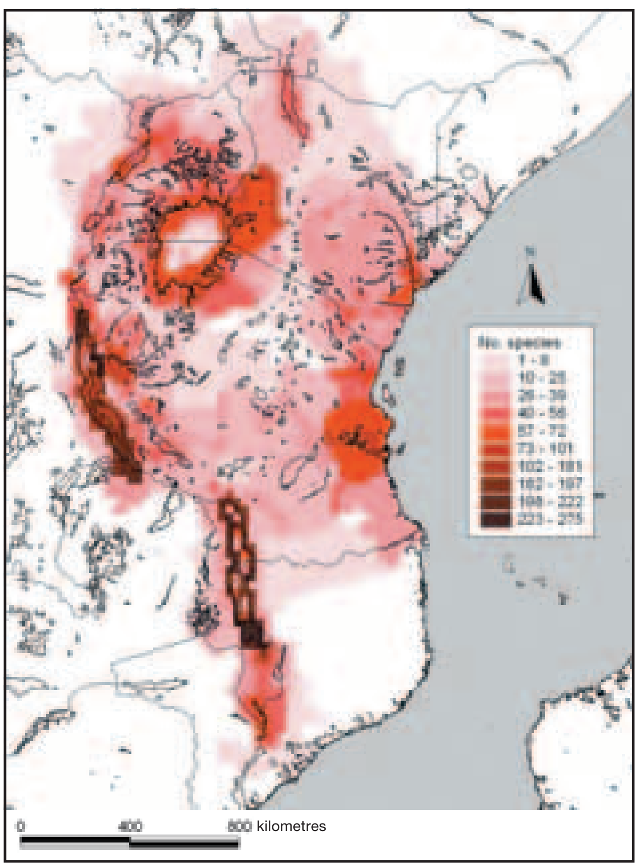
W. Darwall

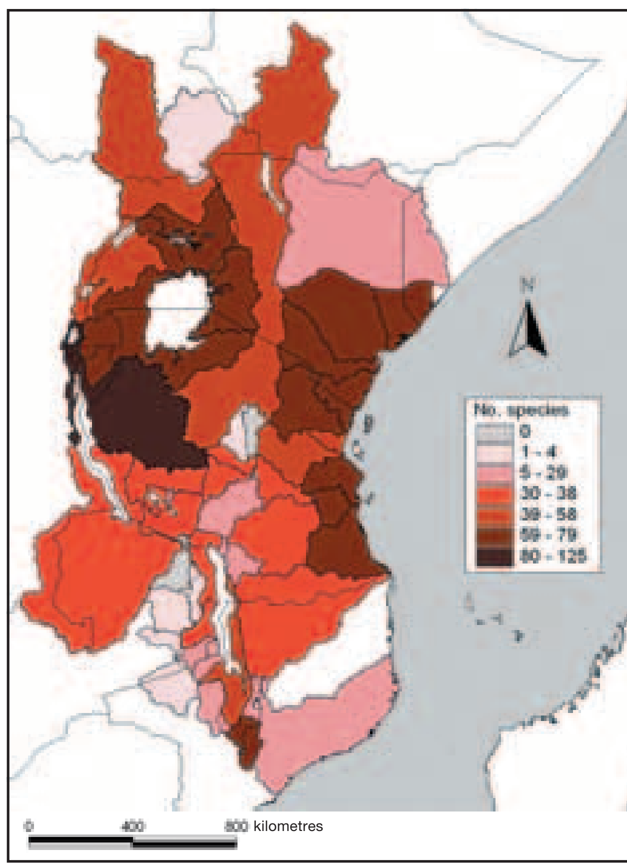
Taeniolethrinops praeorbitalis, a demersal cichlid endemic to Lake Malawi.

Figure 3.2 TOP LEFT. **River basin boundaries as selected at "Level 3"** (these data for the Hydro 1K river basin layer are distributed by the Land Processes Distributed Active Archive Center [LP DAAC], located at the U.S. Geological Survey's EROS Data Center http://LPDAAC.usgs.gov).

Figure 3.3 BOTTOM LEFT. **Species richness of fishes (mapped to a 0.25 degree grid following natural breaks).**

Figure 3.4 BOTTOM RIGHT. **Species richness of fishes among "Level 3" river catchments** (these data for the Hydro 1K river basin layer are distributed by the Land Processes Distributed Active Archive Center [LP DAAC], located at the U.S. Geological Survey's EROS Data Center http://LPDAAC.usgs.gov).





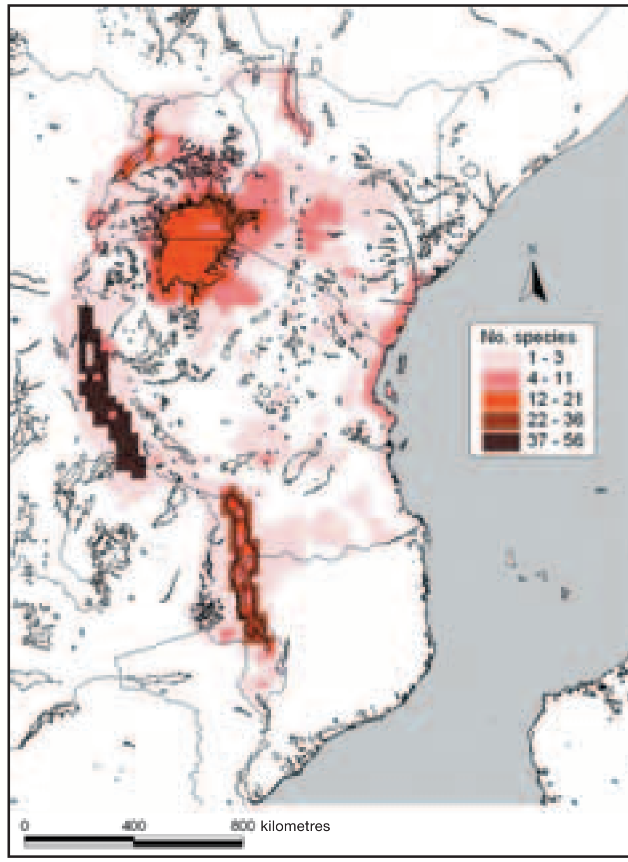


Figure 3.5 TOP RIGHT. **Species richness of molluscs (mapped to a 0.25 degree grid following natural breaks).**

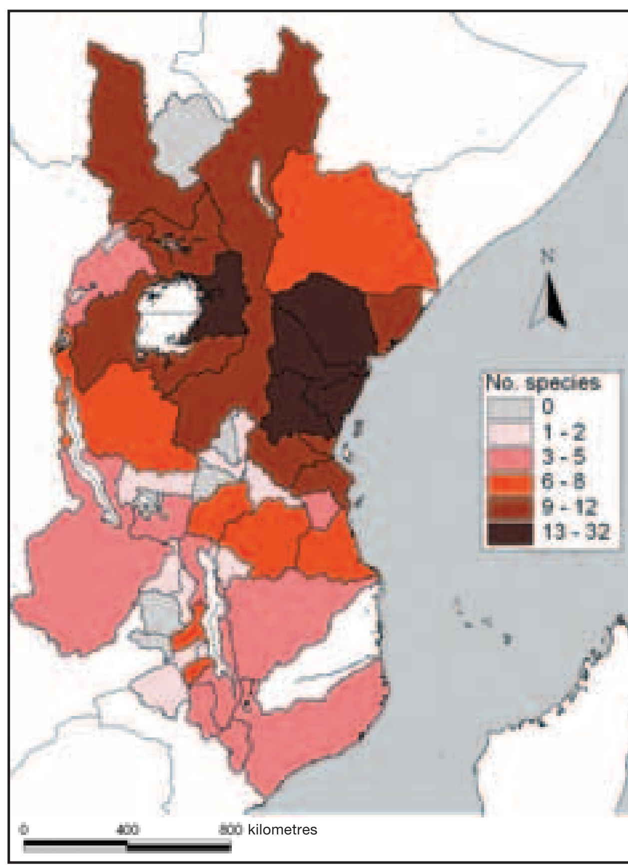


Figure 3.6 BOTTOM RIGHT. **Species richness of molluscs among "Level 3" river catchments** (these data for the Hydro 1K river basin layer are distributed by the Land Processes Distributed Active Archive Center [LP DAAC], located at the U.S. Geological Survey's EROS Data Center http://LPDAAC.usgs.gov).

3.3.1 Species richness

Fishes

The greatest concentrations of fish species are within the African Great Lakes, Malawi, Tanganyika and Victoria (Figure 3.3). The bulk of species in these lakes is from the family Cichlidae and most are endemic to single lakes. Beyond the Great Lakes, the Rufiji/Ruaha, Pangani, Malagarasi, Shire and Tana River basins also have high species richness and Lakes Albert, Edward, Turkana and Kivu also support a large diversity of fish species, again predominantly cichlids many of which are lake endemics.

Given that the river catchment is now widely accepted as the appropriate management unit for freshwater ecosystems, species distributions were also analysed across river catchments. The Malagarasi and Rusizi River catchments adjacent to Lake Tanganyika are highlighted as holding the greatest numbers of fish species (Figure 3.4). The Lake Victoria, East African coastal rivers and Lower Shire catchments are also rich in species. Note that this map only shows species richness within river catchments and does not include the many lake restricted species.

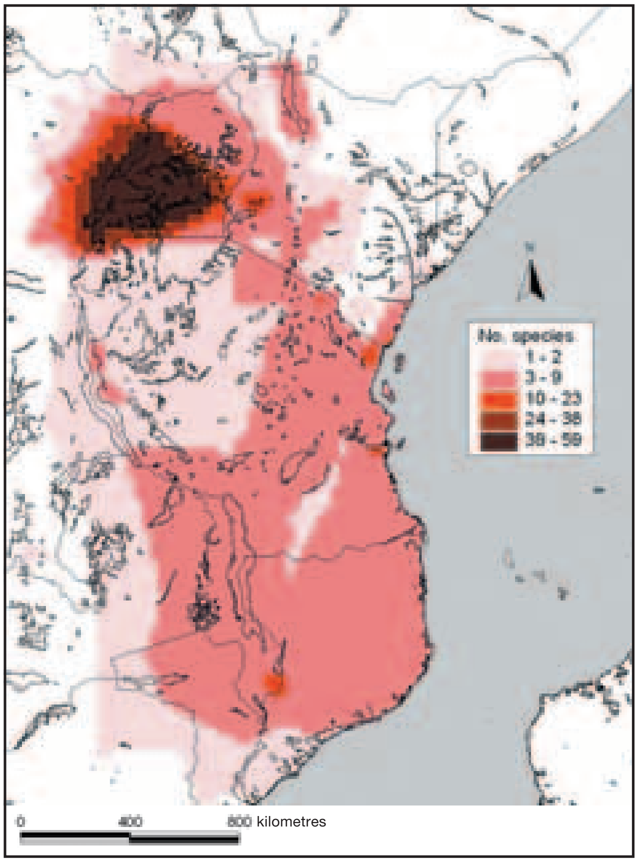
Molluscs

The highest concentrations of mollusc species are, as for the fishes, within Lakes Malawi, Tanganyika and Victoria (Figure 3.5). Of these three lakes, Lake Tanganyika is the richest with a species flock of endemic gastropods (Family: Thiaridae) and a total of 62 mollusc species recorded. It should, however, be noted that an estimated 80 mollusc species have previously been recorded in Lake Tanganyika (West *et al.* 2003) but confusion regarding taxonomy left a number of these taxa unassessed in this study.

The river catchments of the east coast of Kenya and northern Tanzania and the east coast catchments of Lake Victoria hold the greatest numbers of mollusc species (Figure 3.6).

Odonates

The greatest concentration of odonate species was in the south-western part of Uganda where species densities reached a peak of 59 species within a 0.25 degree grid



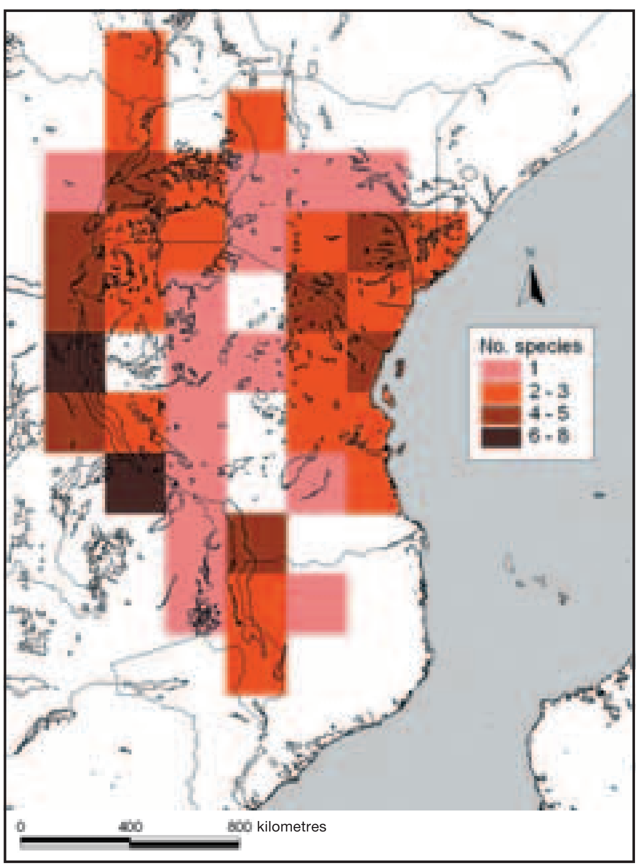


Figure 3.7 TOP LEFT. Species richness of odonates (mapped to a 0.25 degree grid following natural breaks).

Figure 3.8 BOTTOM LEFT. Species richness of crabs (mapped to a 2 degree grid following natural breaks).

square (28 x 28 km) (Figure 3.7). This apparent centre of species richness could, however, be a reflection of greater survey effort in Uganda. Elsewhere species densities were relatively evenly distributed throughout the region.

Crabs

Thirty seven freshwater crabs are known from Eastern Africa. Point data for the locations of all species were obtained but, given the limited survey intensity throughout the region, it is thought likely that most species are more widespread than the point localities suggest. Crab distributions were again centred on the three largest lakes, namely, Lakes Malawi, Tanganyika and Victoria, and the Pangani and Tana River basins (Figure 3.8). The 0.25 degree grid employed for other taxa was not considered an appropriate resolution suggesting a higher level of precision than that obtained. The 2 degree grid employed better reflects the suspected wider distributions for these taxa.

3.3.2 Threatened species

Fishes

Two-hundred-and-fifty-two of the 901 fish taxa assessed at the global level (mostly endemic to the region) are threatened (28% of the total number of fish taxa assessed), with two species (*Aplocheilichthys* sp. "Naivasha" and *Barbus microbarbis*) thought to be extinct. This assessment provides a significantly improved picture for the regional level of threat than that previously obtained from the 100 species assessed for the 2003 IUCN Red List of which 87% were assessed as either threatened or extinct. These earlier assessments focused on the Lake Victoria fish community in an effort to highlight the apparent large-scale decline and loss of cichlid species due to the combined impacts of invasive species, eutrophication and possibly overfishing. Clearly this picture was not representative of the threatened status for fish throughout the region. It should of course be noted that, given the high levels of endemism in many of the Rift Valley lakes, a similar catastrophe could arise if the appropriate conservation measures are not put in place.

The main centres of threatened fish species are within Lake Victoria (for the reasons given above), particularly in the most intensively surveyed south-eastern part of the lake, and Lake Malawi (Figure 3.9). Many of the Lake Victoria cichlids were previously thought to be extinct but, following additional and more extensive surveys, it appears that a number of these species still exist in small

Barbus sp., Lake Malawi

A combination of rocky-shore 'mbuna' and planktivorous 'utaka' endemic to Lake Malawi.

pockets in the lesser-known parts of the main lake and in the smaller satellite lakes (e.g., Bisini, Kanyaboli and Nabugabo). The majority of these species are now assessed as either Critically Endangered (where small sub-populations have now been found), or as Critically Endangered – Possibly Extinct where survey intensity is still considered insufficient to confirm that they are truly extinct. In Lake Malawi there are 117 species assessed as Vulnerable D2 on account of their highly restricted distributions (these species are excluded from the map in Figure 3.9 as Vulnerable D2 species are not directly threatened by ongoing activities but rather by intrinsic factors[1]). In some cases these species may be restricted to a section of rocky shore of less than a few hundred metres length. Such species are assessed as Vulnerable due to the risk from stochastic events that may possibly eliminate entire populations given their highly restricted ranges.

Most of the restricted range species are within the group of mouthbrooding rocky shore cichlids known locally as *mbuna*. Nine more widely distributed demersal cichlids are threatened by the commercial trawl fisheries operating in the southern parts of Lake Malawi and, in some cases, in Lake Malombe. Finally, three cyprinid species are threatened by heavy fishing pressure during

A fishing weir spanning one of the rivers flowing into Lake Malawi.

1 Vulnerable D2 species are threatened because they have a restricted area of occupancy of less than 20 km^2, or are restricted to less than five "locations".

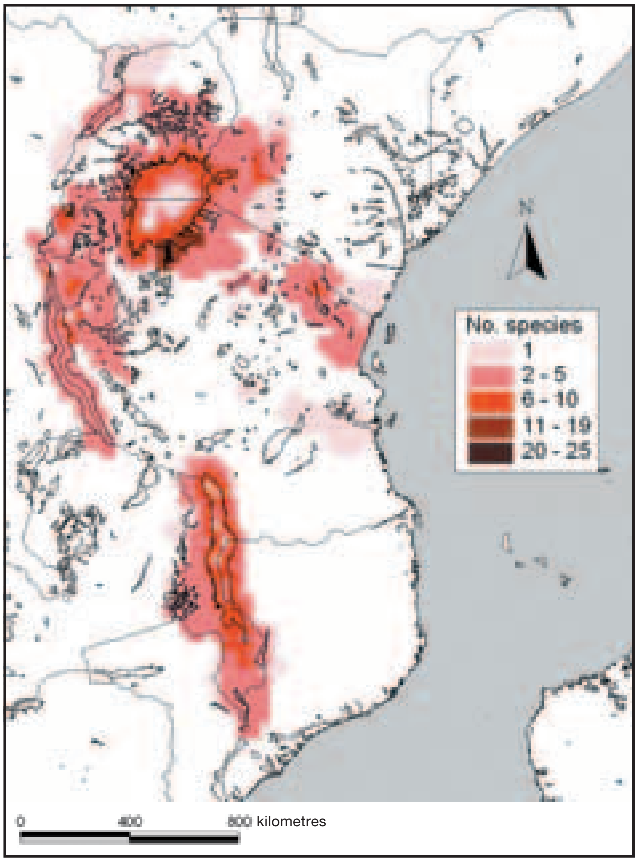
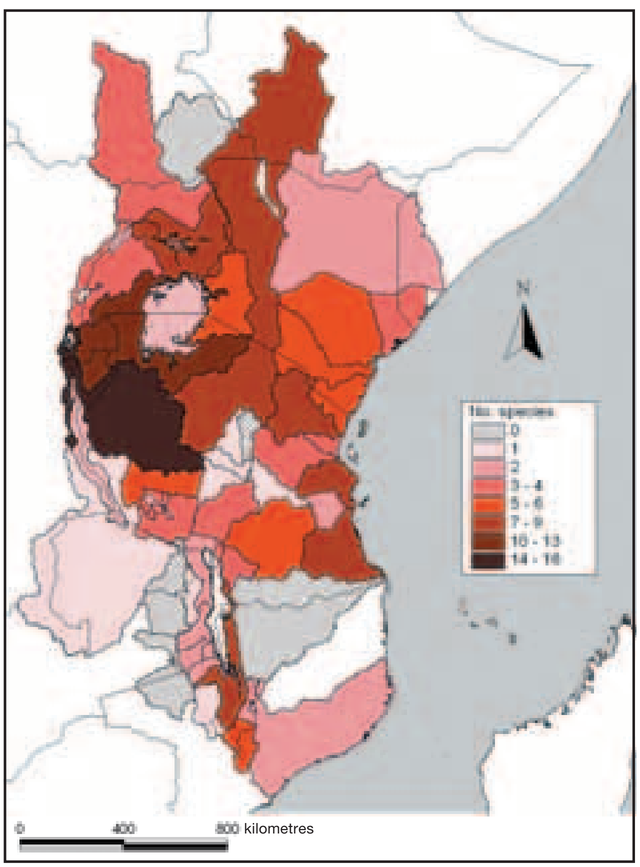
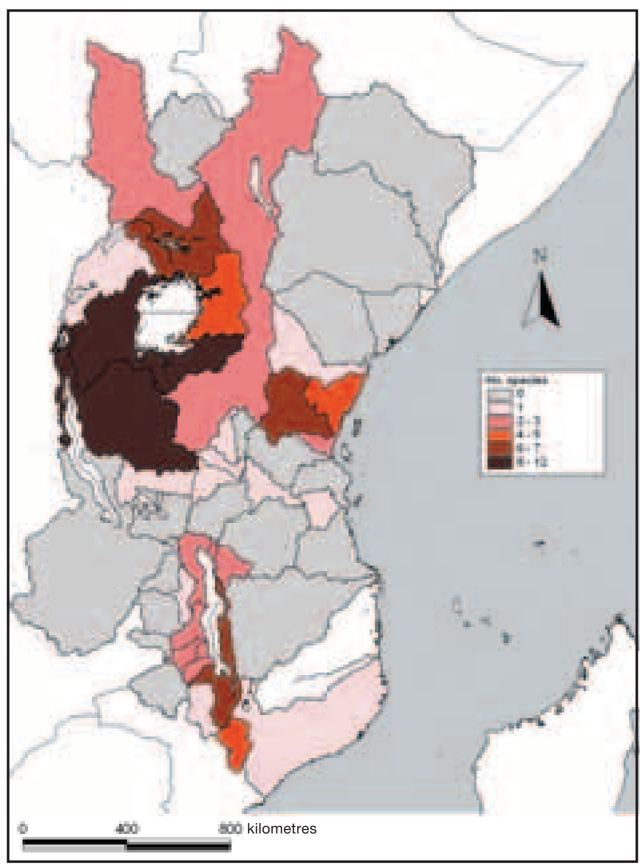


Figure 3.9 TOP LEFT. **Globally threatened fish species (excluding those assessed as VU D2) (mapped to a 0.25 degree grid following natural breaks).**

Figure 3.10 BOTTOM LEFT. **Globally threatened fish species in "Level 3" river basins** (these data for the Hydro 1K river basin layer are distributed by the Land Processes Distributed Active Archive Center [LP DAAC], located at the U.S. Geological Survey's EROS Data Center http://LPDAAC.usgs.gov).

Figure 3.11 BOTTOM RIGHT. **Globally threatened fish species in "Level 3" river basins (excluding all species assessed as VU D2).**





the annual spawning migrations when nets are set across river mouths as they ascend the rivers to spawn in the headwaters. An additional threat to river-spawning species is sedimentation of the spawning gravels in the river headwaters, a product of the large-scale deforestation occurring throughout Malawi (Mkoka 2004).

The catchment for the Malagarasi River system flowing into the north-eastern side of Lake Tanganyika is shown to hold the greatest number of threatened species where the major recorded threats are loss of habitat due to agricultural encroachment into wetland areas and the eutrophication and sedimentation of the riverine habitat (Figure 3.10). It is suggested that the current boundaries of the Ramsar site, which encompass the lower Malagarasi-Muyovozi Wetland, might be extended to provide a more comprehensive cover for the catchment.

With the exclusion of Vulnerable D2 species the Malagarasi River catchment and the southern and western drainages to Lake Victoria hold the greatest numbers of threatened species (Figure 3.11). The Pangani and Lake Kyoga/Victoria Nile catchments also hold high numbers of threatened species most of which are threatened by overfishing and sedimentation. Overfishing is also the main recorded threat to the many fish species in the southern Lake Malawi catchment and the Shire River.

Molluscs

Twenty-five species of mollusc (16% of the total assessed) are globally threatened. These species are mainly found in the north-eastern margins and catchment of Lake Victoria, the shores of Lakes Malawi and Tanganyika, and in the East Coast river drainages near the Kenya-Tanzania border (Figures 3.12 and 3.13). The main threats identified are increased sedimentation and habitat loss due to deforestation of river catchments, drainage of wetlands, and agricultural encroachment. No particular family is more threatened than any other. Of the five critically endangered species three, *Gabiella candida*, *G. parva*, and *Incertihydrobia teesdalei* are in the family Bithyniidae. *G. candida* is only known from a small stretch of shoreline at Butiaba in Lake Albert where it is subject to increasing levels of water pollution, and sedimentation. *G. parva* is only known from south-western Uganda in Lake Bunyoni which is fast developing as a popular tourist destination and where the water quality of the lake is declining due to the associated pollution and sedimentation from increasing agriculture. *I. teesdalei* is only found in Lake Jilore (Kenya) where it is subject to rapidly increasing siltation of the lake

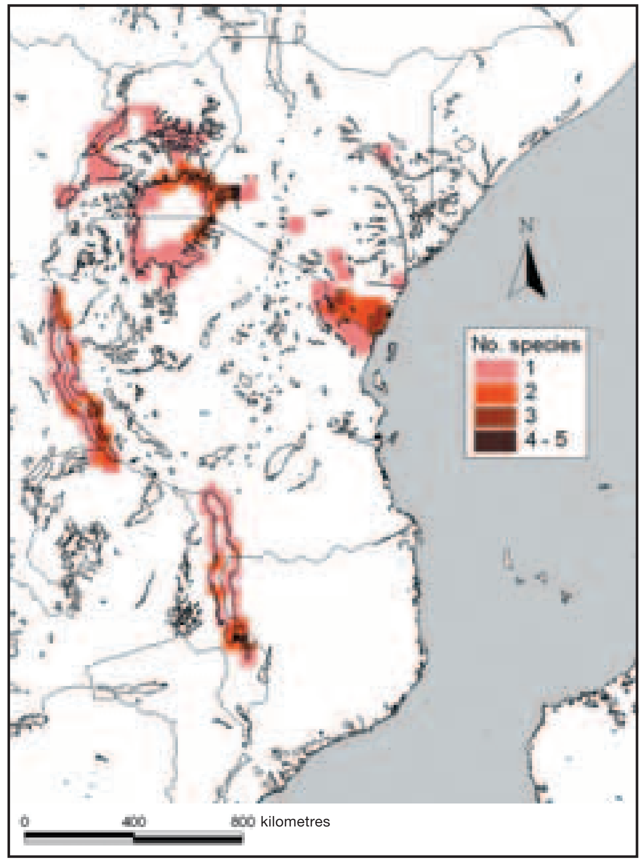


Figure 3.12 TOP RIGHT. **Globally threatened mollusc species (excluding all species assessed as VU D2) (mapped to a 0.25 degree grid following natural breaks).**

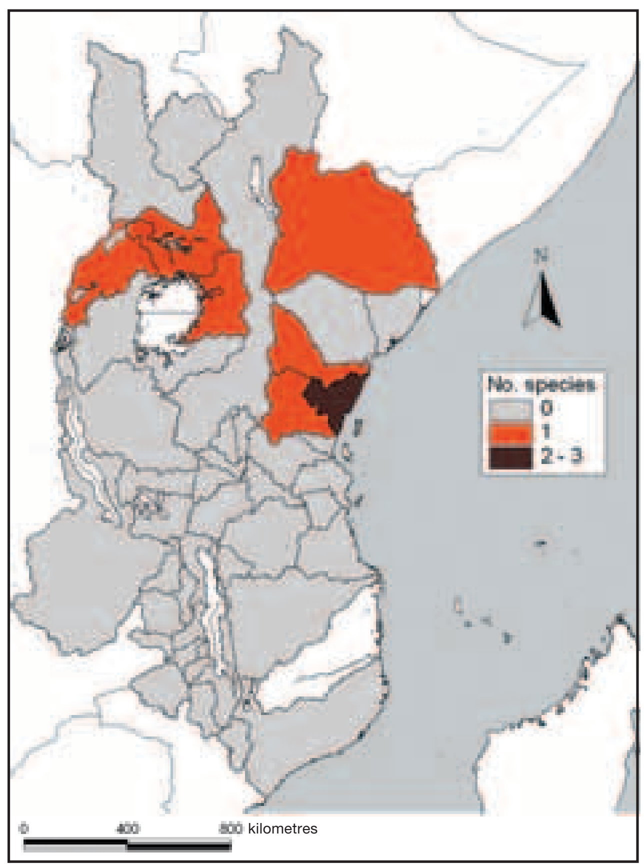


Figure 3.13 BOTTOM RIGHT. **Globally threatened mollusc species for "Level 3" river basins (excluding all species assessed as VU D2).**

Paramelaria crassiganulata, a Data Deficient species endemic to Lake Tanganyika.

(mainly due to livestock) which is now reported to dry out completely at times. The other two critically endangered species, *Bulinus tropicus torensis* (at a crater lake near Fort Portal) and *Eupera crassa* (Dagusi Island), are only found in single locations and have been impacted by a decline in water quality.

Odonates

Twenty-one species of odonate (7% of the total assessed) are assessed as globally threatened with the greatest concentration of threatened species in the Eastern Arc Mountain Range in Tanzania (Figure 3.14). The high level of threat to these montane species is thought to be a reflection of the extensive deforestation that has taken place throughout the area, most likely impacting on both the terrestrial and aquatic phases of the species. The other major threat to odonates was identified as the drainage of swamps. Those species inhabiting lakeshore habitats are generally less threatened with the exception of *Platycypha pineyi* which is assessed as Critically Endangered due to its limited distribution and reliance on diminishing lakeshore forests. The Eastern Arc Mountain Range, identified as one of the Global Hotspots by Conservation International, is the focus of a significant research and conservation initiative through the Critical Ecosystem Protection Fund (CEPF). It is therefore anticipated that new information will become available for species in this area.

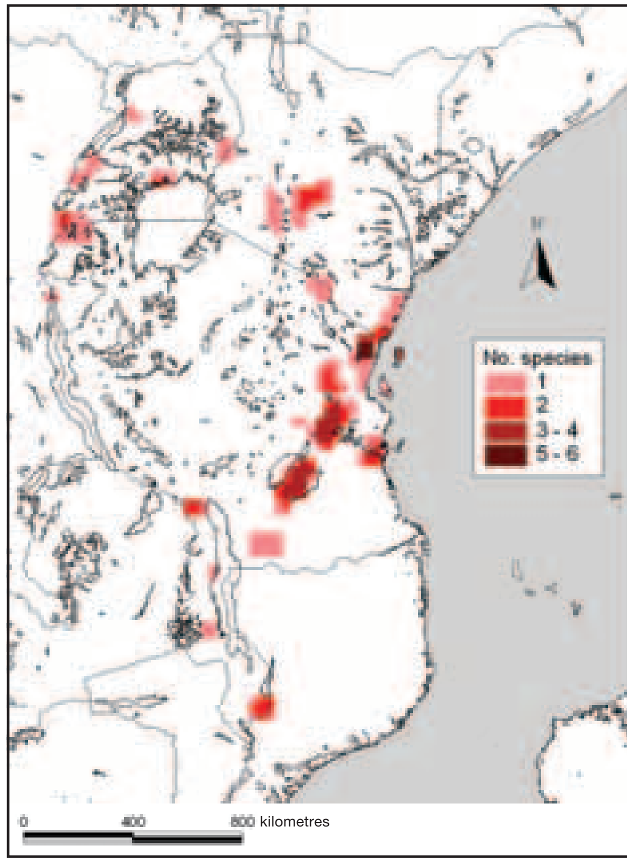


Figure 3.14. Globally threatened odonates (mapped to a 0.25 degree grid following natural breaks).

Critically Endangered *Platycypha amboniensis* which is only known from the Aberdare Mountains and Mount Kenya.

Crabs

Twenty species of freshwater crab (54% of the total assessed) are assessed as threatened. More extensive survey is required to establish distribution ranges which are currently limited to point localities. Based on this limited knowledge the greatest numbers of threatened species are known from the area around Lakes Kivu (Rwanda) and Mutanda (south-western Uganda), and the headwaters of the Tana River in, or near to, the Kora National Reserve and Meru National Park in Kenya (Figure 3.15). The threats to these species remain largely unknown but many are thought to have highly restricted ranges and their scarcity in museum collections has been used to infer low or declining populations.

3.3.3 Restricted range species

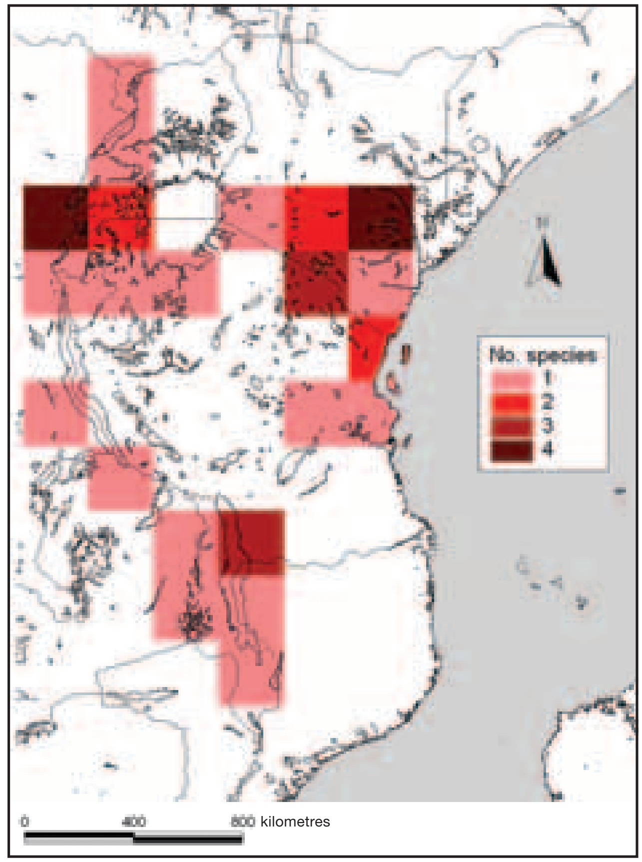
Extent of Occurrence (EOO) is defined as the area contained within the shortest continuous imaginary boundary which can be drawn to encompass all the sites of occurrence of a taxon (IUCN 2001). No thresholds have yet been set for defining restricted range for freshwater taxa, and this is the focus of ongoing work by the IUCN Species Survival Commission. For the purposes of this study a threshold for restricted range of EOO less than 2,000 km^2 was used as it was found to select an appropriate proportion of the total species set.

Fishes

The majority (61%) of the 297 restricted range fish species are found in the shoreline habitats in the southern part of Lake Malawi and its islands such as Likoma and Chizumulu (Figure 3.16). Most of these species are rocky shore mouthbrooding cichlids with very restricted larval and adult dispersal. In the river basin flood plains a number of killifish species (Cyprinodontiformes) are restricted to small temporary pools where they are able to survive the dry season as their fertilised eggs remain viable until the rains return to re-flood the pools.

Molluscs

One-hundred-and-eighteen species of mollusc are thought to be endemic to the region and an additional 38 species might also be endemic but this is yet to be confirmed. Of these, 55 species have recorded distribution ranges of less than 2,000 km^2. A number of the lacustrine taxa are restricted to very short stretches of coastline as many of the species-rich groups, such as *Lavigeria*, brood their



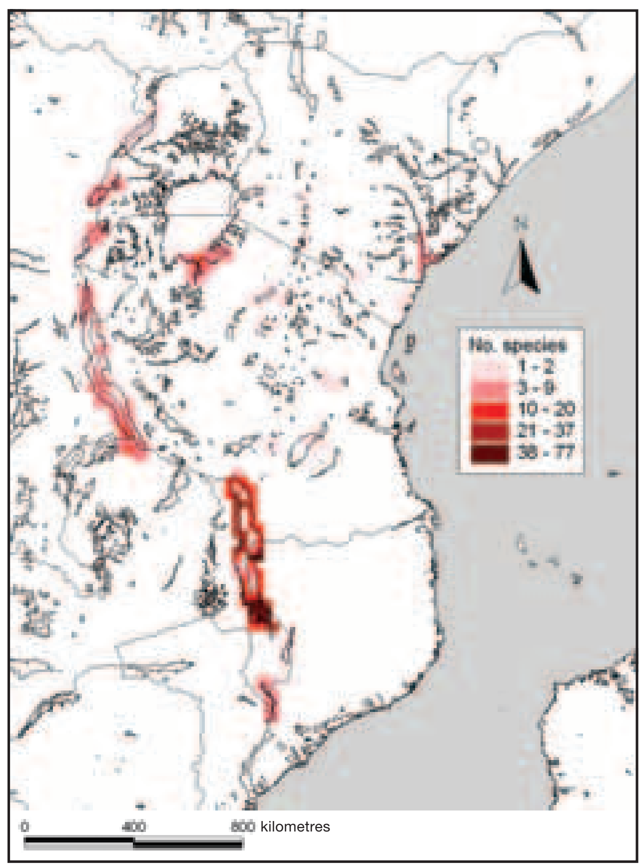
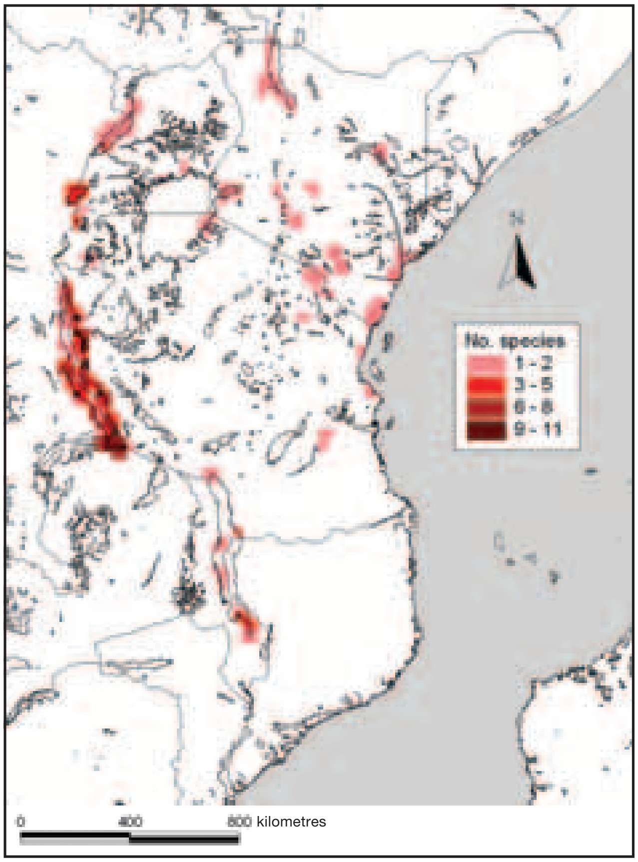


Figure 3.15 TOP RIGHT**. Globally threatened crabs (mapped to a 2.0 degree grid following natural breaks).**

Figure 3.16 BOTTOM RIGHT**. Regionally endemic restricted range fish species (EOO < 2,000 km^2) (mapped to a 0.25 degree grid following natural breaks).**



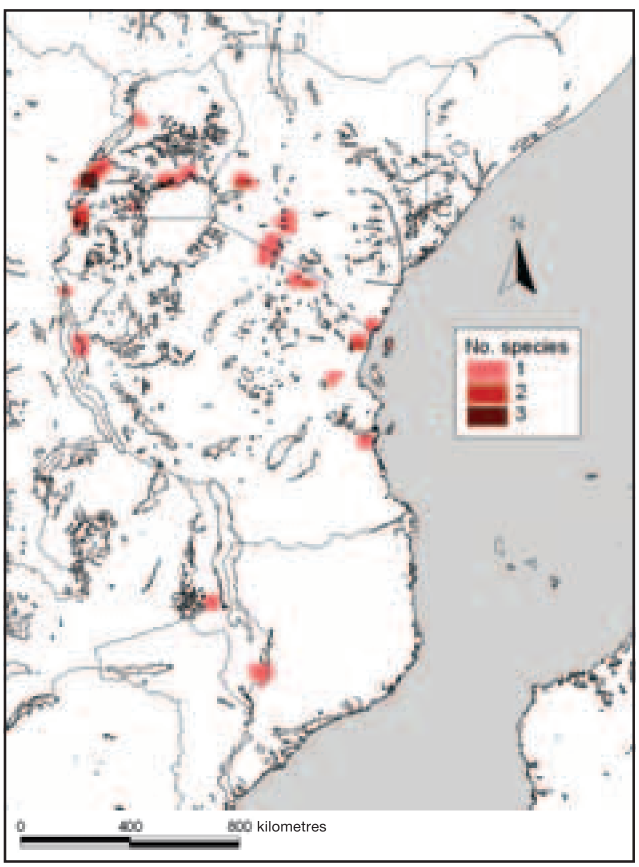


Figure 3.17 TOP LEFT. **Restricted range regionally endemic molluscs (EOO < 2,000 km²) (mapped to a 0.25 degree grid following natural breaks).**

Figure 3.18 BOTTOM LEFT. **Restricted range regionally endemic odonates (EOO < 2,000 km²) (mapped to a 0.25 degree grid following natural breaks).**

young and so have limited dispersal. A large proportion of these restricted range species (19 species) are gastropods (predominantly belonging to the family Thiaridae) found on the shores of Lake Tanganyika (Figure 3.17).

Odonates

Twenty-six species are endemic to the region of which 15 species have recorded ranges of less than 2,000 km² (Figure 3.18). Many of these species are found in Uganda and along the Kenya-Tanzania border.

Crabs

Crab distributions are only known from point data at this time so it was not possible to determine or map restricted range species.

3.4 Protected areas for freshwater ecosystems

Protected Areas, and in particular those within mountain regions, form a vital component of the conservation and management of freshwater resources, ecosystems and biodiversity (World Parks Congress 2003). Those sites that have been set up for the protection of wetlands and their biodiversity usually target the actual wetland location and not the water catchment that the wetland relies upon. Where headwater catchments within mountain regions have been protected, such as within Forest Reserves, the benefits to freshwater ecosystems have usually been considered an added bonus rather than the primary objective. The Protected Area concept needs to be expanded to target entire water catchments, or at least the catchments for headwaters, if wetland sites are to be more effectively protected.

3.4.1 Gaps analysis

Gaps within the Protected Area network (IUCN Category I–VI protected areas) of sub-Saharan Africa have previously been identified through analysis of the levels of inclusion for various groups of threatened terrestrial taxa. For example, Protected Area coverage for threatened and narrow range plants (Burgess *et al.* in press), threatened mammals (Fjeldsa *et al.* 2004) and threatened birds (De Klerk *et al.* 2004) have all highlighted gaps in the network, namely the Eastern Arc Mountains, lowland coastal

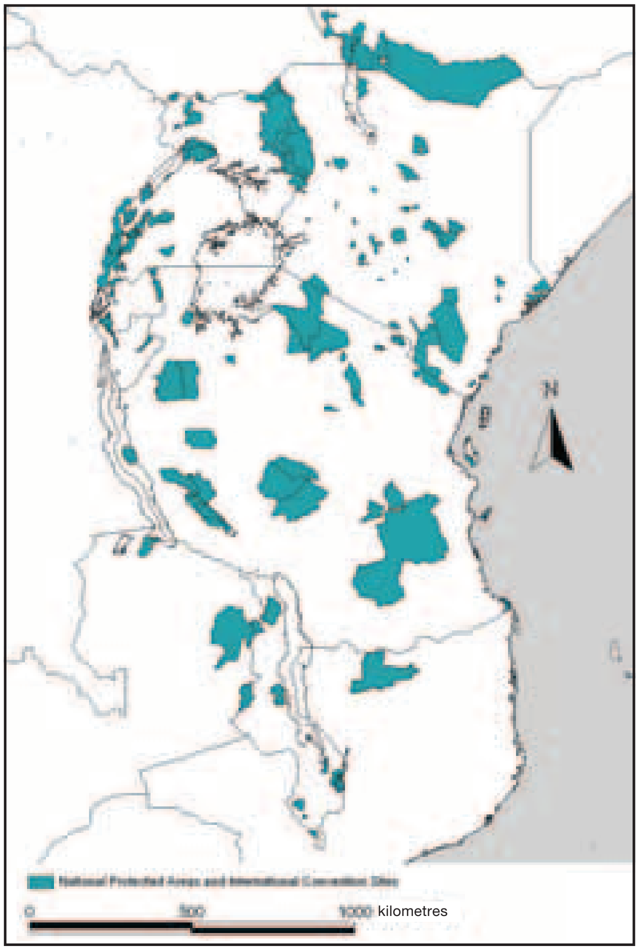


Figure 3.19. Locations of National Protected Areas and International Convention Sites.

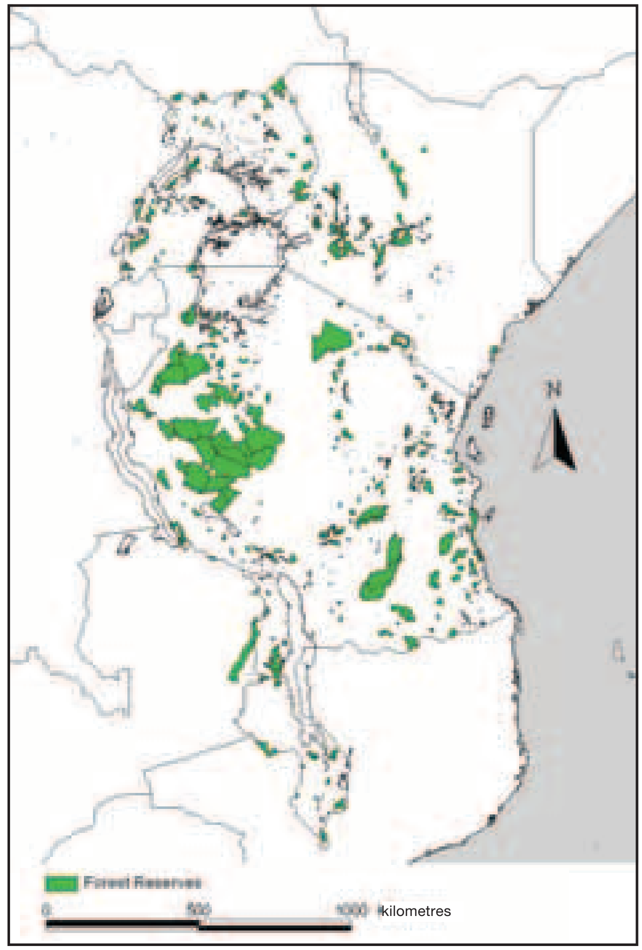


Figure 3.20. Locations of Forest Reserves.

Eastern Africa and the Albertine Rift (for mammals and birds). These gaps were, however, somewhat reduced following inclusion of the network of Forest Reserves in the analyses. There is great potential for Forest Reserves to provide catchment protection, especially to important headwaters sustaining downstream wetland ecosystems (World Bank and WWF 2003; Burgess *et al.* in press). No similar analyses were found for freshwater taxa.

The preliminary analysis presented here for gaps in the inclusion of freshwater taxa in the Protected Areas network shows the level of inclusion within National Protected Areas and International Convention Sites (Figure 3.19), and Forest Reserves (Figure 3.20), as categorised and mapped by the WDPA (World Database on Protected Areas) Consortium in the *2003 World Database on Protected Areas* (see http://www.biodiversity.org/wcpa and http://sea.unep-wcmc.org/wdbpa/).

Fishes

Only four species of fish (all of which are threatened) are completely included within National Protected Areas or International Convention Sites (Table 3.5). *Aplocheilichthys* sp. "Naivasha" is restricted to the Lake Naivasha Ramsar Site. *Ctenochromis* aff. *pectoralis* and

Table 3.5. Inclusion of Freshwater Fish within National Protected Areas and International Convention Sites (PAs) and Forest Reserves (FRs). * Numbers of species for which distributions have been mapped.

	No. and (% of total) species totally enclosed within PAs	No. and (% of total) species partly enclosed within PAs	No. and (% of total) species partly enclosed within PAs and FRs	No. and (% of total) species only enclosed within FRs
All species (total 1,061*)	4 (3.8%)	756 (71.3%) Av. 8.8% of total range	783 (73.8%) Av. 11.8% of total range	27 (2.5%) Av. 20% of total range
Threatened species (total 241*)	4 (1.7%)	116 (48.1%) Av. 13.7% of total range	126 (52.3%) Av. 17.2% of total range	10 (4.1%) Av. 13.2% of total range

Labeo sp. "Mzima" are both fully enclosed within the Tsavo West National Park. The fourth species, *Nothobranchius* aff. *taeniopygus*, is only known from a single locality on the Soroti-Moroto road (north-eastern Uganda) and this area is almost entirely encompassed within a number of Protected Areas including the Bokoria Corridor Game Reserve and South Karamoja and North Teso Controlled Hunting Areas. Nearly three quarters of all fish species and half of the threatened fish species have a part of their distribution within a Protected Area. However, on average the protected part of their distributions accounts for only 8.8% and 13.7% of the total distributions of all species, and threatened species, respectively. With inclusion of the Forest Reserves an additional 27 species (10 threatened) are included and the average portion of the distribution covered increases by 3% for all fish and by 3.5% for threatened fish.

Molluscs

Only four mollusc species are fully enclosed within National Protected Areas or International Convention Sites (Table 3.6). *Pisidium artifex* and *Pisidium kenianum* are both restricted to the Mount Kenya National Park, *Pisidium invenustum* is only found in the Mount Kilimanjaro National Park, and *Sphaerium hartmanni naivashaens* is restricted to the Lake Naivasha Ramsar Site. Of the 33 threatened species mapped only *Pisidium artifex* is fully incorporated within a Protected Area. Just over three quarters of all species and half of the threatened species have part of their distribution within a Protected Area. However, on average the protected parts of their ranges only accounts for 9% of the total distribution for all species and 21% for all threatened species. When including the Forest Reserves an additional four species (one threatened) are included and the average range covered increases by 2% for all molluscs and by 0.4% for threatened molluscs.

Odonates

Only three odonate species (none of them threatened) were fully enclosed within Protected Areas (Table 3.7). *Aciagrion heterosticta* is fully enclosed within the Central Karamoja Controlled Hunting Area, Bokoria Corridor and Pian Upe Game Reserves, and the East and North Teso Controlled Hunting Areas. *Phyllomacromia africana* is enclosed within the Murchison Falls National Park and *Pseudagrion assegaii* is found within the Pian Upe Game Reserve. Slightly less than 90% of all species, and just over 60% of all threatened, have at least a part of their range within a Protected Area. This covers on average 19.6% of the range of all odonate species and 21.3% of the threatened species. When Forests Reserves are added an extra 8 species (4 threatened) are included and the average proportion of the distribution covered increases by 3.8% for all odonates and 5.3% for all threatened odonates. It should be noted that species ranges recorded are for their terrestrial adult phase. The critical areas for the larval stage will be significantly more restricted and may well fall outside of the current Protected Areas network.

Crabs

A gaps analysis could not be conducted for crabs for which only limited point distribution data were obtained.

Table 3.6. Inclusion of Freshwater Molluscs within National Protected Areas and International Convention Sites (PAs) and Forest Reserves (FRs). * Numbers of species for which distributions have been mapped.

	No. and (% of total) species totally enclosed within PAs	No. and (% of total) species partly enclosed within PAs	No. and (% of total) species partly enclosed within PAs and FRs	No. and (% of total) species only enclosed within FRs
All species (total 206*)	4 (1%)	162 (78.6%) Av. 9% of total range	166 (80.6%) Av. 11% of total range	4 (1.9%) Av. 6.6% of total range
Threatened species (total 33*)	1 (3%)	17 (51.5%) Av. 21% of total range	19 (57.6%) Av. 21.4% of total range	1 (3%) Av. 0.4 % of total range

Table 3.7. Inclusion of odonates within National Protected Areas and International Convention Sites (PAs) and Forest Reserves (FRs). * Number of species for which distributions have been mapped.

	No. and (% of total) species totally enclosed within PAs	No. and (% of total) species partly enclosed within PAs	No. and (% of total) species partly enclosed within PAs and FRs	No. and (% of total) species only enclosed within FRs
All species (total 94*)	3 (3.2%)	83 (83.3%) Av. 19.6% of total range	91 (96.8%) Av. 23.4% of total range	8 (8.5%) Av. 12.7% of total range
Threatened species (total 14*)	0	9 (64.3%) Av. 21.3% of total range	13 (92.9%) Av. 26.6% of total range	4 (28.6%) Av. 11.6 % of total range

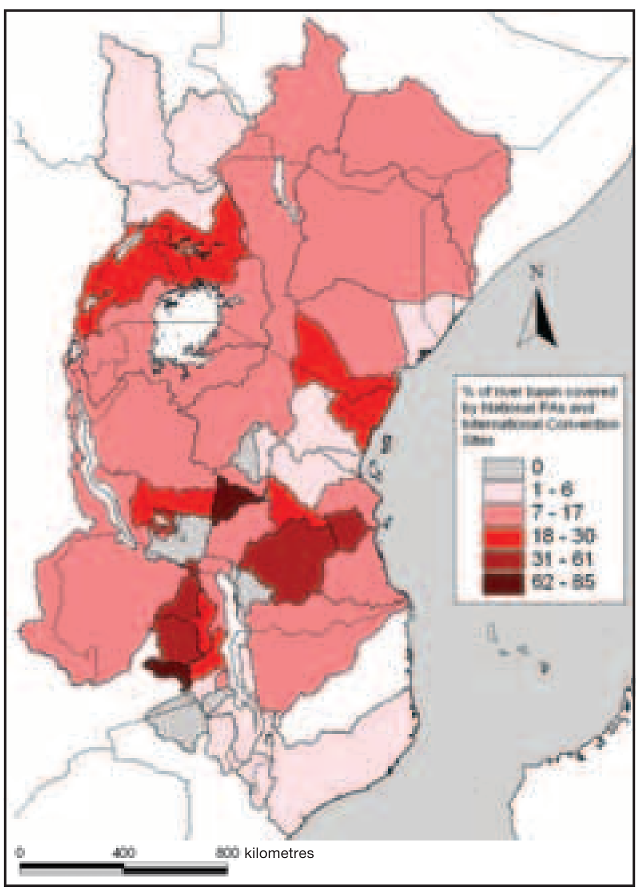
Summary

The proportion of species and their distribution ranges included within Protected Areas, International Convention Sites and Forest Reserves is much higher for odonates than for either fish or molluscs as most target the inclusion of terrestrial rather than wetland habitats. The benefits of Forest Reserves, as shown by the above analyses, do not appear highly significant in terms of provision of greater direct protection to freshwater taxa. However, the indirect benefit provided by Forest Reserves, through protection of the river catchments, is likely to be high and should be encouraged.

3.4.2 River catchment protection

As introduced above, it is generally accepted that the most effective management unit for conservation of freshwater taxa is the river catchment. Inclusion of a species distribution within a Protected Area does not, in itself, ensure effective protection of the associated wetland habitat if the quality or quantity of incoming water flow is not also maintained through protection of river basin headwaters. Further analyses are now presented to show the levels of

Figure 3.21. Current inclusion of river catchments in National Protected Areas and International Convention Sites.



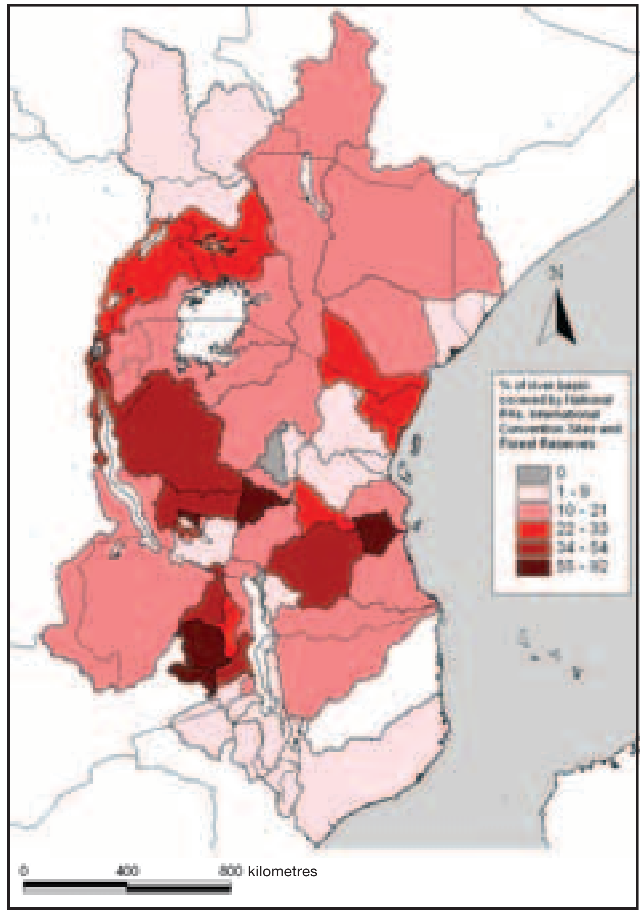


Figure 3.22. Levels of inclusion of river basins within National Protected Areas, International Convention Sites and Forest Reserves.

protection afforded to river basins and their headwaters by the existing Protected Areas network in Eastern Africa (Figure 3.21).

The river basin most fully enclosed within National Protected Areas and International Convention Sites is the upper Great Ruaha basin in the centre of Tanzania. Eighty five percent of this basin is enclosed within the Rungwa and Kizigo Game Reserves and the Ruaha National Park. The Rufiji, Kilombero and Luwegu River system is also largely enclosed within the Selous Game Reserve and to a lesser extent the Udzungwa Mountains National Park. The river basins on the Malawi and Zambia borders are largely included within the Musalangu and Lumimba Game Management Areas and Lukusizi National Park in Zambia, and the Vwaza Marsh Wildlife Reserve in Malawi. Other basins have little or no protection through inclusion within the existing Protected Area network.

When Forest Reserves are included within the analyses the most noticeable increase in the level of basin protection is for the Malagarasi River Basin to the east of Lake Tanganyika (Figure 3.22).

3.5 Important sites for freshwater biodiversity

3.5.1 Key biodiversity areas

Given the known scale and speed of loss of freshwater biodiversity in other regions of the world, such as North America (Master *et al.* 2000), it is imperative to identify areas of exceptional biological diversity and to assess their status if priorities for conservation action are to be developed. This is particularly true for the freshwater biodiversity of Eastern Africa given the high regional dependence on biodiversity products and services, particularly for the rural poor.

It is not possible to target the entire Eastern African region for improved conservation and sustainable use as research and management resources are limited. A methodology is required to help direct actions to those sites for which conservation and management intervention would be most effective in meeting regional targets. A framework methodology has been developed for freshwater taxa based on the experiences and established methodologies of a number of other organisations (Darwall and Vié in press). Important Biodiversity Sites are selected to include: i) threatened species; ii) restricted range species; iii) congregatory and migratory species; and iv) biome restricted species. The quantitative thresholds for applying these criteria are still being developed and tested.

As a preliminary exercise the datasets compiled here for fishes, molluscs, odonates and crabs were combined with similar data compiled for amphibians by IUCN, Conservation International and NatureServe (see http://www.globalamphibians.org) and for waterbirds by BirdLife International (see http://www.birdlife.net/action/science/sites/) to identify areas of greatest species richness (Figure 3.23), numbers of threatened species (Figure 3.24), and regionally endemic restricted range species (Figure 3.25). As the datasets for freshwater-dependent mammals, turtles and crocodiles become available they will be included in future analyses.

Lakes Malawi and Tanganyika are by far the most species rich areas in the Eastern African region with a maximum of 382 species recorded within a single 28 x 28 km grid cell. Such densities of freshwater-dependant species

Figure 3.23. Combined species richness of fishes, molluscs, odonates, crabs and amphibians (mapped to a 0.5 degree grid following natural breaks).

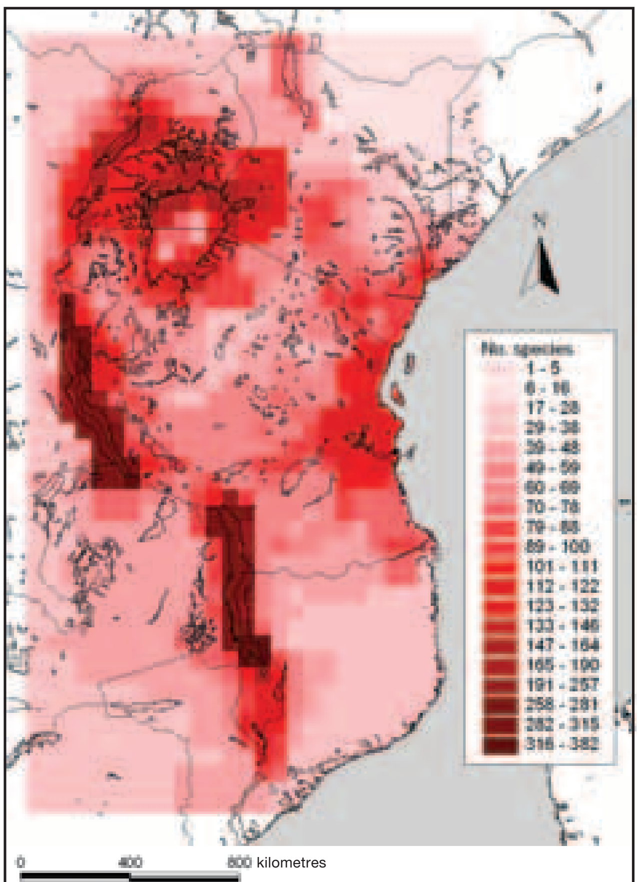
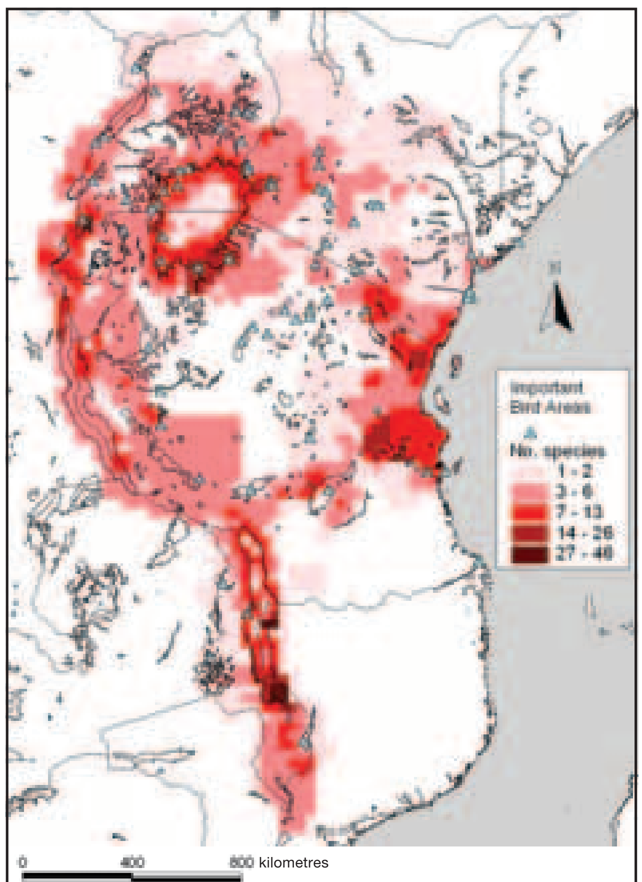


Figure 3.24. Combined distributions of threatened species of fishes, molluscs, odonates, crabs and amphibians (mapped to a 0.25 degree grid following natural breaks).



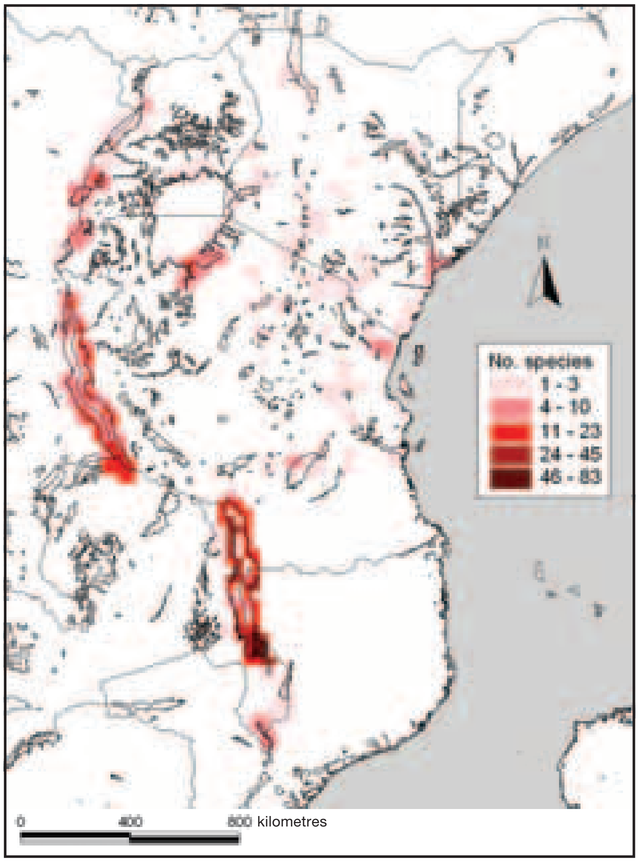


Figure 3.25. Combined distributions of restricted-range species (EOO < 2,000 km²) of fishes, molluscs, odonates, crabs and amphibians (mapped to a 0.25 degree grid following natural breaks).

are thought likely to be some of the highest of any area globally. Lakes Victoria, Albert, George, and Edward are close behind with up to 160 species recorded within a single 28 x 28 km grid cell. The lower reaches of the Rufiji and Pangani River basins are also species rich with up to 140 species recorded in each basin. The lower Tana River has an estimated 110 species recorded. Finally, the high altitude streams, Lake Chala, and the mountain forests of Lake Kilimanjaro are also rich in freshwater-dependent species.

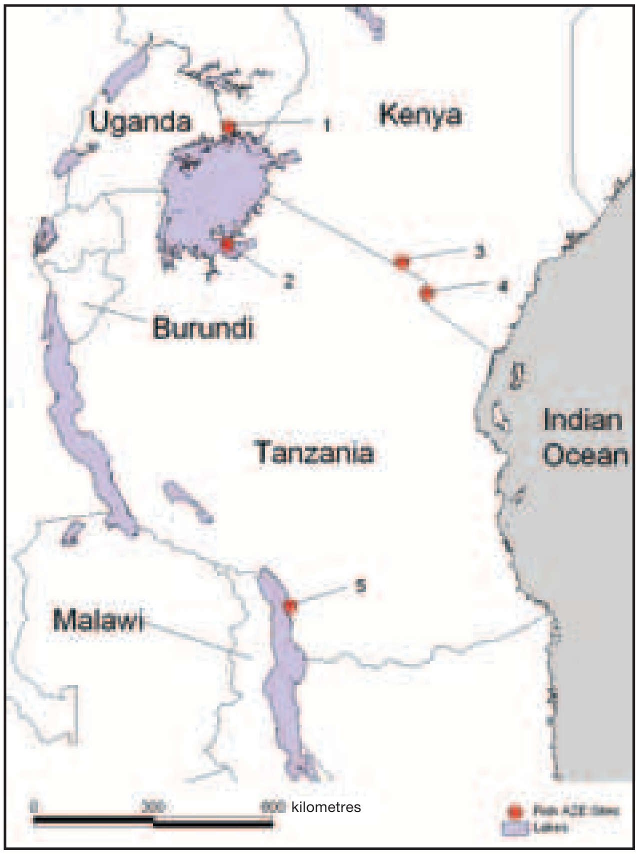
The distribution of threatened taxa (Figure 3.24) follows a similar distribution as for species richness with the majority of threatened species found in Lakes Malawi and Victoria, and in the Rufiji and Pangani River basins. Many of the species in Lake Malawi are threatened mostly on account of their restricted ranges (Figure 3.25).

3.5.2 Alliance for Zero Extinctions – AZE sites

The Alliance for Zero Extinctions (AZE) is an initiative led by a group of biodiversity conservation organisations to identify and protect the last remaining habitats for the world's most threatened species (see http://www.zeroextinction.org). AZE Sites are designated through the application of three criteria, and all must be met in order to qualify: Criterion 1 – the site must contain at least one species listed as Critically Endangered or Endangered by the IUCN Red List; Criterion 2 – The site must be the sole location where the Critically Endangered or Endangered species exists, or contain the overwhelming significant population for one life history segment; and Criterion 3 – the site must have a definable boundary within which the character of the habitats, biological communities, and/or management issues have more in common with each other than with those in adjacent areas. So far these criteria have been applied almost exclusively to terrestrial vertebrates and plants where definable boundaries are relatively easy to identify. However, for freshwater species, especially those in rivers, defining a discreet site is difficult. River systems by their nature have a great degree of connectivity between the headwaters, flood plains, estuaries and deltas. In a preliminary effort to start addressing freshwater taxa 13 candidate AZE Sites are identified (Figures 3.26–3.28, Tables 3.8–3.10). These candidate AZE Sites have been put forward for consideration by the AZE Criteria Committee.

Table 3.8. Candidate AZE sites for fish taxa endemic to Eastern Africa.

Site no.	Species	IUCN Red List Status	Location
1	*Neochromis simotes*	Critically Endangered	Restricted to Kakindu and Ripon Fall, both on the Victoria Nile in Jinja, Uganda.
2	*Haplochromis cavifrons*	Critically Endangered	Endemic to the Vesi Archipelago in the Speke Gulf, Lake Victoria, Tanzania.
3	*Haplochromis* sp. *"amboseli"*	Critically Endangered	Endemic to the Amboseli swamps, Kenya.
4	*Oreochromis hunteri*	Critically Endangered	Endemic to Lake Chala on the eastern slopes of Mount Kilimanjaro.
5	*Oreochromis chungruruensis*	Critically Endangered	Endemic to Lake Chungruru, a crater lake north of Lake Malawi which has no water outlet.



Fishes

Five fish taxa have been identified as fitting the AZE selection criteria (Table 3.8 and Figure 3.26).

Molluscs

Two mollusc species have been identified as fitting the AZE selection criteria (Table 3.9 and Figure 3.27).

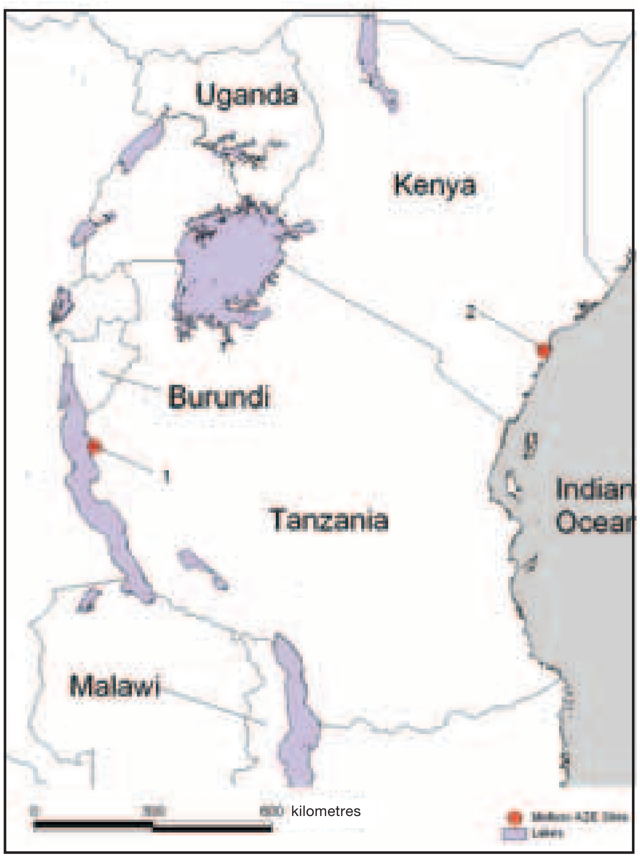
Odonates

Six odonate species have been identified as fitting the AZE selection criteria (Table 3.10 and Figure 3.28).

Figure 3.26 TOP LEFT. Locations of candidate AZE sites for fish taxa.

Figure 3.27 BOTTOM LEFT. Locations of candidate AZE sites for mollusc species.

Figure 3.28 BOTTOM RIGHT. Locations of candidate AZE sites for odonate species.



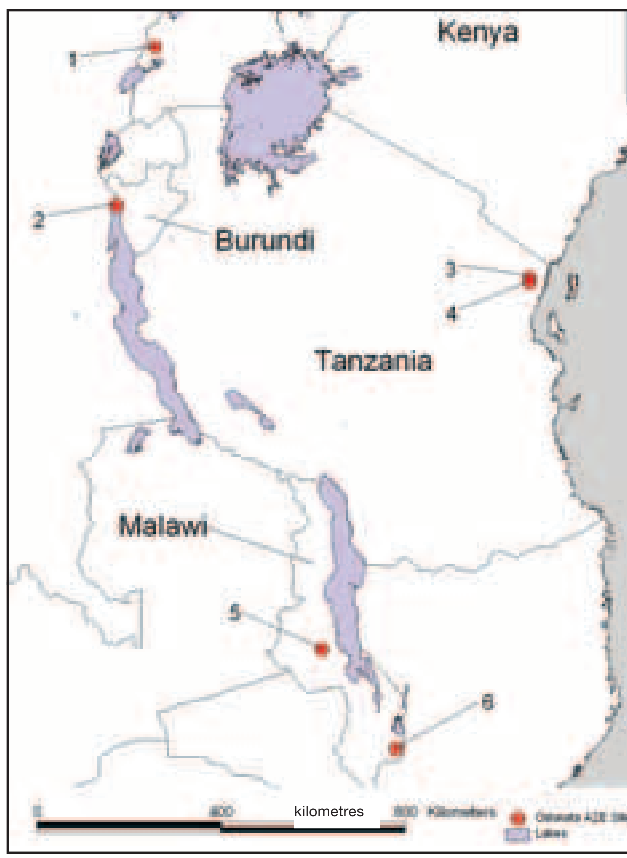


Table 3.9. Candidate AZE sites for mollusc species endemic to Eastern Africa.

Site no.	Species	IUCN Red List Status	Location
1	*Incertihydrobia teesdalei*	Critically Endangered	Endemic to Lake Jilore. However, Brown (1994) suggests that the species' extent of occurrence could extend from Lake Jilore to the coast at Takaungu, Kenya.
2	*Potadomoides pelseneeri*	Critically Endangered	Endemic to the Malagarasi River. Found in the delta area. It has an extremely limited distribution with only a few specimens collected alive.

Table 3.10. Candidate AZE sites for odonate species endemic to Eastern Africa.

Site no.	Species	IUCN Red List Status	Location
1	*Tetrathemis ruwensoriensis*	Critically Endangered	Endemic to the Mutwanga Forest in the Ruwenzori Mountains, western Uganda.
2	*Platycypha pinheyi*	Critically Endangered	Endemic to the northern shores of Lake Tanganyika, Tanzania and the Democratic Republic of Congo.
3	*Amanipodagrion gilliesi*	Critically Endangered	Endemic to the Sigi Forest Reserve in the East Usambara Mountains, Tanzania.
4	*Micromacromia miraculosa*	Critically Endangered	Endemic to the Amani Forest in the East Usambara Mountains, Tanzania.
5	*Chlorocnemis maccleeryi*	Critically Endangered	Endemic to Mount Ntchisi, central Malawi.
6	*Oreocnemis phoenix*	Critically Endangered	Endemic to Mount Mulanje, southern Malawi.

3.5.3 Centres of fish migration

A number of fish species are known to undergo seasonal spawning migrations. Such species are at risk if their migration routes are interrupted by dams, fishing nets, or over-abstraction of water.

The number of recorded migratory species was determined for each river basin (Figure 3.29). Those catchments identified to hold the greatest numbers of known migratory species include the Rufiji (14 spp.), Tana (15 spp.), Malagarasi (18 spp.), Upper and Lower Shire (17 and 19 spp.), and Rusizi (included in the Malagarasi basin), and the Lake Malawi catchment. This analysis can only provide a preliminary picture as the actual numbers of migratory species will be higher than shown as the breeding ecology of many species was not recorded.

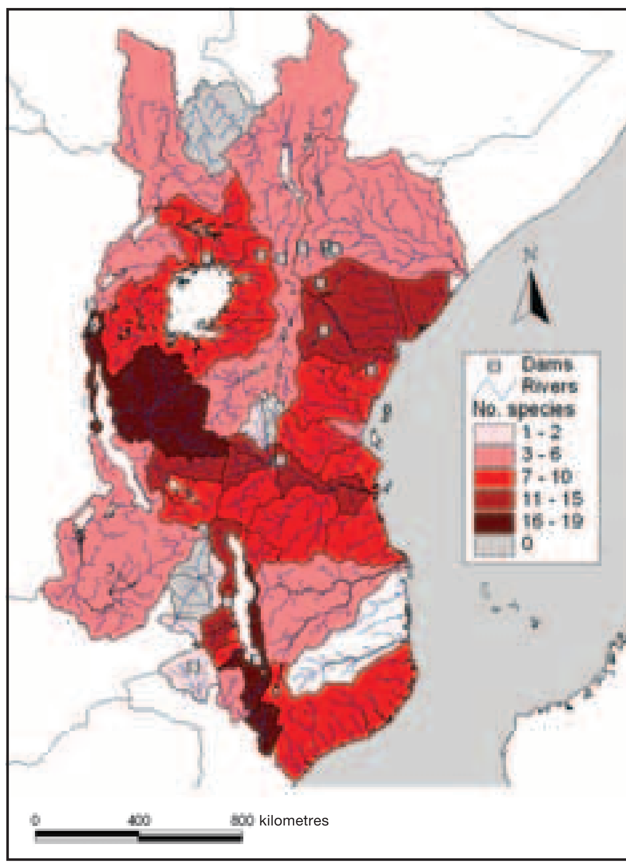


Figure 3.29. Numbers of recorded migratory fish species within river basins. Locations of existing major dams are also displayed (these data for the Hydro 1K river basin layer are distributed by the Land Processes Distributed Active Archive Center [LP DAAC], located at the U.S. Geological Survey's EROS Data Center http://LPDAAC.usgs.gov).

3.6 Application to river basin planning

Species spatial information can also be analysed at the river basin level. Although the data collated in this survey were not often sufficiently resolved to show species distributions within river basins, examples from the fish dataset serve to demonstrate the type of outputs that can be generated (Figure 3.30). In these examples information is displayed which tells us fish species richness is greatest in the lower parts of each basin. In the Rufiji River Basin example the data are already sufficient to help identify which sub-basins hold the highest numbers of species. As the spatial resolution of the dataset is improved then this kind of output will become increasingly useful to basin planners.

Information stored within the attribute tables for each spatial data set can be accessed to provide additional information such as lists of species present in each grid cell, their threatened status, commercial value, migratory behaviour, and distribution range (Figure 3.31). One direct application for datasets such as these is the calculation of environmental flows for which one key objective is to ensure sufficient water remains in a river system to support the downstream ecosystems. Maps identifying the distributions of species at any point in the basin will be essential for such activities. As the information set builds through time these more detailed outputs will become increasingly available.

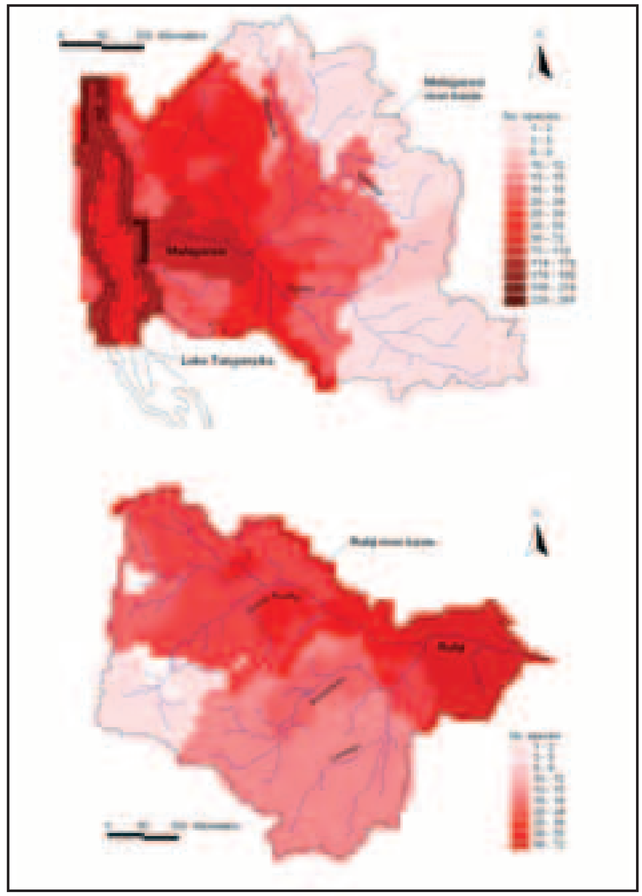


Figure 3.30. Example GIS outputs demonstrating the potential for spatial imaging of species distributions at the river basin scale. Fish distributions within the Rufiji (top) and Malagarasi (bottom) river basins.

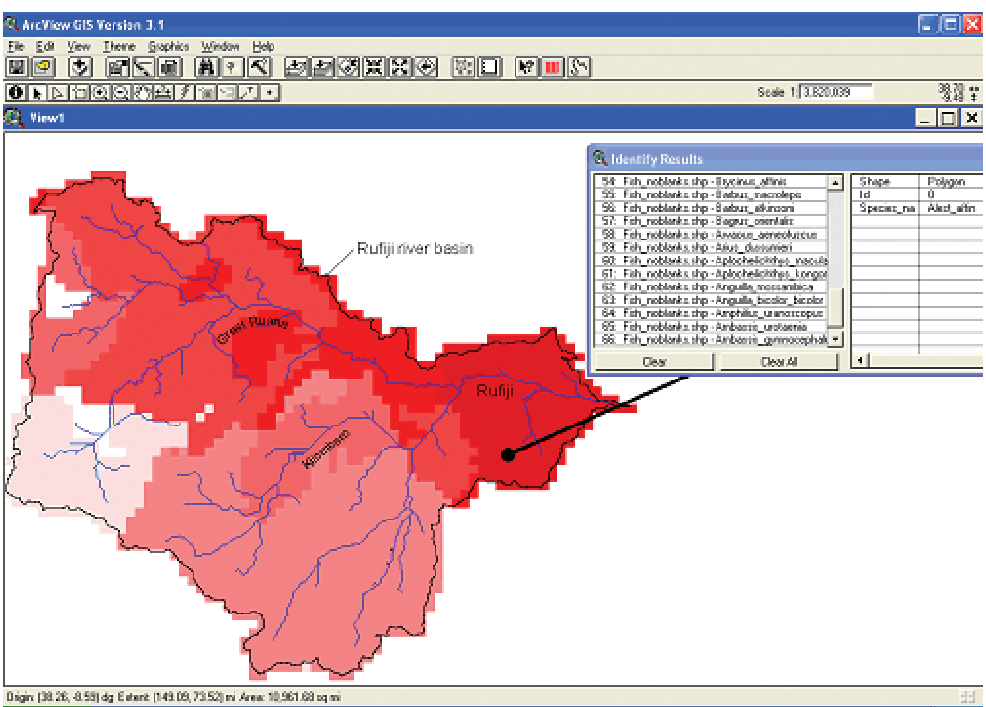


Figure 3.31. An example screen view within ArcView demonstrating the potential to access data stored within the attribute tables of each grid cell.

Chapter 4

Conclusions and Discussion

4.1 The state of knowledge

This dataset brings together and presents more information on freshwater biodiversity in Eastern Africa than has been presented before. It already represents a useful tool for anyone involved in water resource development planning, or conservation and environmental planning within the region. However, it should be noted that the dataset is not yet a comprehensive assessment of all species within the priority taxa of the Eastern African region and should be viewed as a work in progress. Clearly there is scope for improving the quantity and quality of information for a number of taxa and for inclusion of additional species for which data were not made available during the project period. It is, however, hoped that by presenting the dataset at this stage in development researchers, both regional and international, will be stimulated to provide new data and to improve on the quality of those already presented. It is also hoped that, with time, the spatial resolution of data will be improved, particularly for species distributions within river basins.

Geographic bias in sampling intensity has been identified as a problem in representing a true regional picture of species distributions and threatened status. For example, the high density of odonate species in Western Uganda and the high density of threatened fish species in Mwanza Bay in Lake Victoria are most likely products of disproportionately high intensity of field sampling in those areas. As these sampling biases become apparent it is hoped that researchers will be encouraged to focus their efforts on the lesser-known regions.

4.2 Conservation priorities

A number of sites have been identified as regionally important for species richness, species endemism, and threatened species, the main sites being the African Great Lakes, Malawi, Tanganyika and Victoria. The Rufiji, Pangani and Tana River systems were also identified as important centres for freshwater biodiversity. The major threat identified as common to all the taxonomic groups is the continuing loss of habitat through deforestation and agricultural encroachment. It has also been shown that the current network of Protected Areas does not work well to combat these threats to freshwater taxa. Forest Reserves, which often aim to protect forests in the upper river catchments, are identified as potentially important tools in need of increased recognition for their value to the protection of downstream freshwater ecosystems. The main future threats identified also highlight habitat loss as a major issue. Of particular concern is the potential impact of water resource developments, such as the construction of dams for water supply, irrigation and hydro-electric power, which are expected to have a major impact on the associated freshwater biodiversity. The dataset presented here provides a useful resource for designing projects to account for and minimise impacts to the associated freshwater biodiversity upon which so many people depend.

The challenge now is to ensure that the information collated and presented here and in the SIS database is made readily available for policy makers and environmental planners in a format that can easily be employed for integration within the development planning process.

4.3 Application of outputs

The outputs from this study can be applied at the national level in the development of National Biodiversity Strategies, and in monitoring progress towards the goals and targets of Conventions, such as the Convention on Biological Diversity and the Ramsar Convention on Wetlands. At the regional scale, outputs may be employed by organisations such as IUCN to prioritise sites for inclusion in regional research programmes and for identification of internationally important sites of biodiversity. At the river basin scale, the dataset can be employed in the determination of environmental flows when designing and siting water resource developments. Hopefully the provision of this biodiversity information set will help ensure that there is no longer an “information bottleneck” for conservation planning in inland waters nor for the integration of biodiversity information within the development and environmental planning process.

Chapter 5

Future Work

The following priorities have been identified to help ensure the outputs from this study are utilised to greatest effect and that the data set is expanded and improved upon:

a) **Integration of biodiversity information within environmental and development planning.** The following activities are a priority if the biodiversity dataset collated is to be effectively integrated within the environmental or development planning process:
   i) Established links between regional decision makers, policy makers, and the partner organisations must be maintained and strengthened and the datasets must be made available to these people and/or organisations; and
   ii) A "best practice methodology" for the process of integrating biodiversity information within the development and environmental planning process must be developed. The methodology should aim to provide the information in an appropriate format for all stakeholders and to provide guidelines as to when and where the information should be made available. Efforts to move this process forward are being undertaken in a major follow-up to this study through extension of the work to the whole of Africa (a five-year project starting in 2005; funded by the European Union);

b) **Expansion and improvement of the dataset.** The dataset collated, although the most comprehensive yet, should be viewed as a baseline for future additions and improvements (particularly in its spatial resolution). It is hoped that this will be achieved through the ongoing assistance of those members involved in the original assessments (supported through a strengthened and expanded IUCN/SSC Specialist Group Network) and through stimulation of other parties to add to and improve upon the dataset once made widely, and freely, available on the internet. In particular, it is hoped that the taxonomic cover will be expanded to include assessments of aquatic plants, waterbirds, reptiles and mammals.

c) **Identification of Key Biodiversity Areas (KBAs) for inland waters in Eastern Africa.** Work is ongoing to finalise the site selection criteria used to identify KBAs for inland waters. When this is completed the outputs presented here will be used to help identify the most important areas for biodiversity in the inland waters of Eastern Africa, providing a valuable tool for the development of regional priorities. This work is part of a broader collaborative initiative to identify KBAs for terrestrial and marine ecosystems at the global scale led by Conservation International and BirdLife International.

d) **Added value through links to related datasets**. This biodiversity dataset will be made widely available for linking to other information sets such as for poverty alleviation, livelihoods analyses, and socio-economic valuations of wetland ecosystems. A follow-up proposal has been submitted to integrate the information presented here with that from wetland valuation exercises conducted at a number of sites in Eastern Africa. The project will focus on "pro-poor conservation planning for inland waters".

e) **Integration with Conservation Decision Support (CDS) software packages.** Many CDS packages have been developed to assist the integration of multiple information sets in the conservation planning process (e.g., Possingham *et al.* 2001). In particular, software has been developed to directly link datasets from ArcView with the software package MARXAN (Ball and Possingham 2000) (Smith pers. comm.). This software has been designed to help conservationists, developers, and environmental planners evaluate the merits of scenarios for a wide range of priority setting factors. Until now, datasets for inland water biodiversity have not been readily available to take this process forward. The potential application of this software is being investigated.

Chapter 6

Summary

This study aimed to eliminate the information bottleneck for effective biodiversity conservation and livelihood protection in the inland waters of Eastern Africa. In the pursuit of this objective a total of 1,661 taxa of fishes, molluscs, odonates and crabs have been assessed for their threatened status, conservation requirements, preferred habitats, and modes of utilisation. Distribution ranges have been mapped for the majority of taxa. Centres of species richness, threatened status and restricted range have been mapped.

The major threats to biodiversity in inland waters are identified as loss and degradation of habitat, predation and competition from introduced non-native species, and, in some cases, unsustainable use such as through fisheries. Potential impacts from the alteration of water courses and over-abstraction of water, as associated with developments for improved access to safe drinking water, sanitation and hydro-electric power, are highlighted. The dataset provided here can be used to help minimise, or mitigate for, the impacts of these developments.

Regional capacity for biodiversity assessment and conservation planning has been raised through training in the IUCN Red Listing process, field taxonomy, data management in the SIS database, and through expansion of the IUCN/SSC expert network of specialists. A number of national and regional decision makers have been made aware of the study and two follow-up projects have been proposed to help maintain momentum and to develop methodologies for effective integration of biodiversity considerations within the development planning process. The complete dataset and GIS maps will be made widely and freely available throughout the region and beyond providing an important resource for future conservation planning and research throughout the region. A lack of available data can no longer be used as a valid reason for the failure to integrate biodiversity considerations within the development planning process for inland waters throughout Eastern Africa.

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The Species Survival Commission (SSC), created in 1949, is the largest of IUCN's six volunteer commissions. With 8,000 scientists, field researchers, government officials and conservation leaders worldwide, the SSC membership is an unmatched source of information about biodiversity conservation. SSC members provide technical and scientific advice to conservation activities throughout the world and to governments, international conventions and conservation organizations. They provide the best available information critical to the development of conservation products and tools such as the IUCN Red List of Threatened Species. SSC works primarily through its 130 Specialist Groups, which focus on a wide range of plants and animals, or on issues such as invasive species and sustainable use of wildlife. Web: www.iucn.org/themes/ssc

SSC Occasional Papers cover a broad range of subjects including conservation of groups of species in a particular geographical region, wildlife trade issues, and proceedings of workshops.

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