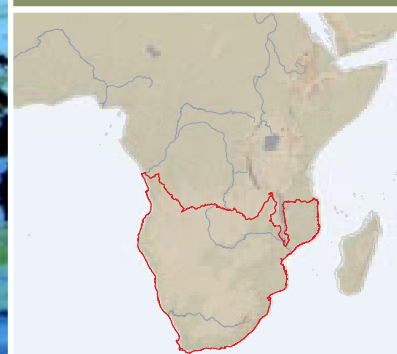


THE STATUS AND DISTRIBUTION OF FRESHWATER BIODIVERSITY IN SOUTHERN AFRICA

W.R.T. Darwall, K.G. Smith, D. Tweddle and P. Skelton



SOUTHERN
AFRICA



The IUCN Red List of Threatened Species™ – Regional Assessment

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Executive Summary

Biodiversity within inland water ecosystems in southern 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 within the development planning process. One of the main reasons cited for inadequate representation of biodiversity is a lack of readily available information on the status and distribution of inland water taxa. In response to this need for information, the IUCN Species Programme, in collaboration with the South Africa Institute for Aquatic Biodiversity (SAIAB) and the South African National Biodiversity Institute (SANBI) conducted a regional assessment of the status and distribution of 1,279 taxa of freshwater fishes, molluscs, odonates, crabs, and selected families of aquatic plants from across southern Africa. 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, including application of the IUCN Red List Categories and Criteria and species mapping using GIS software. Distribution ranges have been mapped for the majority of species so providing an important tool for application to the conservation and development planning processes. The full dataset, including all species distribution files (GIS shape files), is freely available in the CD accompanying this report and through the IUCN Red List website (www.iucnredlist.org).

Three key centres of species diversity identified are: (i) the upper Zambezi at the confluence of the upper Zambezi, Kwando and Chobe rivers above the Victoria Falls, (ii) the Komati and Crocodile river tributaries of the Incomati system in Mpumalanga, South Africa, and (iii) the Mbuluzi river basin, also in Mpumalanga, South Africa and in Swaziland. The combined diversity of fishes, molluscs, odonates, crabs and aquatic plants is exceptionally high in these three areas. A network of river and lake basins are identified as candidate Key Biodiversity Areas (KBAs) most important for the protection of threatened and restricted range species. Ten of these sites are proposed as Alliance for Zero Extinction (AZE) sites holding Critically Endangered or Endangered species in most urgent need of conservation action at the site scale. These proposed AZE sites should form the focus of the most immediate conservation actions if species extinctions are to be prevented. Levels of regional endemism are high, particularly in many of South Africa's coastal drainages, in the Kunene and Kwanza rivers on the west coast of Angola, and also in the Rovuma and Pungwe/Buzi systems on the east coast of Mozambique.

Around 7% of all species assessed are regionally threatened according to IUCN Red List Categories and Criteria. This level of threat may appear low relative to other taxonomic groups but, following comparison with similar studies in other parts of the world, the level of threat is predicted to increase dramatically unless the ecological requirements of freshwater species are given much greater consideration in future development planning, in particular for development of water resources such as for improved water supply, irrigation and provision of hydro-electric power. Major threats are identified as loss and degradation of habitat, in particular from sedimentation due to deforestation and eutrophication, unsustainable levels of water extraction, and the introduction of alien invasive species. The majority of threatened species are found in South Africa, largely reflecting the greater levels of development activity here when compared to other countries in the region. The data set provided here provides a great opportunity for helping development to proceed while minimizing or mitigating for impacts to freshwater biodiversity.

Inland waters throughout the region are poorly represented within the existing protected areas network which is largely designed for protection of terrestrial ecosystems. Future efforts must take account of the upstream and downstream connectivity in freshwater ecosystems. For example, it is recommended that conservation efforts focus on the protection of upper catchment areas, provision of adequate environmental flows, and the inclusion of rivers within protected areas rather than as the boundary markers for protected areas. Integrated river basin management is recommended along with the initiation of additional river/lake basin authorities.

The results of this assessment are to be merged with similar studies being conducted by this project for all other regions of Africa to provide a baseline of the status and distribution of freshwater biodiversity throughout all of Africa. This information source, which will be made freely and widely available, will provide the essential information, currently lacking in many places, to help conservation and development planning proceed in a manner that takes full account of the requirements of freshwater species.

Finally, it is most important that the findings and the data compiled here 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 number of

case studies are running as a key component of the project to develop a series of “Good Practice Guidelines” for the integration of biodiversity information within the environmental and development planning processes.

The key messages from this assessment are:

- The inland waters of southern Africa support a high diversity of aquatic species with high levels of endemism. Many of these species provide direct (e.g. fisheries) and indirect (e.g. water purification) benefits to people. The conservation of these species is most important to the livelihoods and economies of the regions’ people.
- Current levels of threat across the region are relatively low with 7% of species threatened. However, predicted future levels of threat, in particular due to development of water resources, are very high. The level of threat to species in South Africa is higher than in other countries. Steps will need to be taken to minimize or mitigate for predicted impacts to the regions’ freshwater species.
- Data on the distributions, conservation status, and ecology of all 762 known species of fishes, molluscs, odonates, crabs, and 517 selected species of aquatic plants are now freely available through this project and the IUCN Red List website (<http://www.iucnredlist.org/>) to inform conservation and development planners.
- The current network of protected areas is not designed for protection of freshwater species with many falling outside of any protected area. Future protected areas must be designed for the effective conservation of freshwater species.
- The data made available through this assessment must be integrated within the decision-making processes in planning for the conservation and development of inland water resources. Lack of available information should no longer be given as a reason for inadequate consideration for development impacts to freshwater species.
- Species information remains very limited for many parts of the region with Angola and Mozambique, in particular, identified as priorities for future field survey. Information on the status and distribution of aquatic plants needs to be greatly improved throughout the region.

Chapter 1. Background

Darwall, W.R.T.¹, Tweddle, D.², Skelton, P.H.² and Smith, K.S.¹

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The goods and services derived from inland waters have an estimated global value of several trillion USD 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). The best estimate of current tropical river and inland fisheries production is 5.46 million tonnes valued at USD5.58 billion (gross market value), which is equivalent to 19% of the current value of annual fish exports from developing countries (USD29 billion) (Neiland and Béné 2008). 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 allowed the loss of 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). This situation is set to worsen as pressures on water resources increase.

With global development objectives firmly focused on dealing 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/millenniumgoals/>), the stage is set for a potential large-scale impact to freshwater biodiversity. In Africa the development of water resources is a major priority with around 300 million people lacking access to adequate water supply and about 313 million people lacking access to adequate sanitation (World Water Forum Africa Water Report 2005). Given Africa's predicted rate of population growth it will be necessary to provide a

water supply and sanitation to an additional 21 million people each year, on average (World Water Forum Africa Water Report 2005). Access to power (electricity) is also very limited and there are proposals to address this through making use of Africa's extensive potential for hydropower with plans for major development of infrastructure, such as dams. The hydropower potential of the region is estimated to be about 1.4 million GWh, of which less than 3% is utilized (ECA, AU and AfDB 2000). The developments required to meet these requirements for drinking water, sanitation and hydropower will have a significant impact on the region's wetland ecosystems. An immediate initiative is required to assess the status of freshwater biodiversity and to integrate that information into the water development planning process. Without this baseline information it will be difficult to minimize

Collection of water lilies for human consumption. Photo: © SAIAB/Roger Bills



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or mitigate for significant impacts to freshwater biodiversity, the potential loss of livelihoods, and a decline in those national economies dependent on biodiversity goods and services. The outputs of the project presented here are a major step towards fulfilling that requirement for Southern Africa, a region with great problems of water scarcity and lack of supply, significant dependence on freshwater biodiversity products, and widely dispersed, largely inaccessible, information on freshwater biological diversity. This work represents the results of work completed to assess the distribution and status of freshwater biodiversity throughout southern Africa as part of a broader assessment for all of mainland Africa. The first regional report for eastern Africa was published in 2005 (Darwall *et al.* 2005) and a further four reports will be published for central, western, northern and north-eastern Africa. On completion of this work a comprehensive assessment of the distribution and status of Africa's freshwater biodiversity will be published. This work aims to build on the publication *The Freshwater Ecoregions of Africa and Madagascar - A Conservation Assessment* (Thieme *et al.* 2005).

1.1 Global status of freshwater biodiversity

1.1.1 Species diversity

Freshwater animals are generally defined as those species which depend upon freshwater habitats for any critical part of their life cycle. Current estimates suggest the overall magnitude of described freshwater animal species is 126,000, half of which are represented by the very speciose class of Insecta (Balian *et al.* 2008). Some 45% (13–14,000 species) of known species of fish inhabit freshwater, representing almost 25% of the world's known vertebrates. When amphibians, aquatic reptiles and mammals are added to this total, it becomes clear that as much as one-third of all vertebrate species are confined to freshwater. The true number will be much higher than this as, for example, between 1976 and 1994, an average of 309 new fish species, approximately 1% of known fishes, were formally described or resurrected from synonymy each year (Stiassny 1999) and this trend has continued (Lundberg *et al.* 2000). The definition of freshwater plants or hydrophytes is generally accepted to be, "all plants that tolerate or require flooding for a minimum duration of saturation/inundation" (Gopal and Junk 2000). There are an estimated 2,614 aquatic vascular macrophyte plant species within the two better-known plant divisions Pteridophyta and Spermatophyta. About 39% of the *c.* 412 genera containing aquatic vascular macrophytes are endemic to a single biogeographic region, with 61–64% of all aquatic vascular plant species found in the Afrotropics and Neotropics being endemic

to those regions (Chambers *et al.* 2008). While terrestrial and marine ecosystems have a larger percentage of known species, the relative richness of freshwater ecosystems is higher as these species are restricted to living in a habitat which only covers an estimated 0.8% of the world's surface area (Gleick 1996).

1.1.2 Major threats to freshwater species

It is widely recognised that freshwater biodiversity and habitats are under serious threat (Revenga and Kura 2003; Leveque *et al.* 2005; Dudgeon *et al.* 2006) and that the level of threat exceeds, or will soon exceed, that in either terrestrial or marine ecosystems (e.g. WWF Living Planet Index, Millennium Ecosystem Assessment 2005). Dudgeon *et al.* (2006) grouped the main threats under five interacting categories; over-exploitation, water pollution, flow modification, destruction or degradation of habitat, and invasion by exotic species. Environmental changes occurring at the global scale, such as nitrogen deposition, warming, and shifts in precipitation and runoff patterns, are superimposed upon all of these threat categories (Dudgeon *et al.* 2006). The primary *indirect* drivers of degradation and loss of habitat have been population growth and increasing economic development and the primary *direct* drivers of degradation and loss include infrastructure development, land conversion, water withdrawal, pollution, overharvesting and over-exploitation, and the introduction of invasive alien species (Millennium Ecosystem Assessment 2005). In Africa the most immediate impacts are likely to include habitat degradation and flow modification due to the actions of development projects aimed at meeting the growing requirement for access to safe drinking water, improved sanitation, irrigation for agriculture, and hydropower. The Fourth World Water Forum document on Water Resources Development in Africa highlights the situation with statements such as "...the Region (Africa) requires significant investments in infrastructure, such as storage dams, water harvesting, irrigation and hydropower structures, as a priority." These needs are well recognised but the report fails to effectively stress the importance in implementing these developments in ways which will minimize impacts to freshwater biodiversity which is dependent upon functioning freshwater ecosystems. People need not only water and electricity, they also rely heavily upon the direct and indirect services wetland ecosystems provide, such as food (e.g. freshwater fish provide 21% of protein intake in Africa (Revenga *et al.* 1998)), medicines, building material, flood control, and water purification to name but a few. An integrated approach to development is required in order to ensure people can benefit from greater access to water and electricity while still receiving the benefits provided by fully functioning freshwater ecosystems. Development is necessary to support and feed growing populations, but it



Clanwilliam Dam on the Olifants River in the Western Cape Province of South Africa, in full flood. This dam has no fish ladder and has prevented upstream migration of several threatened species, including *Labeobarbus capensis*, *Barbus serra* and *Labeo seeberi*. Anon (1950) describes *Barbus serra* laying four deep on the concrete spillway in December 1942 (the dam was completed in 1935) and “shoal followed shoal in endless procession”. The run of *B. serra* was followed by a run of “many hundreds” of *L. capensis* of 10 lb and more. The reservoir upstream is now populated by alien American bass species. Photo: © Denis Tweddle.

often leads to degradation of freshwater ecosystems when projects are planned and implemented without adequate consideration for the environmental consequences. What may start as a project to supply water, create employment opportunities and raise the standard of living, often becomes a story of environmental damage, loss of opportunities, loss of livelihoods dependent upon wetland biodiversity, and increasing poverty. Only through integrated river basin management can governments and local people work together to provide the water needed to sustain both people and the environment upon which they depend.

Finally, there is the threat posed by climate change and its predicted impact on the rates and patterns of precipitation, and temperature change. The predicted impact of climate change on precipitation across southern Africa is for a 10–20% reduction from the present levels by the end of the 21st Century (de Wit and Stankiewicz 2006), with a predicted average temperature increase of 1.6–1.8°C by 2050 (Hulme *et al.* 2001). Many freshwater species not only require specific rates and cycles of water flow and flooding to survive and to breed but are also

highly sensitive to changes in water temperature – these predicted changes in precipitation and temperature will surely have a significant impact on species survival in freshwater systems.

1.1.3 Species threatened status

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 adopted 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 2007) (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. As an example for freshwater fishes, 56% of species endemic to the Mediterranean Basin, 38% of all European species (Kottelat and Freyhoff 2007), and 54% of species endemic to Madagascar (IUCN 2004) have been assessed as threatened. Given the global level of threat to mammals (23%) and birds (12%), this is recognised as a major concern. Table 1.1 provides an estimate of the percentage of all inland water taxa assessed for the 2006 IUCN Red List and the number of species classified as threatened.

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, nearly one-third (32%) of the world’s amphibian species are threatened, representing 1,896 species, as many as 165 amphibian species may already be extinct and at least 43% of all species are declining in population, indicating that the number of threatened species can be expected to rise in the future (Stuart *et al.* 2004).

1.2 Situation analysis for southern Africa

Southern Africa’s wetlands are among the most diverse, both physically and biologically of any in the world (Taylor *et al.* 1995), yet their rate of loss is suspected to be very high. For example, Begg (1988) showed that in the Mfolozi catchment of Natal, South Africa, 58% of the original wetland area had been lost by the mid-1980s. Inventories are being planned (Finlayson, M. pers. comm.) to update and improve the baseline data on wetland area, distribution, seasonality, characteristics and values, so that rational management plans can be designed. Most of the larger wetlands of southern Africa have now been described, Hughes and Hughes (1992) in particular list the major characteristics of them, including their fauna, flora, human impact and utilization.

Southern Africa consists mainly of a broad swathe of high land, the Central African Plateau, mostly above 1,000 metres, draining to the north-west into the Congo basin and east to the Zambezi, which passes through the comparatively low land of Mozambique to join with the drainage from the southern part of the Rift Valley, before passing to the sea. In the centre of southern Africa,



Allocnemis leucosticta (Sélys, 1863), a damselfly species endemic to South Africa where it is found in woodland or forest rivers. Photo: © Mike Samways.

Table 1.1 Estimated numbers of extant inland water-dependent species and the number of these that were at risk of extinction according to the 2006 IUCN Red List. Birds, mammals and amphibians are the only taxa to have been comprehensively assessed. DD = Data Deficient and refers to the number of species assessed for which there were insufficient data to assign a threat category. Data sources: Revenga and Kura 2003; Balian *et al.* 2008; with assistance from Wetlands International, and the IUCN Red List Unit; see also <http://www.globalamphibians.org>.

Taxon	Estimated total number of inland water-dependent species or subspecies	Estimated percentage assessed for the 2006 IUCN Red List	Number of species assessed as threatened on the 2006 IUCN Red List
Plants	2,614	<0.2% (36 species)	30 (DD: 1)
Insects	>125,000	<0.5% (544)	165 (DD: 63)
Molluscs	>5,000	<15% (756)	400 (DD: 110)
Crustaceans	>14,000	<4% (533)	455 (DD: 32)
Fishes	>15,000	<15% (2,157)	947 (DD: 332)
Reptiles	500	<35% (175)	105 (DD: 6)
Amphibians	3,908	100% (4,028)	1,056 (DD: 889)
Waterbirds	868	100% (1,313)	108 (DD: 8)
Mammals	c.135	100% (129)	39 (DD: 11)

Botswana's Okavango Delta wetland lies in the Cubango and Kalahari internal drainage basin, overflowing to the Zambezi when Angola's rainfall is very high. Further south, the Orange River drains a large basin falling away westwards from the high mountains of Lesotho and the Drakensberg. All around the Central African Plateau hundreds of rivers drain the catchment, often originating in dambos (shallow wetlands). Notably in Mozambique, mangrove forest forms along the coast towards the equatorial regions. Even the most arid of the southern African countries, Namibia, has a significant coastal wetland system. To a great extent the nine countries of the region either share their borders with great rivers or have them passing across international boundaries. The Zambezi in particular is, to a varying extent, shared by Angola, Zambia, Namibia, Botswana, Zimbabwe, reaching the sea in Mozambique. The presence of so many transboundary river basins raises the need for shared management and use of water resources between countries. International water law relies on the basin states working together and has led to the formation of a number of transboundary river basin authorities since 1995, when the majority of the Southern African Development Community (SADC) nations agreed and signed the Protocol on Shared Watercourse Systems (Pallet 1997).



An example of one of the extensive wetlands in southern Africa - the Barotse Floodplain on the Zambezi River at full flood in May 2003. The floodplain at this point, beside the town of Mongu, is about 50 km wide and was completely under water at the time. Photo: © SAIAB/Denis Tweddle.

The general distribution and status of freshwater biodiversity across the region has been described in some detail within the context of the set of freshwater ecoregions delineated for Africa by Thieme *et al.* (2005). The freshwater ecoregions of the southern Africa region are shown in Figure 1.1 and are summarised in Table 1.2.



Figure 1.1 Delineation of freshwater ecoregions within the assessment area, labelled as defined by WWF-US (Thieme *et al.* 2005).

Table 1.2 The 22 ecoregions defined in Thieme *et al.* (2005). Major habitat types: FSL, Floodplain, Swamps and Lakes; MS, Mediterranean Systems; HMS, Highland and Mountain Systems; SDFR, Savannah-Dry Forest Rivers; SSS, Subterranean and Spring Systems; XS, Xeric Systems. Biological distinctiveness: GO, globally outstanding; CO, continentally outstanding; BO, bioregionally outstanding; NI, nationally important.

Ecoregion	Major Habitat Type	Biological Distinctiveness	Ecoregion delimitation	Conservation Status
Kafue	FSL	NI	Kafue Basin separated from Middle Zambezi by falls in Kafue Gorge. Fauna reflects series of river captures	Vulnerable
Okavango Floodplains	FSL	GO	Internal drainage system, but intermittently connected to Upper Zambezi River at times of high flow. Fauna with western Zambezi affinities	Vulnerable
Upper Zambezi Floodplains	FSL	NI	Defined by the floodplains of the Zambezi and Cuando rivers above Victoria Falls. Victoria Falls are a barrier to upstream movement of Middle Zambezi fauna	Relatively intact
Cape Fold	MS	GO	Coastal rivers of the southern tip of the continent with highly endemic fauna	Critical
Amatolo-Winterberg Highlands	HMS	BO	Defined by the Amatolo-Winterberg Highlands, the southern extent of the montane escarpment aquatic region. Mixed fish fauna linked to the evolution of the Orange-Vaal river basin, with endemic and range-restricted species	Vulnerable
Drakensberg-Maloti Highlands	HMS	BO	Delineation follows boundaries of the Drakensberg-Maloti Highlands, a residual portion of the peripheral uplands of the Great Escarpment	Critical
Eastern Zimbabwe Highlands	HMS	NI	Defined by the high-elevation easternmost rim of the central-southern African plateau along the eastern Zimbabwe-Mozambique border.	Endangered
Cuanza	SDFR	CO	Affinities with Southern West Coastal Equatorial Bioregion, fauna distinct from those of Zambezi and Congo with a number of endemic species	Vulnerable
Lower Zambezi	SDFR	NI	Difference in riverine character separates low gradient Lower Zambezi, particularly extensive delta, from steeper gradient Middle Zambezi. Distinct fish fauna with Zambian, Congo and East Coast elements.separates both from Upper Zambezi	Endangered
Middle Zambezi Luangwa	SDFR	NI	Middle Zambezi historically formed part of eastern drainage system that included Lower Zambezi, Lower Kafue, Luangwa and Shire rivers	Endangered
Eastern Coastal Basins	SDFR	CO	Coastal basins from Wami in Tanzania south to Luala River in Mozambique. Fauna has affinities with Lower Zambezi fauna but with other distinct species	Vulnerable
Southern Temperate Highveld	SDFR	BO	The South African interior plateaux subregion of the highveld aquatic ecoregion, fauna with mixed tropical and temperate affinities, sharing species with Limpopo and Zambezi systems	Endangered
Zambezi Headwaters	SDFR	BO	Headwaters of Zambezi, Okavango, Kafue and Kunene Rivers. Zambezi shares a number of species with southern Congo tributaries and some northern Zambezi tributaries have distinct species.	Relatively intact
Zambezi Lowveld	SDFR	BO	Overlap region of tropical Zambezi and southern temperate faunas, defined by low-lying portions of the coastal rivers south of the Zambezi Delta to Lake St Lucia	Vulnerable
Zambezi (Plateau) Highveld	SDFR	NI	Northern subregion of the highveld aquatic ecoregion, above 600 m contour of interior plateaux of Zimbabwe; fauna Zambezi but largely depauperate	Critical
Karstveld Sinkholes	SSS	BO	Defined by extent of the Karstveld, extensive dolomite and limestone formations to south-east and east of Etosha Pan. Fauna characterized by stygobiotic, endemic species because of lengthy period of isolation	Endangered

Table 1.2 cont'd, The 22 ecoregions defined in Thieme *et al.* (2005). Major habitat types: FSL, Floodplain, Swamps and Lakes; MS, Mediterranean Systems; HMS, Highland and Mountain Systems; SDFR, Savannah-Dry Forest Rivers; SSS, Subterranean and Spring Systems; XS, Xeric Systems. Biological distinctiveness: GO, globally outstanding; CO, continentally outstanding; BO, bioregionally outstanding; NI, nationally important.

Ecoregion	Major Habitat Type	Biological Distinctiveness	Ecoregion delimitation	Conservation Status
Etosha	XS	NI	Ecoregion defined by Cuvelai drainage basin, including Etosha Pan, fauna adapted to seasonal flooding and long dry spells	Vulnerable
Kalahari	XS	NI	Xeric ecoregion in northern portion of the Kalahari Desert and its endorheic systems, the Makgadikgadi region is the relic of an ancient inland-draining lake. Fish only enter pans in floodwaters from Boteti (Okavango system) and Nata rivers	Relatively intact
Karoo	XS	NI	Semi-arid ecoregion defined by succulent Karoo and Nama Karoo regions, depauperate southern temperate (Cape) ichthyofauna	Vulnerable
Namib Coastal	XS	NI	Coastal and largely ephemeral rivers and wetlands of the Skeleton Coast and Namib Desert, including lower Kunene River, which has endemic fishes and also Zambebian elements	Vulnerable
Southern Kalahari	XS	NI	Delineated based on distribution of relict Kalahari River systems that flowed into Orange basin. Few widespread (Zambebian) fish species in isolated springs and sinkholes	Endangered
Western Orange	XS	BO	Defined by mainstem of the Orange River and tributaries below Orange-Vaal confluence, northern limit of southern temperate (Cape) fauna and southern limit of Zambebian fauna	Endangered

1.2.1 Regional threats

A major threat to southern Africa's wetlands and their biodiversity is the abstraction or modification of water resources for human uses. A broad overview of these issues is presented in the report "Sharing Water in Southern Africa" by Pallet (1997) from which the following points have largely been taken. Given the unpredictable rainfall, very high loss through evaporation (around 65% of rainfall), and low conversion of rainfall to runoff it is clear that southern Africa is generally poor in terms of water resources and faces water management difficulties where it is extremely difficult to satisfy the growing demands for reliable and safe water supplies. In an effort to meet the increasing demand for water and power, many large wetlands have been affected by developments such as dams, flood control measures, or direct abstraction and their ecological function has been impaired – the ability of these wetlands to support people now and in the future has been reduced. Groundwater reserves are also being used, most often for agriculture, at a faster rate than they can be replenished such that the water table is being lowered and wetland areas are disappearing. Abstraction for agriculture accounts for about 70% of the total water consumption from rivers and aquifers. Many small wetlands are also drained to prevent malaria or to plant crops, and rivers are canalized in an effort to control the flow. Such measures destroy or reduce the effective functioning of wetlands and their floodplains with a consequent impact

on their associated biodiversity. A systematic assessment of river biodiversity in South Africa found that 84% of river ecosystems are threatened with 54% critically endangered (Nel *et al.* 2007). Furthermore, of the 112 main river ecosystems only 16 are moderately to well represented within protected areas (Nel *et al.* 2007). It was also concluded that South Africa's river ecosystems are, in general, under more pressure than its terrestrial ecosystems (Driver *et al.* 2005).

Dams

One of the main conclusions of the Report of the World Commission on Dams (World Commission on Dams 2000) is that "On balance, the ecosystems impacts are more negative than positive and they have led, in many cases, to significant and irreversible loss of species and ecosystems. In some cases, however, enhancement of ecosystem values does occur, through the creation of new wetland habitat and the fishing and recreational opportunities provided by new reservoirs... Efforts to date to counter the ecosystem impacts of large dams have met with limited success due to the lack of attention to anticipating and avoiding such impacts, the poor quality and uncertainty of predictions, the difficulty of coping with all impacts, and the only partial implementation and success of mitigation measures." Southern Africa has a large number of dams, in particular in South Africa and Zimbabwe (see Figure 1.2) and more are planned. By 1997 more than 30 large dams had been built in the Zambezi

River basin alone for domestic, industrial and mining water supply, irrigation and power generation, the most notable of these being the Cahora Bassa Dam in Mozambique and Kariba in Zimbabwe. The estimated hydropower potential of the Zambezi Basin is 20,000 MW of which about 4,500 MW had been installed in 1997 (Pallet 1997). With growing demands for hydropower the number of dams is likely to increase. This situation is similar for many of the other large river basins throughout southern Africa.

Water transfers

The uneven distribution of rainfall across southern Africa has left some regions rich in water resources while others have insufficient supplies. The obvious solution from a manager or user's point of view is to transfer water from water-rich catchments to those where water is limited. Many such water transfers have been implemented throughout southern Africa and Pallet (1997) listed 26 major present or proposed water transfer schemes at the time of writing. In Namibia, for example, water is transferred from the Okavango catchment where the Omatoko Dam suffers excessive evaporation, to the adjacent catchment, the Swakop, where the Von Bach Dam has lower levels of evaporation.

Major schemes in South Africa, indicating the amount of water transferred between systems, are illustrated in Figure 1.3. For example, Cape Town's water has been supplemented by the import of water from the Steenbras Dam since 1921. More recent schemes are often much bigger and run the risk of significant impacts which include: (i) flow reduction in the donor rivers and increased flow in the recipient rivers with major implications for channel integrity and ecological functioning leading to a frequent loss of biodiversity; (ii) changes in the physical and chemical status of the river water such as through the transfer of clear water to a normally muddy river which is likely to increase algal growth; (iii) introduction of fine sediments from one river to another leading to a loss of habitats such gravel spawning beds for fishes, as experienced in the Great Fish River which receives water from the Orange River with a subsequent change in the invertebrate fauna, and; (iv) the spread of alien fish species, floating aquatic plants, and animal diseases and their vectors. As an example of the risk in spread of alien species the tunnel linking the Orange with the Great Fish River contains grids, baffles and pepper pot valves, and the water is finally blasted at high pressure against a concrete wall yet four fish species previously absent in the Great Fish River have established populations there, with the

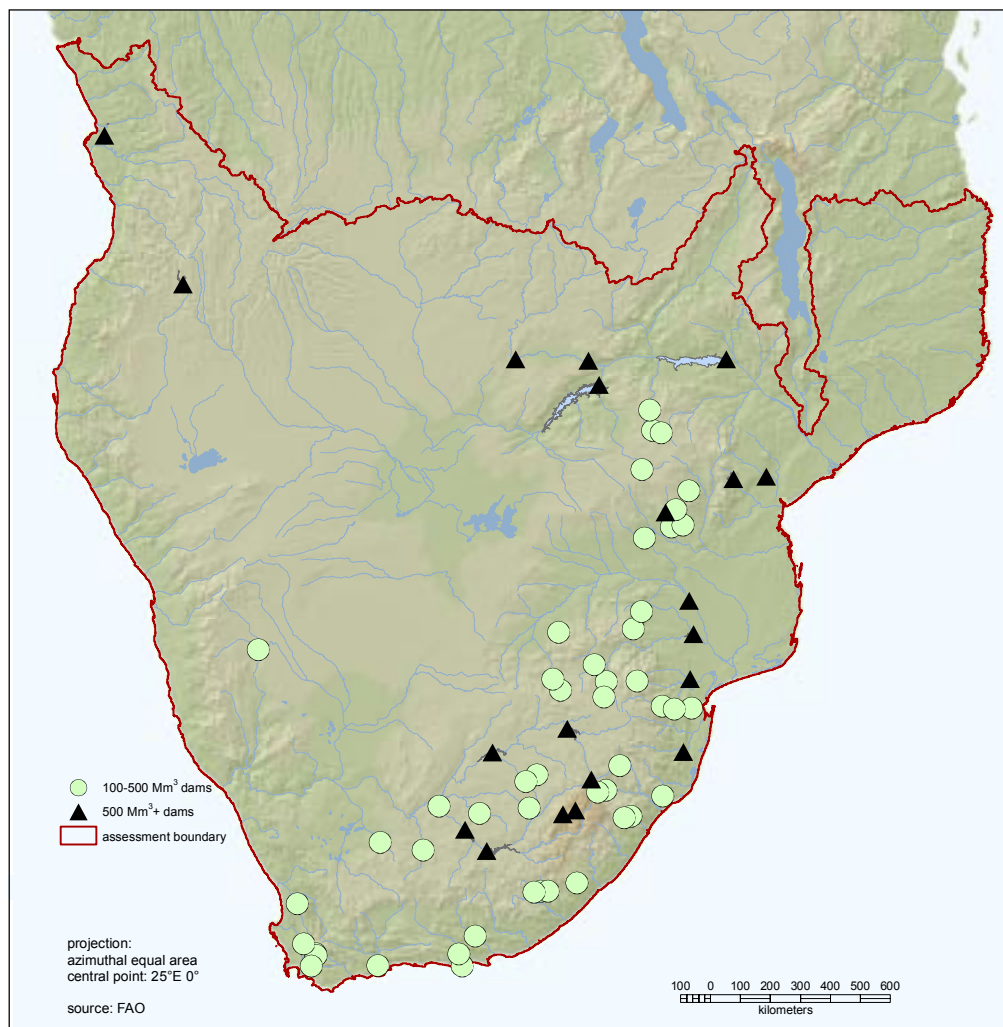


Figure 1.2 Location of large dams (>500 m) and secondary dams (100–500 m) in the southern Africa region. Source: FAO AquaStat 2005.

danger of subsequent competition with the resident endemic species. Many of these changes that accompany a water transfer between river systems may be unavoidable but managers should be made aware of these impacts and make every effort to minimize or avoid any serious damage to the river and lake systems involved and to their biodiversity.

The Lesotho Highland Water Project demonstrates how efforts can be made towards minimizing or mitigating impacts of water transfer schemes. This project was assessed as creating a potentially major threat to the survival of the western Maloti minnow species, *Pseudobarbus* sp. “*cf. quathlambae* Mohale” as a water transfer tunnel linking Lake Katse on the Malibatso River with Lake Mohale on the Senqunyane River allows rainbow trout, *Oncorhynchus mykiss* (Walbaum, 1792), and smallmouth yellowfish, *Labeobarbus aeneus* (Burchell, 1822), to invade the Senqunyane River, which previously held only the Maloti minnow. A project to save the minnow involves translocation of the minnow to fishless tributaries above natural barriers, but the other recommendation to create a waterfall or weir barrier above Mohale Dam to prevent upstream invasion by trout has not been implemented despite World Bank intervention.

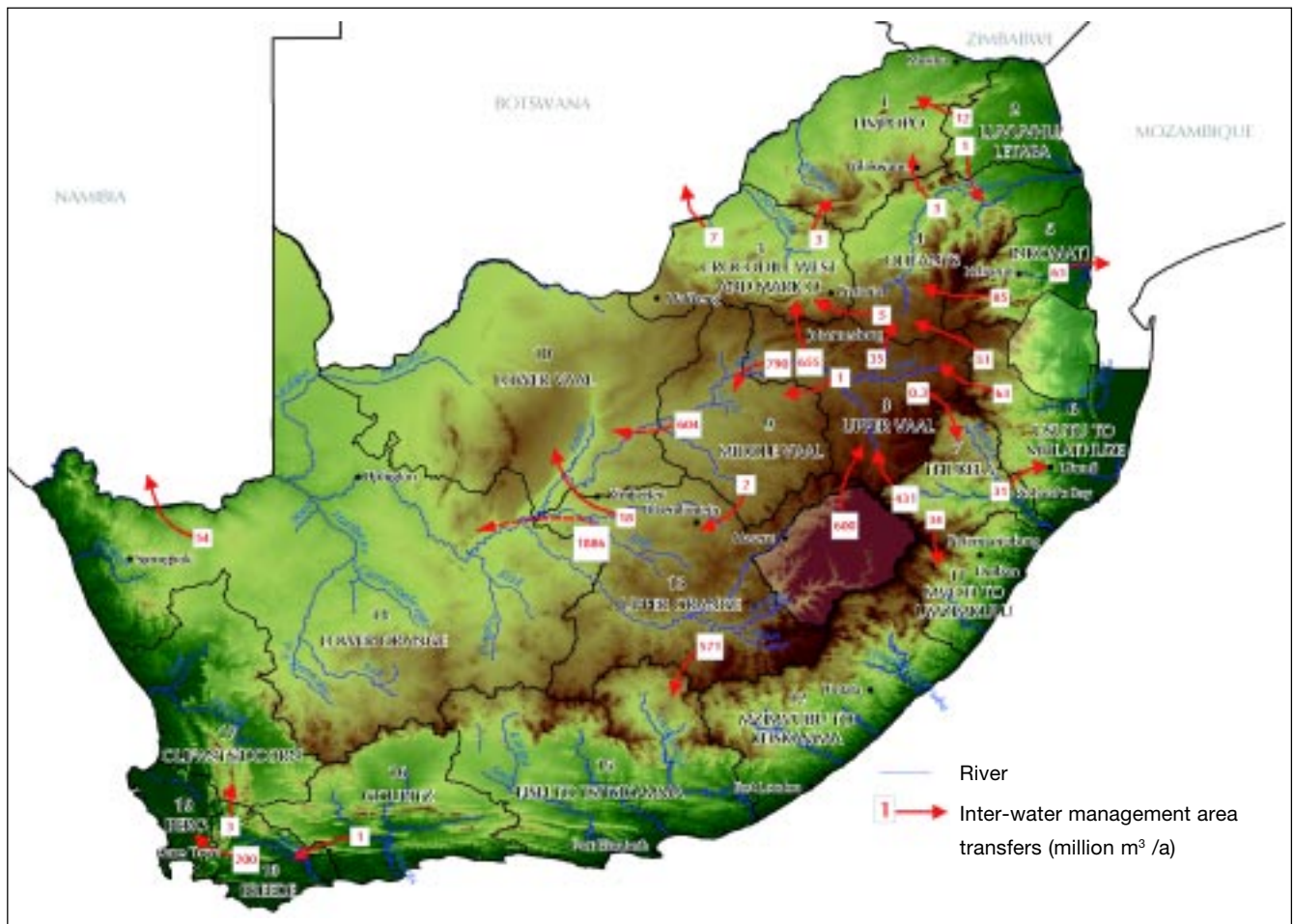
Invasive alien species

The spread of alien invasive plants and animals is also a major threat throughout southern Africa. In particular, a number of introduced fish species have led to local extirpations of indigenous species and the spread of alien plants has been associated with loss of invertebrates such as dragonflies. The following examples are covered in more detail in the chapters for the relevant taxonomic groups.



Sampling the Tsoelikane River in the Lesotho Highlands for *Pseudobarbus quathlambae* during the Maloti minnow conservation project. Photo: © SAIAB/Denis Tweddle.

Figure 1.3 Schematic to show the size and location of water basin transfer projects in South Africa. Source: RSA Department of Water Affairs and Forestry.



In the more temperate waters of the southern part of South Africa, particularly in the Western Cape, alien fishes introduced for angling are a particularly serious threat. Smallmouth bass (*Micropterus dolomieu* (Lacepède, 1802)), together with largemouth and spotted bass (*M. salmoides* (Lacepède, 1802) and *M. punctulatus* (Rafinesque, 1819)) and bluegill sunfish (*Lepomis macrochirus* (Rafinesque, 1819)), all from North America, and banded tilapia (*Tilapia sparmanii* A. Smith, 1840) from further north in Africa now dominate the fish fauna in more than 80% of the Olifants River system, with indigenous fish often surviving in less than 1 km of river in headwater streams. Rainbow trout, *O. mykiss* and brown trout, *Salmo trutta* L. 1758, have had major impacts in cooler headwater streams.

Further north in the more tropical parts of the region, the Nile tilapia, *Oreochromis niloticus* (L., 1758), which is being widely distributed for aquaculture, is having major impacts on indigenous *Oreochromis* species, resulting in extirpation of *O. mortimeri* (Trewavas, 1966) from Lake Kariba in the Zambezi system, at least in the area near the aquaculture cages. In the Limpopo River system to the south, *O. mossambicus* (Peters, 1852) is rapidly being replaced by *O. niloticus* (Tweddle and Wise 2007).

Invasive alien trees (IATs) are a threat to South African odonates (Samways and Grant 2006). IATs shade out the habitat of the sun-loving odonate species. Almost all the threatened species of odonates in South Africa appear to be threatened by multiple impacts, the greatest of which is the effect of IATs (Samways 2004). These trees are being removed through the “Working for Water Programme”, the principal aim of which is to rehabilitate water supplies for human consumption. However, it has become clear that there are major benefits for biodiversity recovery, in particular for odonates. For example, the only known site for *Pseudagrion newtoni* is where alien trees (principally *Acacia mearnsii*) have been removed and the long grass has since recovered.

The highly invasive Nile tilapia, *Oreochromis niloticus*, a specimen from the Kafue tributary of the Middle Zambezi. The species has replaced the indigenous and now threatened *O. mortimeri* in Lake Kariba on the Middle Zambezi River. Photo: © SAIAB/Denis Tweddle.



Disa stream on top of Table Mountain, Cape Town, where pines were removed resulting in the remarkable recovery of many rare endemic species, including the Mahogany Presba *Syncordulia venator*, assessed as Vulnerable. Photo: © Mike Samways.

Sedimentation and pollution

Deforestation, particularly of upper catchment areas, has led to increased runoff carrying greater sediment loads into river and lake systems. Sedimentation of rivers and lake habitats leads to the deterioration of many habitats important to numerous species. Sedimentation is also a problem in many areas where crops are cultivated right to the rivers edge leading to the increased erosion of river banks and increased sediment loads. In some areas pollution from agricultural and industry effluent has led to eutrophication of water bodies with subsequent fish kills and loss of other aquatic flora and fauna.

Prior to this project there had been no comprehensive assessment of the threatened status of freshwater species in southern Africa, although the 2006 IUCN Red List contained some information, shown in Table 1.3. A more comprehensive and updated regional assessment was therefore required to determine the true regional levels of threat to these taxa.

1.2.2 Regional use and value of wetlands and their biodiversity

A key element in promoting the protection of inland waters is 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 world's poor. Until these benefits are realized, 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



Chiloglanis bifurcus Jubb and Le Roux, 1969, an Endangered fish known only from a few headwater tributaries in the Incomati system in Mpumalanga, South Africa, and Swaziland. This species is threatened by sedimentation from forestry and agricultural activities, water extraction resulting in reduced or no flows, introduced alien fishes (*O. mykiss* and *M. salmoides*) and pollution from the Ngodwana paper mill. Photo: © SAIAB/Roger Bills.

placed in an international economic system, would appear low and would mask the social and even survival benefits they may provide (Emerton and Bos 2004). In response to this need, an increasing number of methodologies and studies have attempted to value wetland biodiversity (e.g. from eastern and southern Africa: Emerton 1998; Turpie and van Zyl 2002; Turpie *et al.* 2003; Turpie *et al.* 2004). For example, a valuation of wetlands in the Zambezi system noted that the total use value of the 10 wetlands valued (USD145 million/year) was equivalent to some 4.7% of Zambia's GDP in 1990 which was USD3,120 million (Seyam *et al.* 2001). A follow-up study of the Barotse Floodplain found local use of wetland resources to have a net economic value of some USD8.64 million a year (IUCN Water and Nature Initiative 2004). At the household level, wetlands were calculated to generate an average net financial return of USD405 a year. Ecological-economic modelling of future wetland options showed that any management scenario

Table 1.3 Estimated numbers of inland water-dependent species in southern Africa assessed for the 2006 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 2006).

Taxon	Number of species assessed	Percentage threatened or extinct
Plants	5	20% (plus 20% DD)
Insects	204	1% (plus 4% DD)
Molluscs	45	22% (plus 9% DD)
Crustaceans	27	67%
Fish	371	6% (plus 4% DD)
Reptiles	7	14% (plus 14% DD)
Amphibians	197	11% (plus 62% DD)
Waterbirds	428	2% (plus <1% DD)
Mammals	15	13% (plus 7% DD)

Note: The boundary of the southern Africa region used to extract these data from the IUCN Red List differed slightly from that employed in the current assessment (see map, Figure 1.4) in that it was based on country borders (in order to match the search parameters of the IUCN Red List database) as opposed to river catchment boundaries. This means that the totals reported in the table include species from Angola and Zambia including their Congo drainages, and from Mozambique including its Lake Malawi shoreline, all of which are excluded from the current assessment region.

which omitted consideration of these values, and did not allow for the local-level use of wetland resources, would run the risk of being both economically and financially sub-optimal, as well as jeopardising the economic livelihoods of almost a quarter of a million people. In another example from eastern Africa, a

Basket fishing and spear fishing party in a drying lagoon on the Barotse Floodplain near the town of Senanga, western Zambia. Photo: © SAIAB/Denis Tweddle.



recent wetland valuation for a village in the Rufiji Delta in Tanzania estimated that on average, wetland products are worth almost twice as much as all other sources of farm production and off-farm income for user households (Kasthala *et al.* 2008). As household wealth decreases so the relative importance of wetland products increases – becoming almost eight times as valuable as other sources of production and income for the poorest households.

The wetland valuation methodology employed in these studies would, however, benefit greatly from a more comprehensive source of biodiversity information as provided through the assessment reported here.

1.3 The Precautionary Principle and species conservation

The Precautionary Principle is one of the key elements for policy decisions concerning environmental protection and management. It is applied in circumstances where there are reasonable grounds for concern that an activity may cause harm to the environment but where there is uncertainty about the probability of the risk and the

degree of harm. In cases where potential threats could lead to serious or irreversible damage, lack of full scientific certainty shall not be used as a reason for postponing cost-effective measures to prevent environmental degradation. This principle should be applied to species conservation. Its relevance is demonstrated below through making the case for conserving all of Lake Victoria’s cichlid species.

Even when the economic value of a wetland and its associated biodiversity has been determined as high, it still remains a difficult task to justify the need to conserve all species in those wetlands. This is particularly true where the diversity is already exceptionally high such as in the freshwater fish communities of many 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. In other words the manager might take the view that not all fish species are needed to ensure a productive fishery. This argument may seem logical but a vivid example demonstrating the importance in conserving all species comes from Lake Victoria in East Africa. Here, introduction

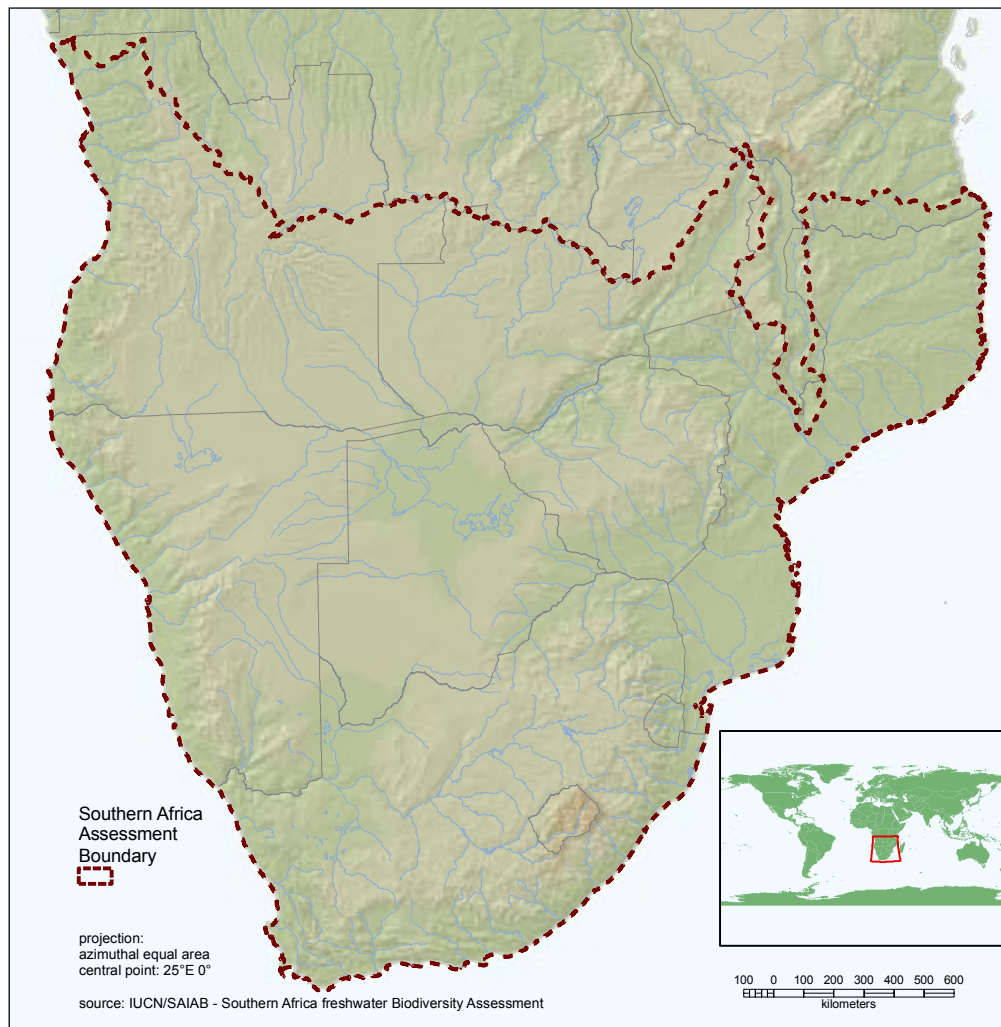


Figure 1.4 The southern Africa assessment region.

of the Nile perch (*Lates niloticus* (L.)) and Nile tilapia (*Oreochromis niloticus*) has contributed to the possible extinction or decline of an estimated 200 species of cichlid fishes 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 for species conservation but, in studying the patterns of recovery for some species, the importance of the precautionary approach becomes clear. 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 (e.g. Witte *et al.* 2008). A few of these species are now starting to dominate in the fish community and form the basis for some of the present day 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 present degraded conditions and future fisheries might be lost. The message given here is to adopt the precautionary approach and assume that all species are important and may one day be key components of fisheries or their supporting foodwebs.

1.4 Objectives of this study

IUCN, in partnership with the Southern Africa Institute for Aquatic Biodiversity (SAIAB), initiated a programme in 2005 to build capacity to conserve and sustainably manage inland water biodiversity resources throughout southern Africa (Figure 1.4). 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 status and distributions of biodiversity throughout the inland waters of southern Africa; 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 regional and global presence of IUCN and partners.

1.5 References

Anon. 1950. Four deep at the barrage. *Piscator*, **4**(14):62.
 Balian E.V., Lévêque, C., Segers, H. and Martens, K. (eds.) 2008. Freshwater Animal Diversity Assessment. *Hydrobiologia* **595**.

Begg, G.W. 1988. The Wetlands of Natal (Part 2). The distribution, extent and status of wetlands in the Mfolozi catchment. Natal Town and Regional Planning Main Studies Report 71:1–262, Pietermaritzburg.

Chambers, P.A., Lacoul, P., Murphy, K.J. and Thomas, S.M. 2008. Global diversity of aquatic macrophytes in freshwater. In: Balian, E.V., Lévêque, C., Segers, H. and K. Martens (eds.) 2008. Freshwater Animal Diversity Assessment. *Hydrobiologia* **595**: 9–26.

Darwall, W., Smith, K., Lowe, T. and Vié, J-C. 2005. The Status and Distribution of Freshwater Biodiversity in Eastern Africa. IUCN SSC Freshwater Biodiversity Assessment Programme. IUCN, Gland, Switzerland and Cambridge, UK.

de Wit, M. and Stankiewicz, J. 2006. Changes in Surface Water Supply Across Africa with Predicted Climate Change. www.sciencexpress.org / 2 March 2006 / Page 1/ 10.1126/science.1119929

Driver, A., Maze, K., Rouget, M., Lombard, A.T., Nel, J., Turpie, J.K., Cowling, R.M., Desmet, P., Goodman, P., Harris, J., Jonas, Z., Reyers, B., Sink, K. and Strauss, T. 2005. National Spatial Biodiversity Assessment 2004: priorities for biodiversity conservation in South Africa, *Strelitzia* **17**. South African National Biodiversity Institute, Pretoria.

Dudgeon, D., Arthington, A.H., Gessner, M.O., Kawabata, Z.I., Knowler, D.J., Lévêque, C., Naiman, R.J., Prieur-Richard, A-H., Soto, D., Stiassny, M.L.J. and Sullivan, C.A. 2006. Freshwater biodiversity: importance, threats, status and conservation challenges. *Biological Review*, **81**:163–182.

ECA, AU and AfDB, 2000. The Africa Water Vision for 2025: Equitable and Sustainable Use of Water for Socioeconomic Development. Economic Commission for Africa, African Union and African Development Bank. Addis Ababa.

Emerton, L. 1998. Economic tools for valuing wetlands in eastern Africa. IUCN — The World Conservation Union, Eastern Africa Regional Office.

Emerton, L. and Boss, E. 2004. Value Counting Ecosystems as an Economic Part of Water. IUCN, Gland, Switzerland and Cambridge, UK.

Gill, A.C. 2000. So many fishes, so little time: an overview of recent ichthyological discovery in continental waters. *Annals of the Missouri Botanical Gardens* **87**:26–62.

Gleick, P.H. 1996. Water resources. In: *Encyclopedia of Climate and Weather* (ed. S.H. Schneider), pp. 817–823. Oxford University Press, New York, USA.

Gopal, B., Junk, W.J. and Davis, J.A. (eds.) 2000. *Biodiversity in wetlands: assessment, function, and conservation, volume 1*. Leiden, The Netherlands: Backhuys Publishers.

Groombridge, B. and Jenkins, M. 1998. Freshwater Biodiversity: a preliminary global assessment. WCMC-World Conservation Press, Cambridge, UK.

- Hughes, R.H. and Hughes, J.S. 1992. *A Directory of African Wetlands*. IUCN, Gland, Switzerland and Cambridge, UK/UNEP, Nairobi, Kenya/WCMC, Cambridge, UK.
- Hulme, M., Doherty, R., Ngara, New, M. and Lister, D. 2001. African climate change: 1900–2100 *Climate Research*. **17(2)**:145–168.
- IUCN 2004. Red list assessment of Madagascar's freshwater fishes. Unpublished report. Available for download from: http://cms.iucn.org/about/work/programmes/species/our_work/about_freshwater/resources_freshwater/index.cfm
- IUCN Water and Nature Initiative. 2003. Case Studies in Wetland Valuation #2. Barotse Floodplain, Zambia: local economic dependence on wetland resources. Available for download at: <http://cmsdata.iucn.org/downloads/casestudy02barotse.pdf>
- IUCN 2007. 2007 IUCN Red List of Threatened Species. <www.iucnredlist.org>.
- Kasthala, G., Hepelwa, A., Hamiss, H., Kwayu, E., Emerton, L., Springate-Baginski, O., Allen, D. and Darwall, W. 2008. An integrated assessment of the biodiversity, livelihood and economic value of wetlands in Mtanza-Msona Village, Tanzania. Tanzania Country Office, IUCN (International Union for Conservation of Nature), Dar es Salaam.
- Kottelat, M. and Freyhoff, J. 2007. Handbook of European Freshwater Fishes. Kottelat, Cornol, Switzerland and Freyhof, Berlin, Germany. Publications Kottelat, Switzerland.
- Lévêque, C., Balian, E.V. and Martens, K. 2005. An assessment of animal species diversity in continental waters. In: Segers, H. and Martens, K. (eds.) 2005. The Diversity of Aquatic Ecosystems. *Hydrobiologia* **542**:39–67.
- Lévêque, C., Oberdorff, T., Paugy, D., Stiassny, M.L.J. and Tedesco, P.A. 2008. Global diversity of fish (Pisces) in freshwater. In: Balian E.V., Lévêque, C., Segers, H. and Martens, K. (eds.) 2008. Freshwater Animal Diversity Assessment. *Hydrobiologia* **595**:545–567.
- Lundberg, G., Kottelat, M., Smith, G.R., Stiassny, M.L.J. and Gill, A.C. 2000. So many fishes, so little time: An overview of recent ichthyological discovery in continental waters. *Annals Missouri Botanical Garden* **87**:26–62.
- de Wit, M. and Stankiewicz, J. 2006. Changes in surface Water Supply Across Africa with predicted climate change. *Science express*, 2 March 2006.
- Millennium Ecosystem Assessment, 2005. *Ecosystems And Human Well-Being: Wetlands And Water Synthesis*. World Resources Institute, Washington DC, USA.
- Neiland, A.E. and Béné, C. (eds.) 2008. Tropical river fisheries valuation: background papers to a global synthesis. The WorldFish Center Studies and Reviews 1836. The WorldFish Center, Penang, Malaysia.
- Nel, J.L., Roux, D.J., Maree, G., Kleynhans, C.J., Moolman, J., Reyers, B., Rouget, M. and Cowling, R.M. 2007. Rivers in peril inside and outside protected areas: a systematic approach to conservation assessment of river ecosystems. *Diversity and Distributions* **13(3)**:341–352.
- Pallet, J. (ed.) 1997. Sharing water in southern Africa. Desert Research Foundation of Namibia, Windhoek.
- Postel, S. and Carpenter, S.R. 1997. Freshwater ecosystem services. In: G. Daily (ed.). *Nature's services*. Island Press, Washington DC, USA.
- Revenga, C., Murray, S., Abramovitz, J. and Hammond, A. 1998. *Watersheds of the World: Ecological Value and Vulnerability*. World Resources Institute and Worldwatch Institute, Washington DC, USA.
- Revenga, C. and Kura, Y. 2003. Status and Trends of Biodiversity of Inland Water Ecosystems. Secretariat of the Convention on Biological Diversity, Montreal, Technical Series no. 11.
- Samways, M.J. 2004. Critical species of Odonata in southern Africa. In: Guardians of the watershed. Global status of dragonflies: critical species, threat and conservation (eds. Clausnitzer V. and R. Jodicke). *International Journal of Odonatology* **7(2)**:255–262.
- Samways, M.J. and Grant, P.B.C. 2006. Regional response of odonata to river systems impacted by and cleared of invasive alien trees. *Odonatologica* **35(3)**: 297–303.
- Seyam, I.M., Hoekstra, A.Y., Ngabirano, G.S. and Savenije, H.H.G. 2001. The value of freshwater wetlands in the Zambezi basin. In: *Globalisation and water resources management: the changing value of water*. awra/iwlr- university of Dundee international speciality conference.
- Stiassny, M.L.J. 1999. The medium is the message: freshwater biodiversity in peril. In: *The Living Planet in Crisis : Biodiversity Science and Policy* (eds. J. Cracraft and F.T. Grifo). Columbia University Press, New York, USA.
- Stuart, S.N., Chanson, J.S., Cox, N.A., Young, B.E., Rodrigues, A.S.L., Fischman, D.L. and Waller, R.W. 2004. Status and Trends of Amphibian Declines and Extinctions Worldwide. *Science* **306**:1783–1786.
- Taylor, A.R.D., Howard, G.W. and Begg, G.W. 1995. Developing wetland inventories in Southern Africa: A review. *Vegetatio* **118**:57–79.
- Thieme, M.L., Abell, R., Stiassny, M.L.J., Skelton, P., Lehner, B., Teugels, G.G., Dinerstein, E., Toham, A.K., Burgess, N. and Olson, D. 2005. *Freshwater ecoregions of Africa and Madagascar: a conservation assessment*. Island Press, Washington DC, USA.
- Turpie, J.K. and van Zyl, H. 2002. Valuing the environment in water resources management. In: Hirji, R., Johnson, P., Maro, P. and Matiza Chiuta, T. (eds.) Defining and mainstreaming environmental sustainability in water resources management in southern Africa. SADC, IUCN, SARDC, World Bank: Maseru/Harare/Washington DC.
- Turpie, J.K., Naga, Y. and Karaja, F. 2003. A preliminary economic assessment of water resources of the Pangani

- River Basin, Tanzania: Economic value, incentives for sustainable use and mechanisms for financing management. IUCN, Eastern Africa Regional Office, Nairobi.
- Turpie, J.K., Ngaga, Y. and Karaja, F. 2004. Maximizing the economic value of water resources in the Pangani Basin, Tanzania. IUCN, Eastern Africa Regional Office, Nairobi.
- Tweddle, D. and Wise, R.M. 2007. Nile Tilapia (*Oreochromis niloticus*). In: Wise, R.M., van Wilgen, B.W., Hill, M.P., Schulthess, F., Tweddle, D., Chabi-Olay, A. and Zimmerman, H.G. 2007. The economic impact and appropriate management of selected invasive alien species on the African continent. Final Report prepared for the Global Invasive Species Programme. CSIR Report Number CSIR/NRE/RBSD/ER/2007/0044/C.
- Witte, F., Welten, M., Heemskerk, M., Van Der Stap, I., Ham L., Rutjes, H. and Wanink, J. 2008. Major morphological changes in a Lake Victoria cichlid fish within two decades. *Biological Journal of the Linnean Society*, **94**: 41-52.
- Witte, F., Goldschmidt, T., Wanink, J.H., van Oijen, M., Goudswaard, P.C., Witte-Maas, E. and Bouton, N. 1992. The destruction of an endemic species flock: Quantitative data on the decline of the haplochromine cichlids of Lake Victoria. *Environmental Biology of Fishes* **43**:1-28.
- WWF 2004. Living Planet Report 2004. WWF International, Gland, Switzerland.
- 4th World Water Forum Africa Regional Document 2005. Local Actions for Global Change.

Chapter 2. Assessment methodology

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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 providing 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 by 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). 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: fishes; molluscs; odonates (dragonflies and damselflies); crabs and aquatic plants.

Although fishes provide a clear benefit to the livelihoods of many 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. Given the wide range of trophic levels and ecological roles encompassed within these five taxonomic groups, information on their distributions and conservation status, when combined, will provide a useful indication of the overall status of the associated wetland ecosystems.

2.1.1 Fishes

Fishes form the most important wetland product on a global scale providing the primary source of protein for nearly 1 billion people worldwide (FAO 2002) and food security for many more (Coates 1995). It is estimated that in Africa inland fisheries land nearly 2.5 million tonnes per year, which accounts for nearly 25% of the world's inland waters capture fisheries (The state of the world's fisheries and aquaculture. FAO 2006 Rome), providing essential nutrition for the poorest of communities and employment and income for many more. For the purposes of this assessment freshwater fishes are defined as those that spend all or a critical part of their life cycle in fresh waters. Those species entirely confined to brackish waters are also assessed. There are over 14,000 freshwater fish species in the world, and by 2006 only 15% of them had had their risk of extinction assessed using the IUCN Red List Categories and Criteria.

2.1.2 Molluscs

Freshwater molluscs are one of the most threatened groups of freshwater taxa in some regions of the world (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 6,000 freshwater molluscs for which valid descriptions exist, in addition to a possible 10,000

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undescribed species. Of these species, only a small number have had their conservation status assessed (around 13% of freshwater molluscs had been assessed for the IUCN Red List in 2006) 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 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 channelization, pollution, sedimentation and siltation also impact heavily on unionid mussels.

2.1.3 Odonates

Larvae of almost all of the known 5,680 species of the insect order Odonata (dragonflies and damselflies) are dependent on freshwater habitats. 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 is represented within the group, which has thus been widely used as an indicator for wetland quality in Europe, Japan, the USA and Australia. Of these 5,680 species, less than 10% had had their risk of extinction assessed using the IUCN Red List Categories and Criteria by 2006. A baseline dataset is needed for Africa to facilitate development of similar long term monitoring schemes.

2.1.4 Crabs

There are an estimated 1,280 species of freshwater crab of which about 100 species are recognised from Africa (Dobson 2004). 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. 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. Of the 100 species native to Africa, around 50% had had their risk of extinction assessed using the IUCN Red List Categories and Criteria by 2006, but many of

these assessments were conducted prior to 1998 and were in need of revision.

2.1.5 Aquatic plants

Aquatic plants are the building blocks of wetland ecosystems, providing food, oxygen and habitats for many other species. They are also a hugely important natural resource providing direct benefits to human communities. Numerous aquatic plants are highly valued for their nutritious, medicinal, cultural, structural or biological properties. They are also key species in wetland ecosystem services, for example, water filtration and nutrient recycling. An aquatic plant is defined as a macrophyte whose photosynthetically active parts are permanently, or at least for several months each year, submerged in freshwater, or floating on the water's surface (Cook 1974 and 1990). Using this definition there are nearly 6,000 aquatic plant species worldwide (based on 1–2% of all vascular plants being aquatic (Cook 1996) and a conservative estimate of the total number of vascular plants of 287,655 (IUCN Red List)). There were only 36 species of freshwater aquatic plants on the 2006 IUCN Red List.

For this assessment, all the aquatic plants identified by Cook (2004) in his publication *Aquatic and Wetland Plants of Southern Africa* were assessed for their conservation status. This publication only covers South Africa, Lesotho, Swaziland, Botswana and Namibia. As the additional expertise required for assessing those species endemic to Angola, Zambia, Zimbabwe and Mozambique could not be found, those species within the families identified in Cook (2004) were not assessed. In addition, the only available species distribution data came from the South African National Biodiversity Institute (SANBI), which is also restricted to the same region as in Cook (2004).

2.2 Data collation and quality control

The biodiversity assessment required sourcing and collating the best information on all known species within the priority taxa (see Section 2.1). The best regional and international experts for these taxa were first identified by SAIAB, IUCN, and through consultation with the relevant IUCN SSC Specialist Groups. These experts were then trained in use of the project database, the Species Information Service Data Entry Module (SIS DEM), and in application of the IUCN Red List Categories and Criteria (IUCN 2001) to assess a species risk of extinction in the wild.

Following the training workshop a number of participating experts were contracted to collate, and input within the SIS DEM, all available information on each of

the priority taxonomic groups. Spatial data were also sourced for later production of species distribution maps (see Section 2.3). The information collated was then used to assess the extinction risk of each species according to the IUCN Red List Categories and Criteria (IUCN 2001) (see Section 2.4). All information was then peer reviewed at a second workshop where each species assessment was evaluated by at least two independent experts to ensure that: (i) the information presented is both complete and correct, and (ii) the Red List assessment has been completed correctly.

2.3 Species mapping

All species distributions were mapped to river sub-basins as delineated by the HYDRO1k Elevation Derivative Database (USGS EROS) (Figure 2.1) using ArcView/Map GIS software. It is recognised that species ranges may not always extend throughout a river sub-basin but until finer scale spatial detail is provided each species is assumed to be present throughout the sub-basin where it has been recorded. River basins were selected as the spatial unit for mapping and analysing species distributions as it is generally accepted that the river/lake basin or catchment is the most appropriate management unit for inland waters.

For the fishes, odonates and crabs, point localities (the exact latitude and longitude where the species was recorded) were used to identify which sub-basins are known to contain the species. These point localities were based on museum records from all major collections, supplemented in a small number of cases by expert knowledge of presence at sites where no voucher specimens were collected. During the evaluation workshop, errors and dubious records were deleted from the maps.

Connected sub-basins, where a species is expected to occur, although presence is not yet confirmed, are known as 'inferred basins'. Inferred distributions were determined through a combination of expert knowledge, coarse scale distribution records and unpublished information. The distribution maps for odonates (on the accompanying CD) do not yet show the point location data as this has been temporarily withheld to enable completion of personal research. For the plants and molluscs the distribution maps are all for inferred basins as digitized point localities were not available.

The preliminary species distribution maps were digitized and then further edited at the evaluation workshop.

Species distributions were also described within the context of the Freshwater Ecoregions for southern Africa as defined and delineated by WWF-US (Thieme *et al.* 2005) (see Chapter 1, Figure 1.1).

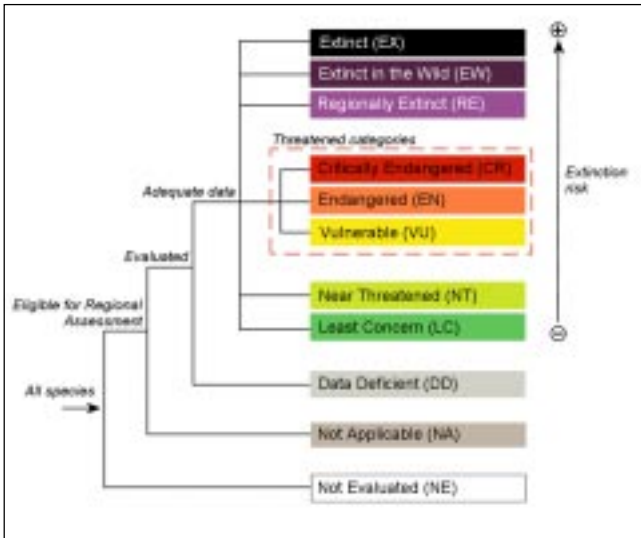
2.4 Assessment of species threatened status

The risk of extinction for each species was assessed according to the *IUCN Red List Categories and Criteria: Version 3.1* (IUCN 2001), (see Figure 2.2). As such, the Categories of threat reflect the risk that a species will go extinct within a specified time period. A species assessed as "Critically Endangered" is considered to be facing an extremely high risk of extinction in the wild. A species assessed as "Endangered" is considered to be facing a very high risk of extinction in the wild. A species assessed as "Vulnerable" is considered to be facing a high risk of extinction in the wild. All taxa listed as Critically Endangered, Endangered or Vulnerable are described as "threatened". For an explanation of the full range of

Participants in the evaluation workshop held at Stellenbosch in the Western Cape Province of South Africa.



Figure 2.2 IUCN Red List Categories at the Regional Scale.



Categories and the Criteria which must be met for a species to qualify under each Category please refer to the following documentation: *The IUCN Red List Categories and Criteria: Version 3.1, Guidelines on application of the Red List Categories and Criteria*, and *Guidelines for Application of IUCN Red List Criteria at Regional Levels*:

Version 3.0 which can be downloaded from http://www.iucnredlist.org/info/categories_criteria.

The following settings and filters were agreed during the initial workshop and were applied in the completion of this regional Red List assessment:

1. Any species having less than 5% of its range within southern Africa should not be assessed, the main assessment being completed for the neighbouring region.
2. Species present in southern Africa prior to 1800 were treated as being “naturalised” and subject to a Red List assessment. Those species arriving in southern Africa post 1800 were not assessed but their distributions were mapped where possible.

For each species the Red List Category is either written out in full or abbreviated as follows:

- | | |
|---------------------------|--------------------|
| Extinct, EX | Least Concern, LC |
| Extinct in the Wild, EW | Data Deficient, DD |
| Regionally Extinct, RE | Not Applicable, NA |
| Critically Endangered, CR | Not Evaluated, NE |
| Endangered, EN | |
| Vulnerable, VU | |
| Near Threatened, NT | |



Figure 2.1 Level 6 river basins as delineated by HYDRO1K Elevation Derivative Database (USGS EROS) and used to map and analyse species distributions.

A regional as opposed to a global species Red List Category is indicated in the text by the superscript ^{RG} following the Category assigned. For example, a species assessed as regionally Vulnerable is documented as VU^{RG}.

Species summaries and distribution maps are presented for all species assessed in the accompanying CD.

2.5 References

- Coates, D. 1995. Inland capture fisheries and enhancement: Status, constraints and prospects for food security. In: *International Conference on Sustainable Contribution of Fisheries to Food Security, Kyoto, Japan, 4-9 December 1995*. KC/FI/95/TECH/3. Government of Japan, Tokyo, Japan and FAO, Rome, Italy.
- Cook, D.K. 1996. *Aquatic Plant Book*. SPB Academic Publishing, Amsterdam/New York.
- Cook, D.K. 2004. *Aquatic and wetland plants of Southern Africa*. Backhuys Publishers.
- Dobson, M. 2004. Freshwater crabs in Africa. *Freshwater Forum* **21**:3-26.
- FAO (Food and Agriculture Organization of the United Nations). 2002. The state of world fisheries and aquaculture 2002. FAO Fisheries Department, Rome, Italy.
- IUCN 2001. IUCN Red List Categories and Criteria: Version 3.1. IUCN Species Survival Commission. IUCN, Gland, Switzerland and Cambridge, UK.
- Kay, E.A. (1995). The conservation biology of molluscs. Including a status report on molluscan diversity. In: Proceedings of a symposium held at the 9th International Malacological Congress. Edinburgh, Scotland, 1986. IUCN - The World Conservation Union, Gland, Switzerland and Cambridge, UK.
- Thieme, M.L., Abell, R., Stiassny, M.L.J., Skelton, P., Lehner, B., Teugels, G.G., Dinerstein, E., Toham, A.K., Burgess, N. and Olson, D. 2005. *Freshwater ecoregions of Africa and Madagascar: a conservation assessment*. Island Press, Washington DC, USA.
- United States Geological Survey's Center for Earth Resources Observation and Science (USGS EROS) HYDRO1k Elevation Derivative Database. Available at: <http://edc.usgs.gov/products/elevation/gtopo30/hydro/index.html>

Chapter 3. The status and distribution of freshwater fishes

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3.1 Overview of the regional fauna

Thieme *et al.* (2005) listed the ecoregions of Africa, the reasons for their consideration as distinct entities, and described each ecoregion. The southern African region covered in this report contains 22 of the defined ecoregions (see Chapter 1: Figure 1.1 and Table 1.2). In terms of the fish fauna, however, there is considerable overlap between the ecoregions, and Skelton (2001) provided a more general classification in which he recognised the following six major aquatic ecoregions: tropical east coast region, tropical interior region, highveld (temperate) region, montane-escarpment region, Cape Fold Mountains region and Kalahari-Karoo-Namib region (Figure 3.1). Skelton (2001) further divided the fauna broadly into two groups, the tropical “Zambezi” fauna and a temperate southern fauna, which is further subdivided into the Karoo group and the Cape group.

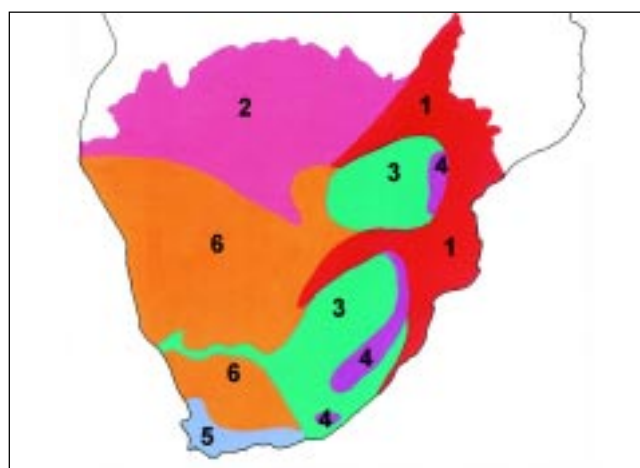


Figure 3.1 Aquatic ecoregions of southern Africa.
1. Tropical east coast region; 2. Tropical interior region;
3. Highveld (temperate) region; 4. Montane-escarpment
region; 5. Cape Fold Mountains region, and 6. Kalahari-
Karoo-Namib region. (From Skelton 2001).

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The distribution of fishes is a result of the geomorphological history of the region and a brief description of this history helps to explain the current distributions and our adoption of a simplified selection of ecoregions based on actual river systems.

3.1.1 Geomorphological factors affecting distribution of the southern African fish faunas

The current fish fauna of the Upper Zambezi system reflects its complex geomorphological history of major changes of river course and numerous minor river captures with neighbouring systems (Skelton 1994; Bills and Marshall 2004). Theories on the evolution of the river systems and their faunas generally concur that an early large river system flowed south-west from the Lake Bangweulu region into the Kafue, Upper Zambezi, Okavango and Kunene rivers. These flowed either into a large central lake in the Okavango Delta-Makgadikgadi region, or into the Atlantic Ocean. The Middle and Lower Zambezi formed a separate east coast system.

Around the late Tertiary, the Middle Zambezi captured the Upper Zambezi and Kafue rivers. The Kunene was captured by a coastal system draining into the Atlantic

Ocean, while Lake Bangweulu was diverted into the Congo system via the Luapula River. The Kunene River was probably the first to break away from the central complex of rivers, followed by the Kafue, while the Okavango and Upper Zambezi are still tenuously connected via the Selinda spillway. This series of major river course changes has resulted in considerable mixing of the fish communities of the Upper Zambezi and neighbouring river systems (Bills and Marshall 2004). Many species in numerous families are shared between rivers from the Zambian Congo system south-west to the Kunene River.

There has also been mixing of fishes from neighbouring rivers by river captures and by migrations across shared headwater swamps (Bell-Cross 1965). These smaller events account for the presence of shared species between the headwater streams of the Upper Zambezi and Congo systems, e.g. *Schilbe yangambianus* (Poll 1954). The headwater streams of the Congo in the vicinity of the Upper Zambezi have been poorly sampled and thus their faunas are largely unknown. There is therefore uncertainty about the overall distribution of several species found by Tweddle *et al.* (2004) in the Upper Zambezi tributaries, as summarised in Table 3.1.

Table 3.1 This table lists species found in northern Zambezi tributaries, some of which are probably of Congo headwaters derivation (e.g. *Schilbe yangambianus*), whereas others (e.g. *Zaireichthys* spp.) may be endemic species. This lists recognised species for which Red List assessments have been prepared. In addition, several other species from northern Zambezi tributaries are under investigation, including, e.g. at least three, probably endemic *Chiloglanis* species (Tweddle *et al.* 2004).

Species	Notes	Category
<i>Schilbe yangambianus</i> (Poll 1954)	Congo forest species. Occurs in East Lumwana River and uppermost reaches of Zambezi River	LC ^{RG}
<i>Hypsopanchax jubbi</i> Poll and Lambert, 1965	Near source of Zambezi, also Kabompo tributary	LC ^{RG}
<i>Barbus bellcrossi</i> Jubb, 1964	Near source of Zambezi	DD
<i>Barbus miolepis</i> Boulenger, 1902	Name provisionally given to large species in Upper Zambezi and Kafue tributaries	LC ^{RG}
<i>Barbus</i> sp. "bellcrossi cf."	Kabompo River	DD
<i>Barbus</i> sp. "eutaenia cf. redeye"	Several northern tributaries of Zambezi	LC
<i>Barbus</i> sp. "eutaenia cf. short stripe"	Zambezi near source and Lwinda tributary	LC
<i>Barbus</i> sp. "purple stripe"	Zambezi near source and other Upper Zambezi tributaries	LC
<i>Barbus</i> sp. "unitaeniatius cf. Kanyanda"	Kanyanda stream (West Lunga system)	DD
<i>Barbus</i> sp. "Zambia chubby head"	Kanyanda stream (West Lunga system)	DD
<i>Barbus</i> sp. "Kabompo stripe"	Kabompo River	LC
<i>Barbus</i> sp. "Kafue spot"	Kafue tributaries	DD
<i>Barbus</i> sp. "mid-Zambezi stripe"	Muzuma River (Middle Zambezi system)	DD
<i>Barbus</i> sp. "paludinosus cf. Mwekera"	Mwekera stream (Kafue headwaters)	DD
<i>Zaireichthys</i> sp. "blotched north"	Maheba River	DD
<i>Zaireichthys</i> sp. "brown north Zambia"	Madamyana River (West Lunga system)	LC
<i>Paramormyrops jacksoni</i> (Poll, 1967)	Angolan Zambezi tributary	DD
<i>Clariallabes</i> sp. "Mwekera"	Mwekera stream (Kafue headwaters)	DD

^{RG} = Regional Red List status

Further south, the boundary between the tropical Zambezan ichthyofaunal province and the temperate southern or Cape ichthyofaunal province is poorly defined as the faunas overlap ecologically and geographically (Skelton 1994). The northern limit of the Cape ichthyofaunal province is the Orange River, the fauna of which includes e.g. *Labeo capensis* (Smith, 1841), *L. umbratus* (Smith, 1841), *Barbus anoplus* Weber, 1897 and *B. hospes* Barnard, 1938, but this system also contains elements of the Zambezan fauna, e.g. *Barbus paludinosus* Peters 1852, *B. trimaculatus* Peters, 1852, *Clarias gariepinus* (Burchell, 1822) and *Tilapia sparrmanii* Smith, 1840. The Orange River is believed to have drained areas further to the north that are currently part of the Okavango and Upper Zambezi systems in the early Tertiary, but by the Mid-Tertiary the Zambezan rivers had been diverted to the East Coast, with the Orange River system occupying more or less its present drainage area (Figure 3.1) (Skelton 1994).

The general pattern of fish species numbers in the southern African region is thus a result of two factors, a general pattern of declining species numbers from tropical to temperate zones, and a pattern of fish distribution that reflects the drainage history (Figure 3.2).

The present distribution pattern for fish species resulting from these historical drainage changes is recognised as six ecoregions. These regions differ from the broad ecoregions recognised by Skelton (2001), as described above, in that the classification adopted here is based more on the actual river systems as opposed to the geomorphological and climatic regions in Skelton (2001). The regions adopted for use in this report are thus (1) the Upper Zambezi, (2) the Middle and Lower Zambezi, (3) tropical East Coast, (4) tropical West Coast, i.e. Angola, (5) Cape Floristic Region (CFR) Western Cape, and (6) southern temperate. These regions are defined as follows:

- 1. Upper Zambezi.** This region encompasses the Upper Zambezi River, i.e. from its source to Victoria Falls, and includes the Okavango Delta and the Cubango River. It also includes the major tributaries of the Upper Zambezi in western Zambia, and also the upper reaches of the Kafue River which, although it now flows to the Middle Zambezi, is believed to have formerly been an Upper Zambezi tributary and has several Upper Zambezi faunal elements (Skelton 1994).
- 2. Middle and Lower Zambezi.** This region covers the Zambezi River from below Victoria Falls to the Indian Ocean, including the Luangwa tributary. The lower reaches of the Buzi and Pungwe Rivers to the south of the Zambezi Delta are linked to the Zambezi along the coastal plain during periods of flooding and thus also have Lower Zambezan faunas.
- 3. East Coast.** This region covers all the rivers flowing into the Indian Ocean from the Ruvuma River on the

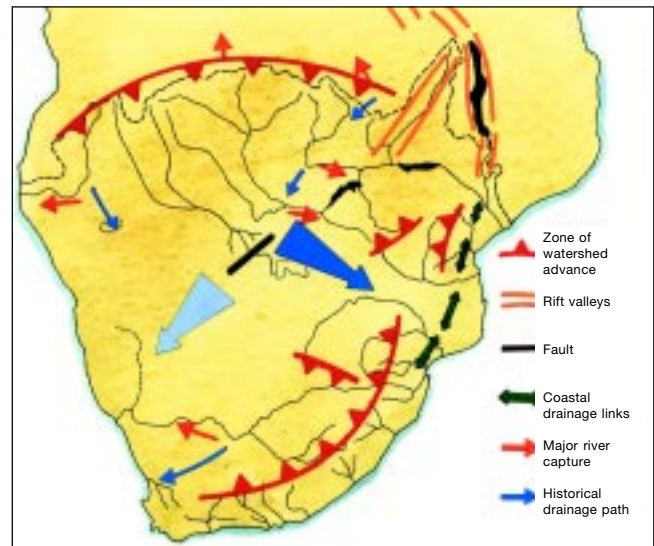


Figure 3.2 Southern African drainage patterns and fish distribution transfers are affected by: (a) advancing watersheds that capture headwaters of opposing drainage systems (e.g. eastern coastal rivers and the Congo headwaters); (b) change to historical drainage paths by major river captures (e.g. Orange River) or blockage by geological faults (e.g. Okavango River); (c) drainage connections occurring across low gradient watersheds during high floods or period of sea level decline (e.g. Mozambique and Maputaland coastal areas); and (d) rift valley faulting that disrupts historical drainage lines and directs drainages (e.g. Lake Malawi cutting across east coast drainages and then draining to the Lower Zambezi via the Shire River). (From Skelton 2001).

Tanzania/Mozambique border south to the southern limits of the tropical coastal fauna in KwaZulu-Natal, with the exception of the Zambezi.

- 4. West Coast, i.e. Angola.** All rivers flowing from Angola into the Atlantic that are not part of the Congo system are included in this region. The region includes the Kunene River, which has a number of Zambezan species as a result of river captures in the past.
- 5. Cape Floristic Region (CFR).** The CFR (equivalent to Skelton's Cape Fold Mountains Region) has a unique fauna with numerous endemic species and

The tigerfish, *Hydrocynus vittatus* Castelnau, 1861, a species popular in the sport fishing community, which is a prominent component of the Zambezan ichthyofauna. Photo: © SAIAB/ Denis Tweddle.



also some species shared with the rest of temperate southern Africa.

6. Southern Temperate. This region covers the Orange River system and the southern coastal systems. The boundary with the East Coast fauna is defined by temperature but is somewhat subjective, thus highland species in the Limpopo/Incomati area are classed in the temperate region, whereas species found only in the lower reaches of these rivers are typical of the East Coast tropical fauna and are classified as such.

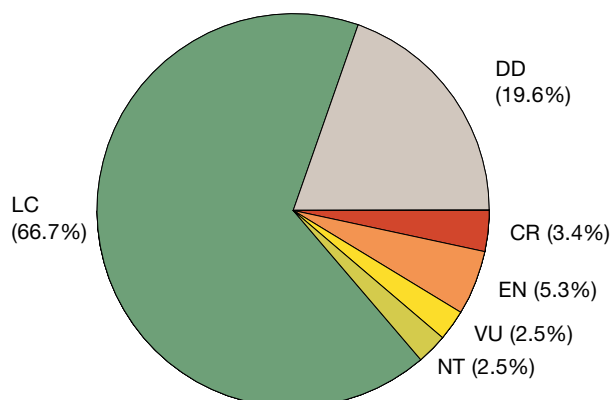
3.2 Conservation status (IUCN Red List Criteria: Regional Scale)

The summary presented here is based on an analysis of species regional Red List status following application of the IUCN Red List Criteria at the regional scale of southern Africa. The regional Red List status of any species which is endemic to southern Africa will be equivalent to its global Red List status.

The majority of fish species in southern Africa (66%) are classed as Least Concern (LC) (Figure 3.3, Table 3.3). Much of southern Africa is relatively lightly affected by industrial development with associated aquatic habitat degradation and pollution. The Zambian Copperbelt is an exception as a large portion of the upper Kafue is seriously impacted by metal pollution. However, most species in this system are considered to have wide, Zambezian, distributions. Those species that are considered to be threatened are affected largely by alien fish species and in some instances poor agricultural practices (e.g. excessive water abstraction in the Cape Floristic Region) rather than by industrial development.

The Red List category with the next highest number of species (20% of the total) is Data Deficient which reflects two factors:

Figure 3.3 The proportion of fish species in each regional Red List Category in the southern African region.



- Recent exploratory surveys in the upper tributaries of the Zambezi system and Mozambique rivers, and other parts of the region to a lesser extent, have resulted in the discovery of many species new to the region, a high percentage of which are undescribed, and their

Table 3.2 The number of fish species in each regional Red List Category in the southern African region.

Regional Red List Category	Number of Species	Number of regional endemics
Threatened Categories	Critically Endangered	12
	Endangered	19
	Vulnerable	9
	Near Threatened	9
	Least Concern	235
Data Deficient	71	57
Total	355	239

Note: All species assessed as regionally threatened which are endemic to the region are also globally threatened. None-native species which would fall into the Not Applicable category have not been included for fishes.

Table 3.3 Summary of the most important threats to freshwater species endemic or near endemic to the Cape Floristic Region. Threats are numbered in order of severity as follows: 0 - Generally impacted by human activities but with no dominant threat; 1 - Alien fish; 2 - Habitat destruction; 3 - Pollution (including pesticides); 4 - Utilization; and 5 - Genetic integrity.

Species	Main threats	Conservation status
<i>Pseudobarbus afer</i> (Peters, 1864)	1	EN
<i>Pseudobarbus</i> sp. "afer Gamtoos"	1	EN
<i>Pseudobarbus</i> sp. "afer Krom"	1	CR
<i>Pseudobarbus</i> sp. "afer Forest"	0	NT
<i>Pseudobarbus tenuis</i> (Barnard, 1938)	1, 2	NT
<i>Pseudobarbus</i> sp. "tenuis Keurbooms"	1, 2	EN
<i>Pseudobarbus asper</i> (Boulenger, 1911)	1, 2	EN
<i>Pseudobarbus burchelli</i> Smith, 1841	1, 2, 3	CR
<i>Pseudobarbus</i> sp. "burchelli Breede"	1, 2	NT
<i>Pseudobarbus</i> sp. "burchelli Heuningnes"	1, 2	CR
<i>Pseudobarbus burgi</i> (Boulenger, 1911)	1, 2, 5	EN
<i>Pseudobarbus</i> sp. "burgi Verlorenvlei"	1, 2	EN
<i>Pseudobarbus pblegethon</i> (Barnard, 1938)	1, 2	EN
<i>Pseudobarbus</i> sp. "phlegethon Doring"	1	CR
<i>Sandelia capensis</i> (Cuvier, 1831)	1, 2, 5	DD
<i>Galaxias zebratus</i> Castelnau, 1861	1, 2, 5	DD
<i>Barbus andrewi</i> Barnard, 1937	1, 2, 4, 5	EN
<i>Barbus serra</i> Peters, 1864	1, 2, 4	EN
<i>Barbus calidus</i> Barnard, 1938	1, 2	VU
<i>Barbus erubescens</i> Skelton, 1974	1, 2, 3	CR
<i>Labeobarbus capensis</i> (A. Smith, 1841)	1, 2, 4	VU
<i>Labeo seeberi</i> Gilchrist & Thompson, 1911	1, 2	EN
<i>Austroglanis barnardi</i> (Skelton, 1981)	1, 2	EN
<i>Austroglanis gilli</i> (Barnard, 1943)	1, 2	VU

overall distributions are unknown. Angolan rivers have been poorly explored but many species have been described from single sites and are very poorly known.

2. New understanding of species definitions resulting from genetic and behavioural studies (e.g. using electric organ discharges and acoustic signals for mormyrid species) has resulted in several 'species complexes' being recognised that were formerly considered as single species. These two factors have created uncertainty about individual species distributions and as a result many of these species are considered to be Data Deficient.

A total of 40 species are assessed as regionally threatened, with a further nine classed as Near Threatened. These species are concentrated in two main areas, the Cape Floristic Region (CFR), where highly restricted natural distributions of endemic species are threatened mainly by alien invasive fishes and water abstraction, and Mpumalanga and Gauteng, where industrial development, pollution, water abstraction and other agricultural and forestry activities are major problems. In addition, Mpumalanga has a major alien fish problem, where trout fishing development around Dullstroom endangers all wetland biota including birds. These areas

are given most emphasis in this report. Smaller numbers of threatened species occur in areas such as the Zambezi River system where the main threat is alien invasive species.

3.3 Patterns of species richness

3.3.1 All fish species

In the southern African region, the Upper and Middle Zambezi River systems, together with the Pungwe and Buzi systems, contain the most diverse fish faunas (Figure 3.4).

Some of the variation in apparent richness seen in Figure 3.4 is an artefact due to differences in sampling intensity. The Zambezi system and Buzi River, for example, have been thoroughly sampled in recent years by SAIAB researchers, resulting in several new distribution records, while the faunas of rivers in Mozambique and Angola have only been lightly sampled. Nevertheless, the general pattern of rich tropical faunas and decline in species richness towards the temperate south is correct.

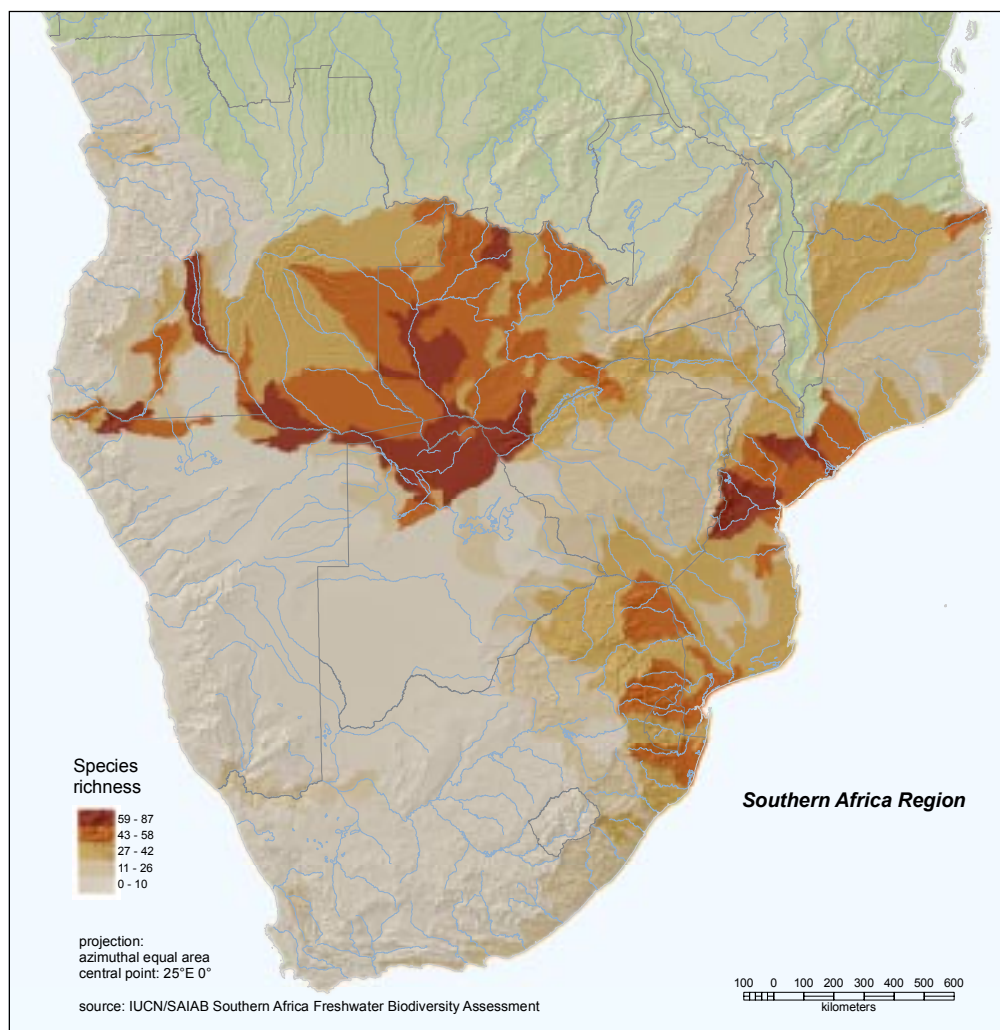


Figure 3.4 The distribution of species in the southern African region, showing a decline in number of species from tropical north to temperate south, with tropical species penetrating further south on the better-watered, warmer east coast.



Oreochromis andersonii (Castelnau, 1861), a Vulnerable species which is part of the species rich fish community of the Upper Zambezi, Kafue, Okavango and Kunene Rivers. Photo: © SAIAB/Denis Tweddle.

The Buzi River fish community is presently recognised to harbour 62 species (36 genera) of which 13 are endemic (21% of the community) (Bills and Weyl 2002). The Buzi's fish fauna is more diverse than the Lower Zambezi from which much of its community is derived, and probably of similar diversity to the neighbouring, but less well explored Pungwe River. Its high diversity is probably a combination of its origin, the diverse lower Zambezi fauna, plus the wide range of habitat types that occur in the Buzi. Unlike the lower Zambezi, the Buzi has high mountain streams with rocky substrata as well as the large riverine floodplains. Consequently, there are several habitat specialists such as rheophilic (species preferring fast flowing water) catfishes, kneriids, cichlids and cyprinids that are unique to the Buzi River.

3.3.2 Threatened species

There is a marked difference between the overall distribution of fishes in southern Africa and the distribution of species in threatened Categories. The high concentration of threatened species in the CFR is particularly striking (Figure 3.5, Table 3.3), reflecting the high degree of endemism and restricted distributions of the CFR fauna. The threats to the CFR fauna reflected in Figure 3.5 are severe (Table 3.3). All species are threatened by invasive alien fishes, while habitat destruction is also a threat to most.

Other areas worthy of note for their threatened species are the rivers immediately to the south of the Limpopo River, while in the Limpopo itself several species now under threat used to be more widely distributed in the system, e.g. *Opsaridium peringueyi* (Gilchrist and Thompson, 1913), *Barbus rapax* Steindachner, 1894 and *Chiloglanis swierstrai* Van der Horst, 1931.

3.3.3 Restricted range species

Species with restricted ranges are irregularly distributed throughout the region. The definition of restricted range for this study is taken to be confinement to one river



Austroglanis barnardi (Skelton, 1981), an Endangered catfish from tributary streams of the Olifants River in the CFR, threatened by alien fishes and habitat destruction. Photo: © SAIAB/Roger Bills.

system or in some cases two adjacent systems with recent or historical links. Larger systems with numerous large tributaries, such as the Zambezi, are not included. In this map, the southern temperate fauna in the CFR features prominently (Figure 3.6). Other areas with high numbers of localized species are the Kunene and Kwanza rivers on the west coast. The high concentration of species in the Kwanza may, however, prove to be exaggerated as a result of the scarcity of data for neighbouring rivers. In addition, a number of species need further taxonomic study, with a possibility that some species known from only a few specimens may prove to be synonymous with other more widespread species. Nevertheless, once these problems are resolved, the western coastal region will still be an area of particular importance for localized species.

As in the Kwanza, the high number of species apparently restricted to the east coast Rovuma system may partially reflect inadequate sampling of adjacent drainages. In the Pungwe/Buzi systems to the south of the Zambezi there are several endemic species. Mozambique rivers in general are in need of further sampling.

The northern tributaries of the Upper Zambezi also have several species with restricted ranges. Further sampling may result in some species being found to have wider distributions, but will also undoubtedly lead to discoveries of more species. For instance, a single sample from the Kanyanda Stream, a very minor tributary of the West Lunga River, contained two *Barbus* species, *B. sp.* "Zambia chubby head" and *B. sp.* "unitaeniatus cf. Kanyanda" distinct from all other *Barbus* species in the system (Tweddle *et al.* 2004).

3.3.4 Data Deficient species

Species may be classed as data deficient (DD) (Figure 3.7) for a number of reasons. In southern Africa, a major reason for assessing species as DD is the lack of information on taxonomic distinction or differentiation, particularly in the Rovuma River basin and in the CFR, where further research is needed on restricted range species differentiation. In the more industrialized areas of South Africa, such as Gauteng and Mpumalanga, human impacts have created uncertainty about the current status of



Kneria sp. 'South Africa', a Critically Endangered species of severely restricted range, known only from a few tributary streams in the upper Crocodile (Incomati) system near Lydenburg, Mpumalanga, South Africa. Photo: © SAIAB/Roger Bills.

several species, and in addition the taxonomy of the *Chiloglanis* species and small spotted *Barbus* species has still to be resolved. This has resulted in a high proportion of species being assessed as DD. In terms of mapping taxonomic uncertainty the map is slightly misleading for more northerly parts of the region as the highest number of unidentified and/or undescribed species occurs in the northern tributaries of the Upper Zambezi and Kafue tributaries, apparently as a result of faunal exchange with southern Congo tributaries. Most of these species have, however, been assessed as Least Concern (LC) rather than DD because of the relatively large size of the tributary systems in which they occur and the relevant lack of immediate human impact on the health of those streams. It is also clear that in many cases,

such as in Angola, species assessed as DD could not be mapped at all due to insufficient information - these species will not appear on the distribution map further biasing the representation.

3.3.5 Extirpated species

No species have been extirpated from the Southern Africa region. One species, the Maloti minnow, *Pseudobarbus quathlambae* (Barnard, 1938) has become extinct in South Africa. It was, however, only known from its type locality, the Mkhomazana River in KwaZulu-Natal, where the introduction of trout led to its demise. The species is otherwise distributed in several highland tributaries of the Orange River in Lesotho where it is also threatened primarily by trout (see Section 3.5.1.1 below) and the Mkhomazana population was probably derived from headwater stream capture.

The Berg River redfin (*Pseudobarbus burgii*) has been extirpated from the Eerste River. It is unknown whether this would have represented a unique lineage. Similarly local populations of redfin barbs have been lost across the CFR, for reasons described below under Section 3.4, while tributary populations of the three large migratory

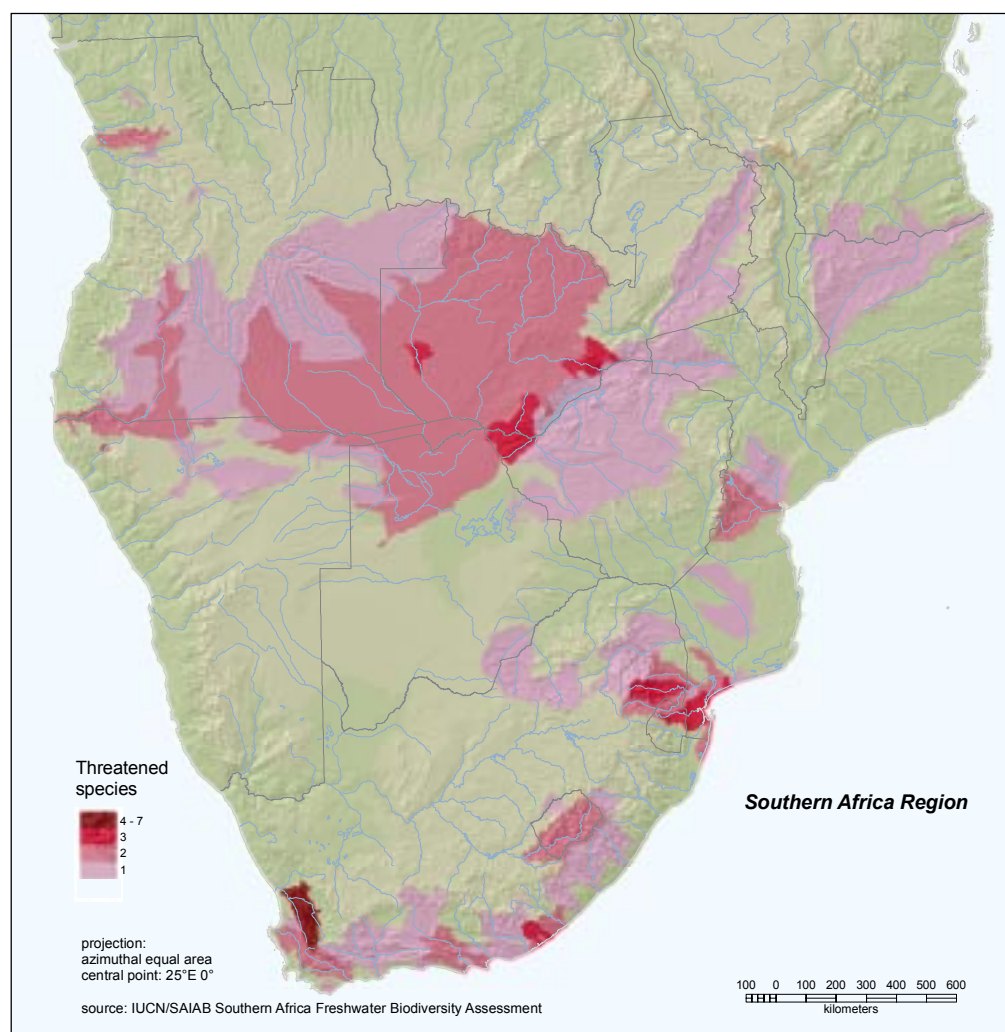


Figure 3.5 Distribution of species in regionally threatened categories. Areas of high endemism and restricted species ranges such as the CFR show the highest number of threatened species, while the broad range of 1–2 threatened species in the Zambezi system is a result of the endemic *Oreochromis* species threatened by Nile tilapia *Oreochromis niloticus* (L. 1758) invasion.

cyprinids (*Labeo seeberi*, *Labeobarbus capensis* and *Barbus serra*) of the Olifants River in the Clanwilliam Olifants system have also been lost.

3.4 Major threats to fishes

3.4.1 Cape Floristic Region

3.4.1.1 Alien fishes

Internationally, alien fish species top the list of threats to indigenous fish populations (Cowx 2002) and this is certainly the case for the indigenous fishes of the CFR. Without the impact of alien fishes none of the species or unique lineages in the CFR would have been assessed as Critically Endangered. Cederberg tributaries of the Olifants River system in the north-western parts of the CFR provide some of the most extreme examples of how alien fishes have devastated indigenous populations. A typical scenario is to find five to six indigenous species above a small natural barrier, with no indigenous species surviving below the barrier where alien, North American smallmouth bass (*Micropterus dolomieu* (Lacepède, 1802)) are present. For example, in the Rondegat River, the indigenous species *Pseudobarbus pblegethon*, *Barbus calidus*, *Labeobarbus*

capensis, *Austroglanis gilli* and *Galaxias zebratus* survive above a small waterfall that prevents *M. dolomieu* from spreading upstream. Below the waterfall only a few large *L. capensis* are able to survive with the bass, but without successful recruitment.

Smallmouth bass together with largemouth and spotted bass (*M. salmoides* (Lacepède, 1802) and *M. punctulatus* (Rafinesque, 1819)), bluegill sunfish (*Lepomis macrochirus* (Rafinesque, 1819)), all of which originate in North America, and banded tilapia (*Tilapia sparrmanii* A. Smith, 1840) from further north in Africa now dominate the fish fauna in more than 80% of the Olifants River



Barbus erubescens Skelton, 1974, a Critically Endangered species endemic to the Olifants River system in South Africa. The major threat to this species is from invasive alien fish species. Photo: © SAIAB/Roger Bills.

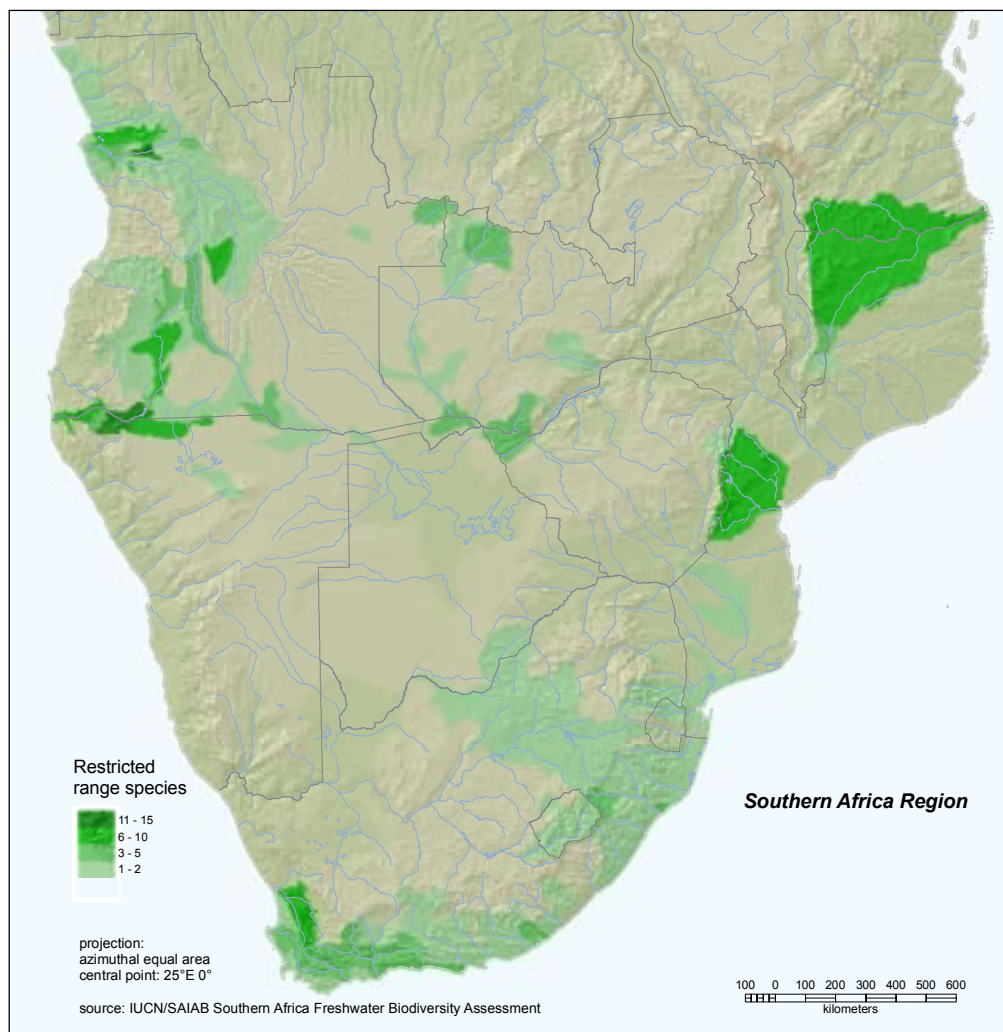


Figure 3.6 Distribution of species severely restricted in range, illustrating the high endemism of species in the Kwanza and Kunene Rivers in Angola, the CFR, Rovuma, Pungwe/Buzi systems, and to a lesser extent, the northern tributaries of the Upper Zambezi.

system, with indigenous fish often surviving in stretches of less than 1 km in headwater streams.

Throughout the CFR the three bass species have had a catastrophic impact on indigenous fish species. In the Jan Dissels River, for example, movement of *M. dolomieu* up the system has resulted in the extinction of the lower catchment specialist redbfin minnow *P. phlegethon*. A remnant of the original fish community remains in the upper reaches of this river as bass have not yet managed to penetrate these parts of the river system on account of their poor jumping abilities and the presence of cascades.

Lepomis macrochirus has a similar habitat preference to the bass species. Brought in as a food source for the bass (Harrison 1952), it has had a severe impact on indigenous fish populations and in some cases even out-competes the bass. *Tilapia sparrmanii* is beginning to out-compete the indigenous Cape kurper (*Sandelia capensis*) populations that occupy a similar niche. The Cape kurper itself has become an alien in the Twee River catchment (Hamman *et al.* 1984) where it threatens the survival of the indigenous Twee River redbfin (*Barbus erubescens*) and a unique population of the Cape galaxias (*Galaxias zebratus*). The Twee River catchment has also received

Clanwilliam yellowfish (*Labeobarbus capensis*) which is alien to the upper reaches of the Twee River catchment although it occurs in the rest of the Olifants River system. In addition to these alien fish species of CFR origin, rainbow trout (*Oncorhynchus mykiss* (Walbaum, 1792) and bluegill sunfish have also been introduced (Marriott 1998). As a result *B. erubescens* was regarded as the most threatened fish species in South Africa until recent genetic studies revealed historically isolated redbfin lineages that are even more restricted and under more severe threat from alien fish species (Swartz 2005).

Several rainbow trout populations from North America and some brown trout (*Salmo trutta* L., 1758) populations from Europe have become established or are maintained by continued stocking. Where they have established breeding populations they have caused the extinction or decline of indigenous fish populations. Trout usually occupy colder headwater streams above the distribution of bass, and where they overlap with bass, indigenous fish species are usually absent from the entire catchment. As trout are able to move upstream more easily than bass they may extend above natural barriers causing fish extinctions in the upper reaches whereas bass are more often restricted to the lower reaches below these barriers.

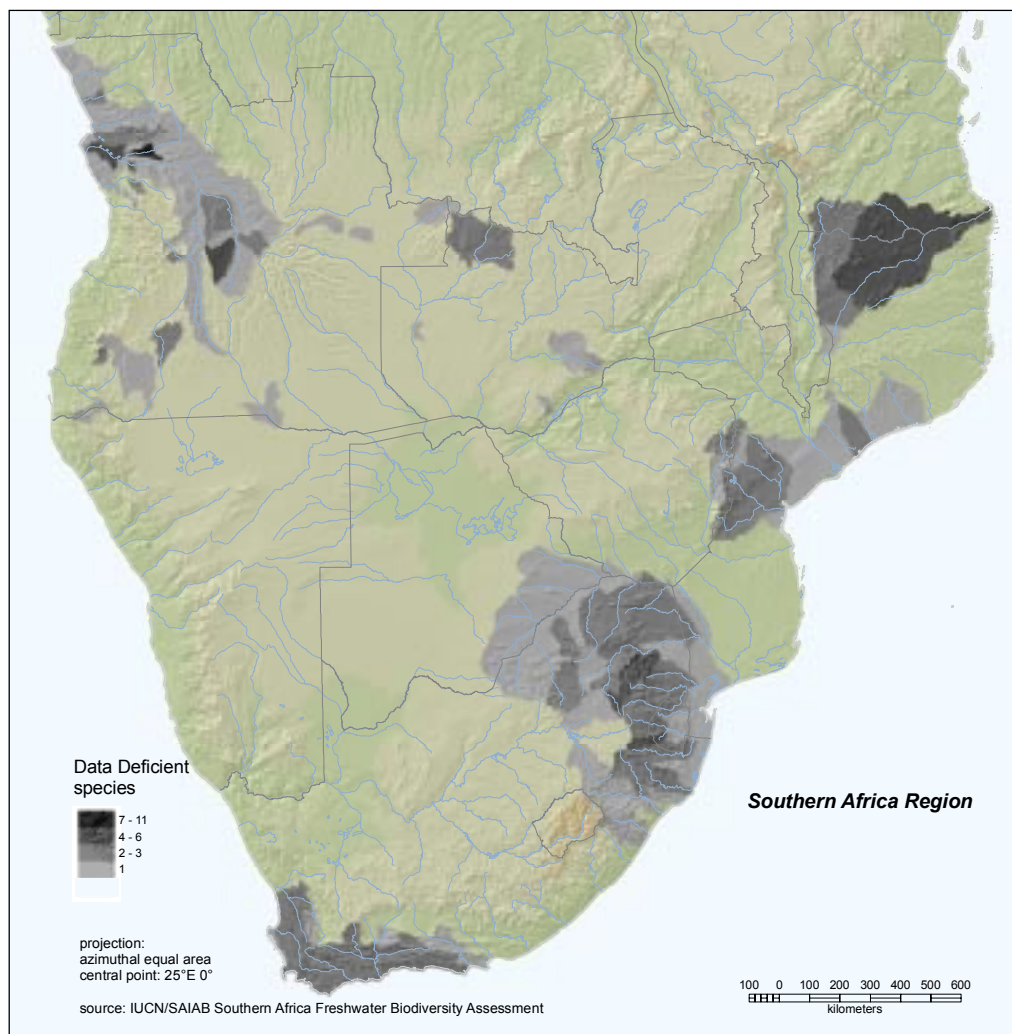


Figure 3.7 Distribution of species classified as Data Deficient, showing highest numbers in the Ruvuma and Kwanza systems on account of insufficient collecting, and in the Gauteng-Mpumalanga provinces – an area where human activities have impacted ecosystem health. It should be noted that the map is incomplete in that it fails to show those many species which could not be mapped due to lack of information on distribution ranges.

In two tributaries of the Olifants River system, the Heks River near Citrusdal and the Krom River in the Cederberg, all species except austroglanid catfishes were eradicated.

The sharptooth catfish (*Clarias gariepinus* (Burchell, 1822)) from further north in Africa is also rapidly becoming a major alien threat (Cambray 2003). It now occurs in the mainstream areas of the Berg, Breede, Gouritz and Olifants river systems and there is concern regarding its potential impact in tributary streams where indigenous fish populations survive. It has already caused a severe decline in the Gamtoos River system population of the smallscale redfin (*Pseudobarbus asper*). Unconfirmed reports suggest that sharptooth catfish are also being moved to farm dams in the Gourits River system, the one remaining secure river system for the smallscale redfin.

3.4.1.2 Water abstraction

River habitat destruction takes several forms in the CFR, a primarily winter rainfall region, the most important being excessive water abstraction that leaves rivers with little or no flow in drier months. Abstraction is often accompanied by the building of weirs to divert water or to allow pumps access to deeper water. In addition, bulldozing is done to channel rivers as a flood control measure, often associated with alien tree infestation. Alien trees also use more water than the indigenous vegetation. Bulldozing directly destroys structure and habitat needed for fish to survive and affects, in particular, the two *Austroglanis* species in the Olifants River system that depend on cobble habitat to avoid predation (Bills 1999). Sedimentation associated with the above and other farming activities further decreases habitat heterogeneity.

Potential future threats include utilization of aquifer resources. These aquifers provide most of the base flow of rivers in the CFR and help maintain wetlands and sanctuary streams for indigenous fish, other water-

Clarias gariepinus, a species native to much of Africa which has become an invasive alien in some river systems outside its natural range, particularly in the CFR in South Africa. Photo: © SAIAB/Roger Bills.



dependent organisms, and wetland-adapted fynbos vegetation. The utilization of aquifers to address water shortages for Cape Town and surrounding areas, already a major problem, could cause the extinction of range-restricted fish species. Effective management of water resources to allow natural flows, the control of resident alien fish populations, and the management of alien and indigenous fish introductions will have a significant impact on the conservation status of CFR freshwater fishes.

3.4.1.3 Dams and inter-basin water transfers

Large dams prevent migration of larger cyprinids and act as a reservoir for the spread of alien fish species. The disappearance of the Clanwilliam sandfish (*Labeo seeberi*) from the upper Olifants arm of the Olifants River system is believed to be the combined result of the Clanwilliam (see Chapter 1) and Bulshoek dams preventing upstream migration, and the establishment of alien fish species in the spawning habitats. Large dams also attract the attention of anglers, increasing the chance of alien fish introductions. Inter-basin transfer schemes (IBTs) have allowed alien fish to move between the Breede, Berg and Eerste River systems, but no translocations of indigenous fish species through IBTs have been recorded to date in the CFR. Changes in the species composition in Theewaterskloof Dam could allow indigenous species to move from the Breede to the Berg and Eerste River systems in future. All IBTs remain a potential pathway for alien fish invasions or for the translocation of indigenous species that could affect the genetic integrity of receiving indigenous populations.

3.4.1.4 Fishing

Direct utilization of CFR fishes is not a major threat except where fishing is being promoted for populations of threatened species. For example, the promotion of indigenous yellowfish (*Labeobarbus*) and large barb (*Barbus*) species as an alternative to fishing for alien species may help to reduce the demand for introductions of alien sport fishes, but it may at the same time impact on threatened native species if fishing pressures are too high. For example, the few remaining river areas with recruiting populations of the Endangered *B. andrewi* should not be fished. In addition, these large cyprinids can themselves become the target of a renewed wave of introductions to promote recreational angling resources in areas outside their natural range. Apart from being potential alien species in their own right, these species could also hybridize with cyprinids from the receiving system, homogenizing allopatric genetic diversity.

3.4.1.5 Pollution

The effects of pollution are not well documented or understood in the CFR. Rivers associated with cities and towns suffer from sewage, industrial and general waste pollution, with associated urban problems such as

channelization. It is, however, the agricultural pesticides that require urgent research attention. Many of the chemicals used by farmers are lethal to fish, and the generally lower number of fish in agricultural areas may be due to pesticides rather than other impacts such as sedimentation.

3.4.2 Mpumalanga

Although the fish fauna of the Mpumalanga region is dominated by Zambezian elements it is characterized by relatively high endemism with many restricted range species. Examples include several endemic cyprinids, an undescribed *Kneria* species and the cichlid *Chetia brevis* Jubb, 1968. The most striking component of the fauna is a radiation of six suckermouth catfishes (*Chiloglanis* spp.). Threats to the fishes, as in other regions, are alien fish species, water abstraction, water regulation (aseasonal flows from dams), pollution from industrial areas in the western highveld, widespread agricultural pollution, and sedimentation from forestry.

Invasive alien fish species are again a major threat. For example, *Barbus treurenensis* was extirpated from its type locality because of trout and was then restricted to a single population in the upper reaches of the Blyde River. It has, however, since been successfully re-introduced after eradication of the trout, and was successfully translocated to a second sanctuary stream. Trout also threaten the *Kneria* species and development of trout fisheries has impacted wetlands in general and thus their biota, while the American bass species threaten *Chetia brevis*.

Other threats in the area, as a result of human activities in an area of high populations and industrial and agricultural development, are: (1) aseasonal and/or constant water releases from dams e.g. Ncwena Dam, Crocodile River; (2) pollution and water abstraction as a result of farming

Flyfishing for yellowfish on the Pongola River. Photo: © Peter Hill.



activities; (3) industrial pollution, such as at Ngodwana and from mining activities, particularly mine water, and; (4) sedimentation caused by forestry plantations. *Chiloglanis bifurcus*, for example, faces a number of threats, including water flow regulation, water abstraction, pollution and sedimentation.

3.4.3 Zambezi system

3.4.3.1 Threats to *Neolebias lozii* Winemiller and Kelso-Winemiller, 1993

In the Upper Zambezi system, one species, *N. lozii*, is Critically Endangered. This species is apparently restricted to the Kataba River and its tributary, the Sianda stream, a small tributary system of the Upper Zambezi, which it joins on the eastern side of the Barotse Floodplain (Tweddle *et al.* 2004). The streams it inhabits are small and associated with seasonally flooded plains (dambos) bordered by open woodland. It occurs in and under dense floating mats of vegetation adjacent to the stream margin and in dense emergent vegetation (Winemiller and Kelso-Winemiller 1994; Tweddle *et al.* 2004). Canalization of the streams accelerates run-off from the floodplain in the dry season, and no *N. lozii* were found in the canalized section of the Kataba. Increasing human population, leading to intensification of agriculture, together with deforestation of the woodland bordering the dambos, and possible pollution by fertilizer and herbicides, is likely to threaten the habitat. A large headwater swamp sustains the Kataba such that any reduction in flow due to groundwater abstraction is a potential threat.

3.4.3.2 Alien invasive Nile tilapia *Oreochromis niloticus* threat to *O. andersonii* and *O. mortimeri* (Trewavas, 1966)

Insufficient data are available to confirm the apparent declines in abundance of *O. andersonii* in the Upper Zambezi system (Tweddle *et al.* 2004), but anecdotal evidence suggests a major decline in stocks on the Barotse Floodplain since the 1960s as a result of heavy fishing pressure. In addition, the rapid spread of alien *O. niloticus* through the Kafue system has had a major impact though data are again lacking, and the situation is set to worsen as this alien species is now being promoted for aquaculture in the Upper Zambezi catchment. It now seems inevitable that *O. niloticus* will continue to spread throughout the range of *O. andersonii*. The elimination of *O. andersonii* is predicted in areas where *O. niloticus* invades, as a result of the effects of competition, predation and possibly hybridization. In view of these spreading threats to the Zambia system as a whole, *O. andersonii* is assessed as Vulnerable. The Okavango population is not immediately threatened, but this system is intermittently linked to the Zambezi and thus *O. niloticus* will invade the system unless a barrier is constructed across the Selinda Spillway to prevent migration. *Oreochromis andersonii* is also

recorded from the Kunene River, where *O. niloticus* does not yet occur. The alien species *Oreochromis mossambicus* (Peters, 1852) is, however, being extensively cultivated in Namibia and may hybridize with *O. andersonii* if it escapes into the Kunene. Establishing refuges in lakes that are not directly connected to the main rivers or to aquaculture establishments may allow small populations of *O. andersonii* to survive.

Oreochromis mortimeri occurs in the Middle Zambezi system including the Luangwa River, and is assessed as Critically Endangered because of the introduction of *O. niloticus* for aquaculture in Lake Kariba and other areas of the Zambezi system. There are no natural barriers to the spread of this alien species throughout the range of *O. mortimeri*. In Lake Kariba, *O. mortimeri* has already been eliminated from areas of the lake where cage culture of *O. niloticus* is already practiced (Figure 3.8). In the Limpopo system the situation is similar where *O. niloticus* replaces *O. mossambicus* in dams (B. van der Waal pers. comm.; Tweddle and Wise 2007).

The competitive success of *O. niloticus* over other tilapias is the result of a combination of faster growth and larger size resulting in success in competition for nesting grounds, high fecundity as a result of large size, ability of juveniles to survive and avoid predation in extreme shallows despite the adverse conditions such as large temperature fluctuations, a much broader-ranging diet, and ability to hybridize with other tilapias (Tweddle and Wise 2007). The apparently inevitable replacement of indigenous tilapiines by introduced Nile tilapia has major implications for conservation programmes.

Nile tilapia is being promoted (at the time of writing) by an aquaculture development project run by American Peace Corps based at Mwekera Fish Farm on the Kafue system. Nile tilapia is already present in the Upper Zambezi system in numerous ponds in the Mwinilunga area. Investigation of fish ponds at Mwinilunga revealed

hybridization between Nile tilapia and the indigenous three-spot tilapia, *O. andersonii*, which is reported to grow as well as *O. niloticus* in ponds.

The Upper Zambezi River is an internationally shared water body and thus States on the system have an obligation to prevent the spread of exotic species that will affect neighbouring countries.

3.5 Conservation recommendations

The species assessed as Critically Endangered in the southern African region are primarily in the CFR, Mpumalanga, and the Zambezi system. Other areas, such as Angola and Mozambique, are poorly known and need further exploration. These areas are not heavily impacted, however, and despite our lack of knowledge few species are likely to be threatened.

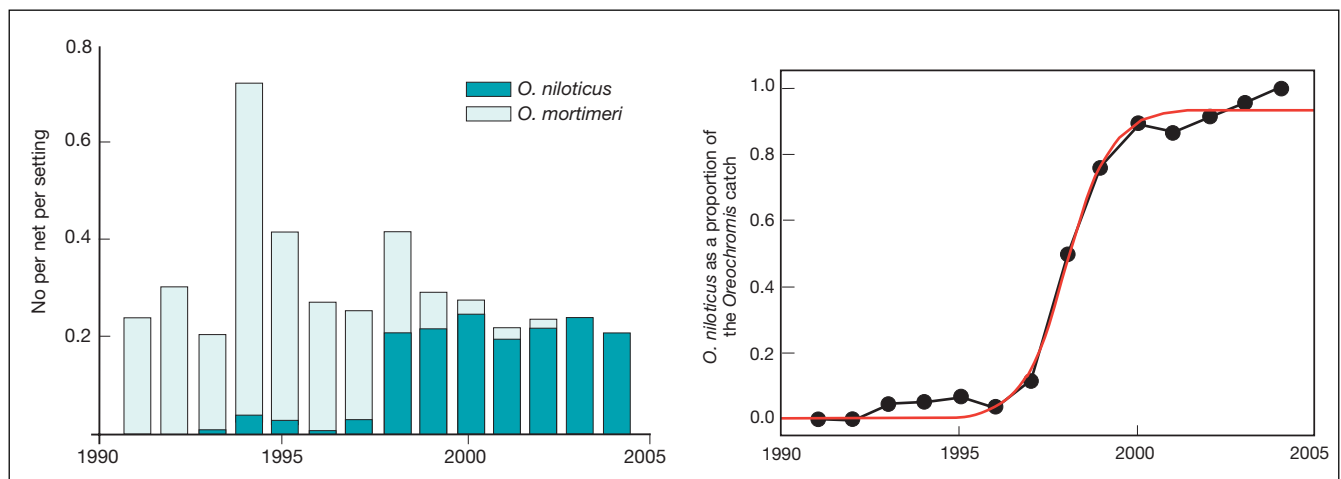
3.5.1 Species specific conservation programmes

Species conservation is not solely about protecting fish species, but should also include protection of the habitat, thus catchment conservation is the recommended

Oreochromis mossambicus, a species which is threatened within its native range by invasive alien species such as *O. niloticus* and which in turn also threatens other species, such as *O. andersonii*, through hybridization in areas where it has been introduced outside its own native range. Photo: © SAIAB/Roger Bills.



Figure 3.8 The replacement of *O. mortimeri* by *O. niloticus* in gillnet catches in Lake Kariba (data supplied by Ms P. Chifumba).



approach in most cases. Several initiatives are under-way in the region but some species currently have little or no protection. The recent initiatives, examples of which are given here, provide important lessons for future conservation programmes.

3.5.1.1 Maloti Minnow Conservation Project

The Maloti Minnow Conservation Project, carried out for the Lesotho Highlands Development Authority, is a model for other threatened species. The most important populations of the species are in the Senqunyane River (approximately 77% of the overall extent of occurrence of this species) and Matsoku River (20% of extent of occurrence) where they are threatened by transfer of fish species (rainbow trout, *Oncorhynchus mykiss*, and smallmouth yellowfish, *Labeobarbus aeneus* (Burchell, 1822)) through water supply tunnels connecting to the Katse Reservoir. Hence, mitigation for the projected loss of Maloti minnow habitat is given high priority in the Lesotho Highlands Water Project.

Actions taken included a survey of all known populations and rivers where the species might possibly occur. No new populations were discovered and the status of some existing populations was found to have deteriorated. Genetic studies revealed two main lineages, *Pseudobarbus quathlambae* in the eastern Lesotho streams and *Pseudobarbus* sp. “quathlambae cf. Mohale” in the Senqunyane catchment. Recommendations for the latter lineage included translocation into other fishless streams in the area above natural barriers to upstream fish movement (now successfully accomplished) and the construction of a barrier to upstream movement of alien fishes above Mohale Dam. The latter mitigation recommendation has not so far been implemented. Recommendations for the eastern lineage include barrier construction and selective eradication of alien trout, but this has yet to be implemented (Skelton *et al.* 2001).

This project is an example of a programme designed specifically for the conservation of a single (but now recognised as two) fish species where development of water resources poses a specific threat to the survival of the species. While not yet 100% successful in achieving its overall aims, it has succeeded in securing the survival of the eastern lineage and has raised the profile of biodiversity conservation in the southern African region.

3.5.1.2 River Health Programme – RHP (www.csir.co.za/rhp)

The Department of Water Affairs and Forestry (DWAF) initiated the formal design of the RHP in 1994. The main purpose of the programme was to serve as a source of information on the overall ecological status of river ecosystems in South Africa. The RHP primarily makes use

of in-stream and riparian biological communities (e.g. fish, invertebrates, vegetation) to characterize the response of the aquatic environment to multiple disturbances. The rationale is that the integrity or health of the biota inhabiting the river ecosystems provides a direct and integrated measure of the health of the river as a whole.

The goal is for information provided through the RHP to support the rational management of these natural resources. Its objectives are to: (a) measure, assess and report on the ecological state of aquatic ecosystems; (b) detect and report on spatial and temporal trends in the ecological state of aquatic ecosystems; (c) identify and report on emerging problems regarding aquatic ecosystems, and; (d) ensure that all reports provide scientifically and managerially relevant information for national aquatic ecosystem management.

The RHP has so far produced several ‘State of the River Reports’ on river systems throughout South Africa, including assessments of current status of the faunas. These provide valuable information on which to base conservation programmes.

3.5.1.3 Yellowfish Working Group (www.fosaf.org.za/fosafs/aboutyell.htm)

Nine “yellowfish” species (large *Barbus* and *Labeobarbus*) occur in South Africa. The Yellowfish Working Group, hosted by FOSAF (Federation of Southern African Fly Fishers) was initiated in 1994 and is a dynamic organization consisting of anglers, conservation officials, members of government, academics and industry representatives (Wolhuter and Impson (eds.) 2007). It is growing in scope and influence. It encourages riparian owners to establish yellowfish conservation and management associations, originated a comprehensive set

Labeobarbus kimberleyensis (Gilchrist and Thompson, 1913), a yellowfish species endemic to the Orange River system where it is promoted as a flagship angling species with most anglers practicing catch and release. Photo: © SALAB/Roger Bills.



of reports on the status of yellowfish species, developed a yellowfish genetics research programme, and popularizes angling qualities of indigenous species.

3.5.2 Cape Floristic Region – CapeNature alien fish eradication programme

CapeNature, a provincial nature conservation organisation in South Africa, has identified alien fish as the primary reason for the decline of indigenous fish species in the Cape Floristic Region (CFR). CAPE (Cape Action for People and the Environment) is a programme of the South African Government, with support from international donors, to protect the rich biological heritage of the CFR. As part of this programme, an alien fish eradication programme has been initiated. A comprehensive EIA is currently being undertaken, building on baseline information collected for PhD and Post-doctoral studies, to assess the potential impact of the fish poison rotenone on aquatic organisms and the general functioning of the river ecosystem. Provided the EIA shows a low risk to existing aquatic biodiversity, three rivers (two in the Cederberg tributaries of the Olifants River system on the west coast and the upper reaches of the Krom River system on the south coast) will initially be targeted for rehabilitation by eradicating the alien fish. These rivers are otherwise nearly pristine and re-introduction of indigenous fish populations will be possible if complete eradication of the aliens can be achieved. In most cases, however, indigenous fish populations are expected to re-occupy rehabilitated stretches of river from upstream source populations. The rehabilitation projects are expected to improve the conservation status of some threatened species, not only by re-establishing new populations, but also by increasing the size of some populations, making them less susceptible to extinction due to demographic fluctuations. The key to success of the project is to secure the rehabilitated areas against re-invasion by alien fish. This can only be achieved where there is an existing downstream barrier, but in certain cases the construction of such a barrier will be considered if the costs are realistic in terms of the overall goals of the project.

This is a pilot programme targeted at smaller streams where eradication is considered to be most feasible. If successful, consideration will be given to eradication in larger streams using the lessons learned from the pilot programme.

3.5.3 Mpumalanga

Taxonomic and survey work is needed to establish the status and distribution of some species in the Mpumalanga district. Several small, upper catchment *Barbus* species, such as those in the chubbyhead group, are still undescribed and their distributions are not fully known. There is also one undescribed *Kneria* species and

geographical variation in some of the *Chiloglanis* species which needs to be investigated. Upland relict populations of species such as *Varicorbinus nelspruitensis* Gilchrist and Thompson, 1911 and *Barbus crocodilensis* Fowler, 1934 require protection of upper catchments, with measures such as control of excessive water abstraction, farmer outreach and education programmes, and emphasis on pollution prevention, such as treatment of mine effluent water.

3.5.4 Zambezi

3.5.4.1 Further exploration

Exploration of the headwaters of the Upper Zambezi in 2004 yielded many species not previously found in thorough surveys of the floodplains and mainstream river further downstream (Tweddle *et al.* 2004), including several species that have yet to be identified (Table 2). While some of these may also be found in southern Congo tributaries, an area which is also very poorly surveyed, most are believed to be previously undescribed species. While most of these species are considered to be of Least Concern because the tributary systems in which they occur are large and very lightly impacted, there is still a need for more detailed exploration of these tributary systems and taxonomic investigation of the species concerned.

3.5.4.2 Limitation on the use of alien invasive species in aquaculture programmes

The use of Nile tilapia in the Upper Zambezi system for aquaculture is a major problem that will impact on indigenous tilapiines with a risk of driving them to extinction. All ponds containing the species need to be screened off and drained and all stocks completely destroyed. If carried out, compensation will have to be provided to affected farmers, who will also have to be provided with a new, pure strain of *O. andersonii* from unpolluted stocks from the Barotse Floodplain.

The indiscriminate spread of exotic species throughout the Zambezi and other systems without any consideration for the conservation of indigenous fish faunas needs to be stopped. In addition to the spread of *O. niloticus* another example of alien species introduction is *O. andersonii* which has been introduced into the Lake Tanganyika ecosystem, where it does not naturally occur. The widespread promotion of alien fishes for aquaculture despite the large and growing body of evidence on their devastating impacts on indigenous species means that it is time for a change in aquaculture philosophy and practice, Africa-wide. FAO, the World Fish Centre and other organizations, such as the US Peace Corps, that promote the farming of alien fish species should be strongly encouraged to be more responsive to biodiversity concerns and, where necessary, promote the culture of suitable native species.

3.5.4.3 *Neolebias lozii* (CR)

Neolebias lozii is apparently restricted to the Kataba River and its tributary, the Sianda, on the eastern side of the Barotse Floodplain. At present, apart from some canalization of these streams, the overall ecology appears healthy and the streams are in a rural area with no immediate threat of urbanization. If this species is to persist in this highly restricted locality then it is most important to maintain stream flow and particularly the emergent and riparian vegetation in these streams. This requires restriction on clearing the canalized stretches and, most importantly, no abstraction of water from the upstream catchments, or interference with the flooded plain at the headwaters of the Kataba River. There is currently no awareness of the presence of this species in the local community so public awareness must be a key component of any conservation plan for this species.

3.5.5 Angola

Apart from collections currently being made by SAIAB in the Kwanza River in collaboration with the Instituto Nacional de Investigação Pesqueira (INIP), there have been few recent collections from Angola because of the security situation. Thus Red List assessments have been based only on publications up to the 1960s (Fowler 1930;



Neolebias lozii, a Critically Endangered species with a highly restricted range in the Upper Zambezi threatened primarily by habitat loss. Photo: © SAIAB/Denis Tweddle.

Pellegrin 1936; Poll 1967). This has resulted in many species being assessed as Data Deficient, while knowledge of distribution is extremely limited. Taxonomic knowledge has advanced considerably since these publications, and the illustrations in the publications show that much work needs to be done.

The new collections made by SAIAB/INIP in the Kwanza show that there are several species complexes, e.g. mormyrids and large cyprinids, that are now the subject of genetic and morphological investigation. The high diversity in the Kwanza confirmed by these surveys highlights the importance of study of the neighbouring

Sampling the Upper Zambezi below Sioma Falls, Zambia. Photo: © SAIAB/Denis Tweddle.



rivers to better understand the relationships of the Angolan fish fauna.

3.5.6 Mozambique

The ichthyofauna of Mozambique is poorly known due primarily to the country's isolation during its 17-year war (1976-1992). Recent collections by SAIAB have improved knowledge of the fauna, particularly of certain protected areas such as, the Lower Zambezi Delta (Bills 1999), the Lugenda/Rovuma rivers in the Niassa Reserve (Bills 2004), the wetlands of the Maputo Special Reserve (Bills 2001), the upper Buzi River in the Chimanimani Transfrontier Conservation Area (Bills and Weyl 2002, Bills unpublished), Banhine National Park (Bills and Da Costa 2005). Much more research is, however, needed simply to describe Mozambique's ichthyofauna and exploring the relationships and biogeography of east coast fishes will take much longer. Areas that have not been recently or ever surveyed include the coastal rivers between the Zambezi delta and the Rovuma River, the coastal plain reaches of all Mozambique's rivers, and the Pungwe River. Numerous undescribed and poorly known species occur in almost all these river systems although the greatest numbers occur within the Rovuma River system. Determining the status of these species will require targeted surveys.

Typically most species show broad distributions within individual or several river systems. As there are relatively few known impacts on these systems this has resulted in assessments of Least Concern for the majority of the fauna. A few species do appear to have restricted distributions and as in other areas of southern Africa a number of these species have been assessed as threatened due to real or potential threats. For example the undescribed *Barbus* sp. 'banhine' of the Banhine National

Park in Gaza Province, southern Mozambique is assessed as Critically Endangered.

Probably the greatest threat to the fauna is alien fishes. *Micropterus* species, *O. niloticus* and various carp species are mainly impacting areas of the Limpopo, Incomati and Buzi systems. Sources of these aliens in the past have been hatcheries or angling introductions in neighbouring South Africa and Zimbabwe. However, a new wave of alien introductions is likely with the immigration of farmers from Zimbabwe who have a history of alien fish movement. If possible alien fish movement should be discouraged in all stakeholder groups.

3.6 References

- Bell-Cross, G. 1965. Observations on the movements of fish across the Congo/Zambezi watershed in the Mwinilunga District of Northern Rhodesia. In: *Proceedings of the Central African Scientific and Medical Congress, Lusaka, Northern Rhodesia*, ed. G.J. Snowball, pp. 415-424. Pergamon Press, Oxford.
- Bills, R. 1999a. Biology and conservation status of the Clanwilliam rock catfish and spotted rock catfish. J.L.B. Smith Institute of Ichthyology, Investigational Report 60.
- Bills, I.R. 1999b. An inventory of fishes from the lower Zambezi River, Mozambique (27/7/1999 to 14/8/1999). J.L.B. Smith Institute of Ichthyology, Investigational Report 62.
- Bills, I.R. 2001. An inventory of fishes from the Maputo Special Reserve and Futi Corridor, Mozambique (21/9/2001 to 6/10/2001). JLB Smith Institute of Ichthyology, Investigational Report no. 63.
- Bills, I.R. 2004. A survey of the fishes and fisheries in the Niassa Reserve, Niassa and Cabo Delgado Provinces,

Notobranchias furzeri Jubb, 1971 from the Banhini National Park in Mozambique. This beautiful species of killifish was originally said to be very restricted in its range but a recent survey has found it to be more widespread than first thought. The male yellow-tailed form is ubiquitous in the park and always occurs with one red-tailed form. The colouration of the red-tailed form changes across the region. The female, bottom right, is uniform throughout the park. Photo: © SAIAB/Roger Bills.



- Mozambique (10-30/8/2003). SAIAB Investigational Report 69.
- Bills, I.R., Boycott, R., Fakudze, M., Khumalo, N., Msibi, J., Scott, L., Skelton, P.H., Terry, S. and Tweddle, D. 2004. Fish and Fisheries Survey of Swaziland (2002–2003). Final report – July 2004. SAIAB Investigational Report 70.
- Bills, I.R. and Da Costa, L. 2005. A survey of the fishes of the Banhine National Park, Gaza Province, Mozambique (25/05-12/06/2005). SAIAB Investigational Report 72.
- Bills, R. and Marshall, B. 2004. Fishes of the Four Corners Area. In: *AWF Four Corners TBNRM Project: Reviews Of Existing Biodiversity Information*. The Zambezi Society and The Biodiversity Foundation for Africa, pp. 352–380.
- Bills, I.R. and Weyl, O. 2002. A new species of the genus *Chetia* (Teleostei: Cichlidae) from the Lecitu River, Buzi System, Mozambique. *Smithiana, Special Publication*, 1:1–13.
- Cambray, J.A. 2003. The need for research and monitoring on the impacts of translocated sharptooth catfish, *Clarias gariepinus*, in South Africa. *African Journal of Aquatic Science* 28:191–195.
- Canonico, G.C., Arthington, A., McCrary, J.K. and Thieme, M.L. 2005. The effects of introduced tilapias on native biodiversity. *Aquatic Conservation: Marine Freshwater Ecosystems*, 16: 463–483.
- Cowx, I.G. 2002. Analysis of threat to freshwater fish conservation: past and present challenges. In: *Conservation of freshwater fishes: options for the future*. Eds: Collares-Pereira, M.J., Cowx, I.G. and Coelho, M.M. pp. 201–220. Fishing News Books, London.
- Fowler, H.W. 1930. The fresh-water fishes obtained by the Gray African expedition – 1929. With notes on other species in the academy collection. *Proceedings of the Academy of Natural Sciences of Philadelphia*, 82:27–83.
- Hamman, K.C.D., Thorne, S.C. and Skelton, P.H. 1984. The discovery of the Cape Kurper *Sandelia capensis* (Cuvier in Cuvier and Valenciennes 1831) in the Olifants River system (Western Cape Province). *The Naturalist* 28(1):24–26.
- Harrison, A.C. 1952. Introduction of exotic fishes to the Cape Province: Bluegills. *Piscator* 6:93–95.
- Marriott, M.S. 1998. Conservation biology and management of the Twee River redbin, *Barbus erubescens* (Pisces: Cyprinidae). Unpublished MSc thesis, Rhodes University.
- Pellegrin, J. 1936. Contribution à l'ichthyologie de l'Angola. *Arquivos do Museu Bocage*, 7:45–62.
- Poll, M. 1967. Contribution à la faune ichthyologique de l'Angola. Museu do Dondo, Subsídios para o Estudo da Biologia na Lunda. *Diamang Publicações Culturais* no. 75.
- Skelton, P.H. 1994. Diversity and distribution of freshwater fishes in East and Southern Africa. *Annales Musée Royale de l'Afrique Centrale, Science Zoologique*, 275:95–131.
- Skelton, P.H. 2001. *A complete guide to the freshwater fishes of southern Africa*. Second edition. Struik, Cape Town.
- Skelton, P.H., Rall, J., Swartz, E., Bloomer, P., Bills, R. and Tweddle, D. 2001. Maloti Minnow Conservation Project, Contract LHDA 1041. Report to LHDA.
- Swartz, E.R. 2005. *Phylogeography, phylogenetics and evolution of the redfins (Teleostei, Cyprinidae, Pseudobarbus) in southern Africa*. PhD thesis, University of Pretoria.
- Thieme, M.L., Abell, R., Stiassny, M.L.J., Skelton, P., Lehner, B., Teugels, G.G., Dinerstein, E., Toham, A.K., Burgess, N. and Olson, D. (eds.) 2005. *Freshwater ecoregions of Africa and Madagascar: a conservation assessment*. Island Press, Washington DC, USA.
- Tweddle, D., Skelton, P.H., van der Waal, B.C.W., Bills, I.R., Chilala, A. and Lekoko, O.T. 2004. *Aquatic biodiversity survey for the "Four Corners" Transboundary Natural Resources Management Area*. Final Report – July 2004. Report for African Wildlife Foundation.
- Tweddle, D. and Wise, R.M. 2007. Nile tilapia (*Oreochromis niloticus*) case study, Appendix 3. In: Wise, R. M., van Wilgen, B.W., Hill, M.P., Schulthess, F., Tweddle D., Chabi-Olay, A. and Zimmermann, H.G. 2007. The economic impact and appropriate management of selected invasive alien species on the African continent. CSIR Report prepared for: Global Invasive Species Programme, Number: CSIR/NRE/RBSD/ER/2007/0044/C.
- Wolhuter, L. and Impson, D. (eds.) 2007. The state of yellowfishes in South Africa, 2007. Report to the Water Research Commission by the Yellowfish Working Group, WRC Report TT302/07, March 2007.

Chapter 4. The status and distribution of freshwater molluscs

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4.1 Overview of the regional fauna

The southern African region covers 22 ecoregions as defined by the World Wildlife Fund (WWF) (Thieme *et al.* 2005) and listed in Chapter 1 (Figure 1.1 and Table 1.2). Although these ecoregions do not relate specifically to the distribution of the mollusc fauna, they will be used in the present report to review the available information on different taxa. In terms of mollusc species richness, the most important ecoregions are the Okavango and Upper Zambezi Floodplains, Kafue, Middle Zambezi, Luangwa, Zambezi Highveld, Zambezi Lowveld and Eastern Coastal.

The gastropod fauna is well known for most of the southern African regions. This is largely because certain species of the genera *Lymnaea* (Lymnaeidae), *Biomphalaria* and *Bulinus* (Planorbidae) act as intermediate hosts for economically important trematodes of humans and domestic animals. National surveys designed to target these genera were carried out in several countries over the past century but recorded others as well. The results of these surveys and of other collections made over many years were collated by Brown (1994) in his seminal work *Freshwater Snails of Africa and their medical importance*. Several families, genera and species are, however, still poorly known and several ecoregions have not been adequately surveyed.

Comparatively little work has been done on the Bivalvia and the systematic status of many species is unclear while



Bulinus tropicus (Krauss, 1848), a widespread species in southern Africa and beyond is known to act as the intermediate host for the conical fluke *Calicophoron microbotrium* (Fischöder, 1901), a common parasite of domestic animals. Within the genus *Bulinus* is found the intermediate host species for urinary schistosomiasis, a serious human disease. Photo: © Chris Appleton.

the biology of most remains poorly understood. The most recent review of the bivalves is that of Mandahl-Barth (1988) which, like Brown's (1994) book, covers the whole of Africa.

A total of 122 freshwater mollusc species is known from the southern African region. Of these, 99 species are gastropods belonging to 15 families (Brown 1994), and 23 species are bivalves belonging to six families (Mandahl-Barth, 1988).

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4.2 Conservation status (IUCN Red List Criteria: Regional Scale)

The summary presented here is based on an analysis of species regional Red List status following application of the IUCN Red List Criteria at the regional scale of southern Africa. The regional Red List status of any species which is endemic to southern Africa will be equivalent to its global Red List status.

Amongst the freshwater molluscs of the southern African region only 10 species (8.6%) are assessed as regionally threatened according to the IUCN Red List Categories and Criteria (Figure 4.1 and Table 4.1). These species, all in the Critically Endangered (CR) and Endangered (EN) categories, are threatened largely because of environmental disturbance and destruction of their habitats.

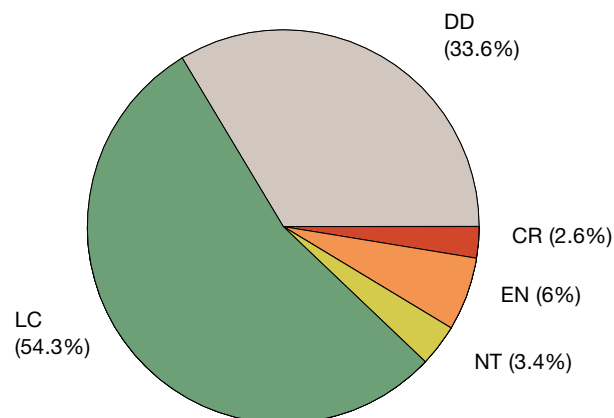
Among those species not listed as threatened, it is significant that as many as 39 species are categorized as Data Deficient (DD). Most of these are small and often overlooked. As such, a large part (33.6%) of the known species are Data Deficient showing that there is a clear need for further research into the freshwater mollusc fauna of the region.

The species in threatened categories are fortunately few. These are listed in Table 4.2 which shows that nine of the 10 threatened species are gastropods and only one, *Etheria elliptica* Lamarck 1807 (Etheriidae), is a bivalve. Six species have been assessed as Not Applicable, five are not native and one has less than 1% of its global range within the region.

4.2.1 Gastropods

Within the family Neritidae, two species, *Septaria borbonica* (Bory de St Vincent, 1803) and *S. tessellaria*

Figure 4.1 The proportions (%) of freshwater mollusc species in each regional Red List category in the southern Africa region. DD = Data deficient; CR = Critically Endangered; EN = Endangered; NT = Near Threatened; LC = Least Concern.



(Lamarck, 1816), are listed as Endangered. They may in fact represent broad and narrow-shelled forms of the same species living on rock and the stems of the reed *Phragmites australis*, respectively. If this is shown to be the case the name *S. borbonica* would take precedence. Whatever the case, both have very limited distributions, being restricted to the lowest reaches of rivers along the coast of KwaZulu-Natal, South Africa and possibly Mozambique as well.

There are many such rivers in this area and they are prime sites for industrial, residential and recreational development (Appleton 2002), especially in KwaZulu-Natal. This, combined with the associated increase in population density and habitat degradation, is an important reason for the threatened status of these species. The known habitats of both *Septaria* spp. are thus under pressure but a much needed survey of the brackish reaches of the KwaZulu-Natal rivers and further south into the Eastern Cape may show them to be more widespread.

Table 4.1 The numbers of freshwater mollusc species in each regional Red List Category in the southern African region.

	Regional Red List Category	Number of Species	Number of regional endemics
Threatened Categories	Critically Endangered	3	3
	Endangered	7	3
	Vulnerable	0	0
	Near Threatened	4	2
	Least Concern	63	15
	Data Deficient	39	33
	Not Applicable	6	0
Total		122	56

Note: All species assessed as regionally threatened which are endemic to the region are also globally threatened.

Table 4.2 Threatened freshwater mollusc species in the southern African region.

Family	Genus	Species	Red List Category
Neritidae	<i>Septaria</i>	<i>borbonica</i>	EN ^{RG}
Neritidae	<i>Septaria</i>	<i>tessellaria</i>	EN ^{RG}
Hydrobiidae	<i>Lobogenes</i>	<i>michaelis</i>	EN ^{RG}
Pomatiopsidae	<i>Tomichbia</i>	<i>caustoni</i>	CR
Pomatiopsidae	<i>Tomichbia</i>	<i>natalensis</i>	CR
Pomatiopsidae	<i>Tomichbia</i>	<i>tristis</i>	CR
Pomatiopsidae	<i>Tomichbia</i>	<i>differens</i>	EN
Pomatiopsidae	<i>Tomichbia</i>	<i>ventricosa</i>	EN
Pomatiopsidae	<i>Tomichbia</i>	<i>zwellendamensis</i>	EN
Etheriidae	<i>Etheria</i>	<i>elliptica</i>	EN ^{RG}

^{RG} = Regional Red List status

Only one species of the family Hydrobiidae is known from the southern Africa region and this species, *Lobogenes michaelis* (Pilsbry and Bequaert, 1927) is assessed as Endangered. *Lobogenes michaelis* has a very limited geographical distribution; three small areas in southern Congo, central southern Zambia and western Zambia (Brown 1994). It has recently been collected at two additional localities, the Kwando River Floodplain in Eastern Caprivi (north-eastern Namibia) and the panhandle of the Okavango Delta (north-western Botswana). These localities may in fact be connected in wet years and represent the southernmost localities for the species.

Seven species of *Tomichia* (family Pomatiopsidae) are known, four of them Endangered and three Critically Endangered. All are endemic to the southern African region and are threatened because of the very limited distribution of each species, sometimes restricted to single localities. All species of *Tomichia* are sensitive to changes in their habitats caused by pollution of all types as well as interference with the natural seasonal wet-dry regime. *Tomichia rogersi* occurs in only two springs in Northern Cape, South Africa, close to the border with Namibia (Brown 1994) and is assessed as Near Threatened because, despite its highly restricted range, there is no evidence of any current decline in range or distribution and no known plausible threat on account of its remote location. All these

Shell of *Tomichia* sp. (Pomatiopsidae) which belongs to a genus of gastropods endemic to the wetlands of the southern and eastern coastal strips of South Africa. The shell pictured was collected by M. Mlambo in a wetland in the Cape Agulhas area. The seven described species of *Tomichia* are all threatened. Photo: © Chris Appleton.



species warrant further study. *Tomichia cauwstoni* was recently 'rediscovered' in a forest stream in Eastern Cape and *T. natalensis* has been collected in recent years in only two rivers in a small area of northern KwaZulu-Natal, in slowly-flowing water shaded by riverine forest. These habitats are quite different from the exposed, ephemeral and often saline pans inhabited by the other species along the southern coast. In general, collections of *Tomichia* from any locality contain specimens varying so much in shell shape that it is difficult, if not impossible, to assign them to any of the described species. This is because most descriptions are based on shell morphology. A molecular study of *Tomichia* from across its range in South Africa would undoubtedly shed new light on the true status of the described species.

Two species of the family Viviparidae are known, both belonging to the genus *Bellamya* (Brown *et al.* 1992). One of these, *Bellamya monardi* (Haas, 1934), is classed as Near Threatened.

Five species in the family Ampullaridae are known in two genera, *Pila* and *Lanistes*. One species is Data Deficient while the others are assessed as Least Concern.

Three species of *Gabbiella* (family Bithynidae) occur in the region and two are ranked as Least Concern and one as Data Deficient.

The family Assimineidae is represented by two genera, *Eussoia* and *Assimineia*, of which the first contains a single species, *Eussoia leptodonta* Nevill, 1881, which is ranked as Data Deficient.

The family Thiaridae is represented by 12 species in five genera. One species is ranked as Near Threatened, two as Data Deficient. One species, *Terebia granifera*

Typical habitat of the Critically Endangered gastropod *Tomichia tristis* (Morelet, 1889) at the lagoon of the Seekoeirivier, Aston Bay, the site at which George Davis collected it in 1978. The snails are fairly abundant in the grassy vegetation just above the mud bank on the far (north) side of the river. It is part of the Seekoeirivier Nature Reserve. Photo: © D. Herbert.



(Lamarck, 1816), is assessed as Not Applicable because it is an invader. The remaining prosobranch snail to be discussed is *Tympanotonus fuscatus* (Linnaeus, 1758) which belongs to the family Potamididae. This is ranked Least Concern.

The southern African region has 56 species of pulmonate gastropods belonging to five families. The family Lymnaeidae includes three species of which one, *Lymnaea columella* (Say, 1817), is invasive and assessed as Not Applicable. A second species, *Lymnaea truncatula* (Muller), is intermediate host for the common liver fluke, *Fasciola hepatica* (Linnaeus, 1758), which can infect man as well as domestic stock. It causes serious health problems in sheep, horses, cattle and goats, but in southern Africa, rarely infects people. Molecular examination of *L. truncatula* collected in Lesotho suggests that, like those from the Bolivian altiplano, they are identical to European specimens and may therefore have been introduced from Europe (S. Mas Coma pers. comm. 2006). A third species, *Lymnaea natalensis* Krauss 1848, is host for another liver fluke, *F. gigantica* Cobbold 1856, which also infects stock animals and people. Both these last two species are widespread and assessed as Least Concern. *L. natalensis* is a very variable species across its range in Africa (Brown 1994) and molecular analysis may reveal that it contains a number of species (S. Mas Coma pers. comm. 2006; J. Lamb and C. Appleton unpublished data 2007).

The invasive species, *L. columella*, has been shown to be susceptible to fasciolid flukes in invaded countries on other continents but not to date in Africa. It is, however, presumed to play a role in fascioliasis transmission here too. There is in fact a fourth lymnaeid in South Africa, *Radix rubiginosa* (Michelin, 1831), which was introduced to northern KwaZulu-Natal from Southeast Asia via the aquarium trade. It is not known how far it has spread, if at all.

Lanistes ovum Peters in Troschel, 1845, an ampullarid snail which is widespread throughout much of Africa where it favours standing and slowly flowing waters with muddy bottoms and vegetation. Pictured here in the Okavango Delta. Photo: © William Darwall.



The family Ancyliidae is represented by 25 species belonging to two genera, *Burnupia* and *Ferrissia*. All these species are assessed as Data Deficient and research on these African ancyliids is strongly recommended. Ancyliids are all very small and likely to be overlooked by collectors in the field which may explain why they are so poorly known. Currently identifications are best made on the basis of proximity to the type localities of the described species. The genus *Burnupia* is usually considered to be indigenous to Africa but a species of *Burnupia* has been identified from South America by dos Santos (2003). This raises biogeographical questions analogous to those surrounding the distribution of the planorbid genus *Biomphalaria*.

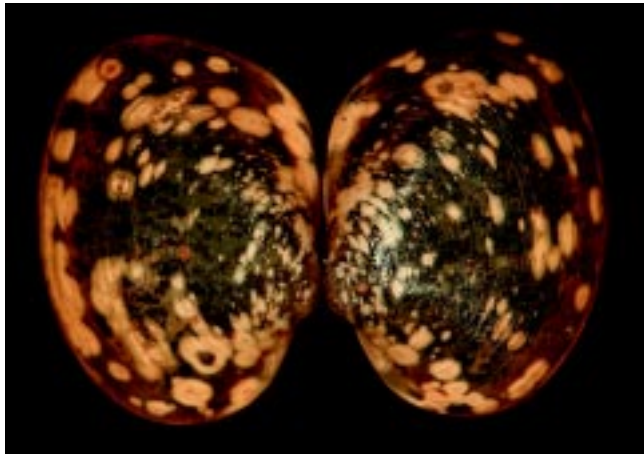
The family Planorbidae comprises two sub-families, the Planorbinae and Bulininae. In the Planorbinae 15 species are found in the southern African region. They belong to eight genera of which one, *Biomphalaria*, includes species that act as intermediate hosts for the bloodfluke, *Schistosoma mansoni* Sambon, 1907, which causes the serious human disease, intestinal schistosomiasis. Within the Planorbinae, all species are well known and assessed as Least Concern except four that are assessed as Data Deficient. The sub-family Bulininae includes 12 species in one genus, *Bulinus*. Within this genus, several species act as intermediate hosts for the blood fluke, *Schistosoma haematobium* (Bilharz, 1852), that causes the debilitating disease, urinary schistosomiasis, in man, and the cattle/antelope parasite *S. mattheei* (Veglia and le Roux, 1929). All species within the genus *Bulinus* are ranked Least Concern, apart from one which is assessed as Not Applicable as less than 1% of its global distribution is within the region.

Two members of the family Physidae occur in the region and each belongs to a different genus. Both species are invasive and are assessed as Not Applicable.

4.2.2 Bivalves

The family Etheridae is represented by one species only, *Etheria elliptica*, which is categorized as Endangered. *E. elliptica* is known from a limited area of south-western Angola (Appleton 1979; Appleton and Curtis 2007; Graf and Cummings 2006; Mandahl-Barth 1988; Pilsbry and Bequart 1927) where it is found in three locations in rapids and waterfalls threatened by proposed dams on the Kunene River. Up-to-date knowledge of its occurrence elsewhere in Angola is lacking, however, thus this assessment needs confirmation. The family Unionidae is represented by two genera, *Unio* and *Coelatura*. The first has one species and the second three species, all of which are assessed as Least Concern. The family Iridinidae includes six species, two each from three genera, *Aspatharia*, *Chambardia* and *Mutela*. Two species are

ranked as Data Deficient and the others as Least Concern. The family Corbiculidae is represented by two species within the genus *Corbicula*, both assessed Least Concern. Three genera of the family Sphaeriidae are represented, *Eupera*, *Pisidium* and *Sphaerium*. All species in these genera are assessed as Least Concern.



Eupera ferruginea (Krauss, 1848) (Sphaeriidae) a Least Concern species that is widespread throughout southern Africa and beyond. Photo: © Chris Appleton.

4.3 Patterns of species richness

4.3.1 All mollusc species

An extensive area of the southern African region supports a high richness of mollusc species with more than 15 species recorded in each river catchment (Figure 4.2). The catchments with the highest densities of species are in the east and centre of the region with the highest (25–34 species) in the following ecoregions: Okavango Floodplains, Upper Zambezi Floodplains, Middle Zambezi Luangwa, Zambezian (Plateau) Highveld, Zambezian Lowveld and Eastern Zimbabwean Highlands in the central parts of the region. Further to the east the Lower Zambezi, Eastern Coastal Basins, Limpopo River Valley southwards to the lowveld of Limpopo and Mpumalanga provinces and eastern parts of KwaZulu-Natal in South Africa also support high numbers of species. Moderate numbers of species (20–24 species) are also found in much of northern Botswana, Zimbabwe, eastern Mozambique and the midlands of KwaZulu-Natal in South Africa.

The high density of species in the catchments of the northern part of Mozambique (Eastern Coastal basins)

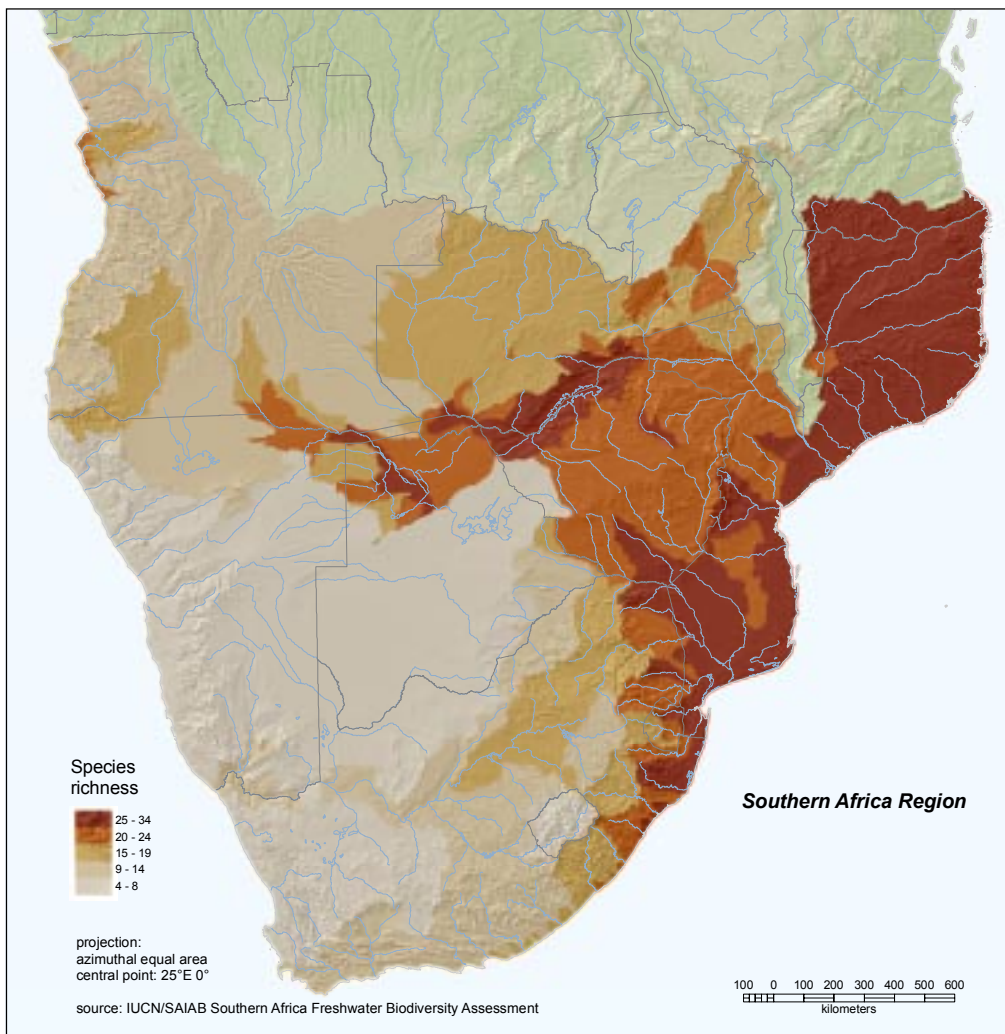


Figure 4.2 Freshwater mollusc species richness in the southern Africa region.



Preserving specimens at Kafue River, Zambia. Photo: © C. Simoonga.

Shell of *Cleopatra elata* Dautzenberg and Germain, 1914, a Least Concern species known to occur in the Okavango system from Rundu to the delta and perhaps also in the Angolan part of the river upstream of Rundu - this needs to be confirmed. In the Zambezi system it is found above the Victoria Falls (in Namibia) and in the Upper Zambezi in Zambia and Angola but this also needs confirmation. It appears not to be present in Lake Kariba itself (based on limited surveys) but does occur immediately below the dam at Chirundu. More survey work is required to identify the full distributions of this species and its congener *C. nsendweensis* Dupuis and Putzeys, 1902 which seem to have overlapping distributions in the region. Photo: © Chris Appleton.



reflects the large number of ancylid species recorded from this area. Unfortunately, as noted earlier, these species are not well known and had to be assessed as Data Deficient.

A number of species are endemic to southern Africa (Figure 4.3). The following three areas showed the highest levels of endemism: (i) a west/central swathe of country in the northern half of the region, extending from Angola and northern Namibia, northern Botswana to the middle Zambezi valley; (ii) much of southern and central Mozambique, and the eastern parts of South Africa extending westwards along the Orange (Gariep) River catchment; and (iii) southern parts of Western Cape Province, South Africa. Within these areas, highest endemism (4-6 species) is found in the central parts of the Kunene River basin and Etosha catchment, and the Okavango River system, Chobe/Linyanti Floodplain and middle Zambezi. The coastal strip of the Western Cape (South Africa) at the southern tip of the continent also supports five endemic species of *Tomichia* most often restricted to brackish or even hypersaline waterbodies such as vleis and springs that are common to the area.

4.3.2 Threatened species

There are few threatened mollusc species in the southern African region (Figure 4.4). Those that are known occur in south-western Angola associated with the Kunene River and a few localities associated with the central Zambezi and Kafue Rivers in Zambia. There are also two widely separated areas in South Africa, the southern coastal strip, and two areas close to the KwaZulu-Natal coast on the eastern side of the country, that support threatened species.

4.3.3 Restricted range species

The definition of restricted range for this study is taken to be confinement to one river system or in some cases two adjacent systems with recent or historical links. Larger systems with numerous large tributaries, such as the Zambezi, are not included and the analysis is restricted to those species endemic to the region. Most of the restricted range species are found in the northern half of the region or along its eastern and southern seaboard (Figure 4.5). Although several of these species are also assessed as threatened, some such as *Tomichia rogersi*, cannot be classified as such. Although this species has a very limited distribution of only two springs, one in Stinkfontein and the other in Lekkersiung in the arid western part of South Africa, just south of the Namibian border (Davis 1981) it is not assessed as threatened because there are currently no known plausible threats to these springs. However, taking into consideration its limited occurrence, these populations should be monitored closely during the coming years.



Freshwater snail survey in Okavango Delta, Botswana. Photo: © Chris Appleton.

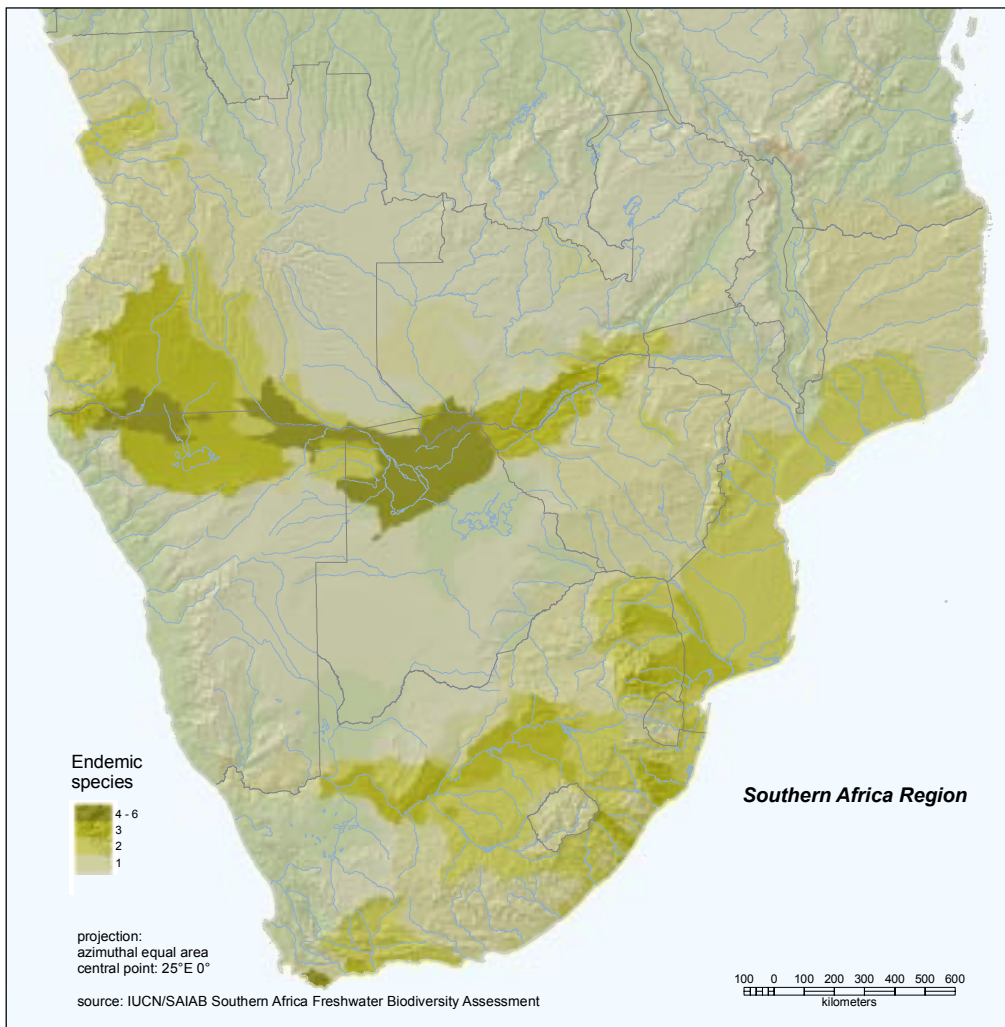
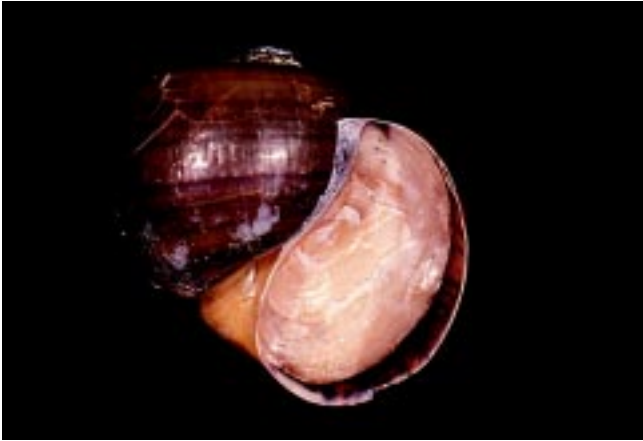


Figure 4.3 Endemism amongst freshwater mollusc species in the southern Africa region.

4.4 Major threats to molluscs

Major threats to molluscs include industrial and mining activities, chemical seepage, human domestic developments and interference in the seasonal wet-dry



Pila occidentalis (Mousson, 1887) (Ampullariidae) - Gadikwe Lagoon, Okavango Delta, Botswana. A Least Concern species endemic to the southern Africa region where it is known from the Kunene and Okavango systems and the ephemeral systems in between and southern Angola. It is also found in the Caprivi area (part of the Upper Zambezi system) and may occur further up the Zambezi but this needs to be confirmed. Photo: © Chris Appleton.

cycles of ephemeral habitats. Examples include the threatened endemic *Tomichia* spp. thought likely to be sensitive to the environmental changes caused by residential and recreational development, as are the two *Septaria* spp. in the coastal lowlands of KwaZulu-Natal, South Africa. The latter are also threatened by habitat degradation from industrial development, notably dune mining. Another threat is that of invasive gastropods. Evidence is accumulating that invasive species such as *Terebia granifera*, *Lymnaea columella* and *Physa acuta* are impacting indigenous species such that the ranges of the latter seem to be decreasing. This appears to be happening between *Terebia granifera* and *Melanoides tuberculata*, between *Lymnaea columella* and *L. natalensis* and between *Physa acuta* and *Bulinus africanus*. The interaction between invasive and indigenous snails needs urgent attention.

The hydrobiid *Lobogenes michaelis* is threatened by increasing water extraction from the Kafue River for the Kafue area, including Lusaka in Zambia. The population in the Kwando River Floodplain was last reported in 1985. A large snail-control programme using the molluscicide Bayluscide® was carried out in Eastern Caprivi in the 1980s, targeting *Biomphalaria pfeifferi*

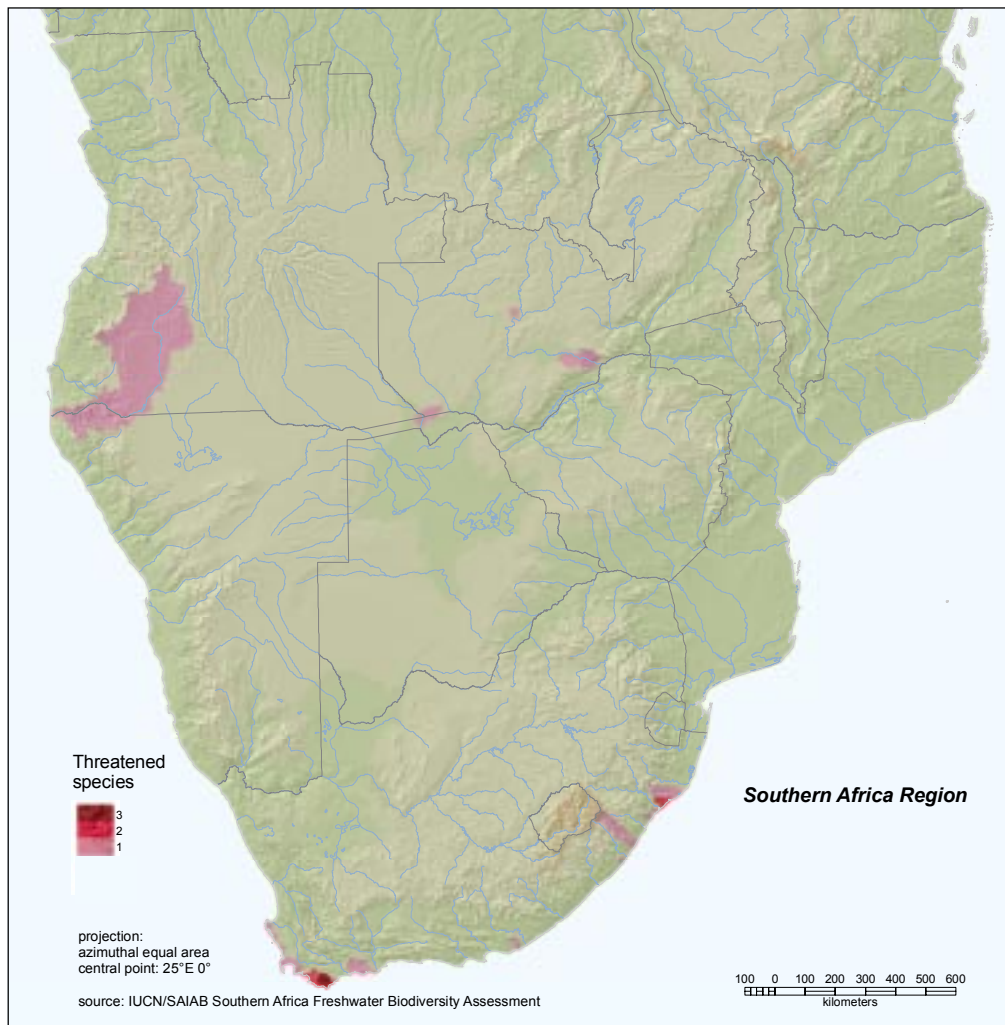


Figure 4.4 The distribution of regionally threatened freshwater mollusc species in the southern Africa region.



Etheria elliptica, a regionally Endangered freshwater oyster which is marginal to the region, being found in the Kunene and Cuanza rivers in Angola, but is widespread throughout other parts of Africa. Within the southern Africa region the species, which requires fast flowing rivers, rapids, and waterfalls, is threatened by the proposed construction of dams on the Kunene River. Photo: © Daniel Graf and Kevin Cummings.

(Krauss, 1848) and intestinal schistosomiasis (Schutte *et al.* 1995). No follow-up surveys were made so that the impact of the spraying of Bayluscide® on the mollusc fauna, including *L. michaelis*, cannot be assessed (B. Curtis pers. comm.).

The river oyster *Etheria elliptica* has a restricted distribution in the Kunene River where it borders Angola and Namibia. Several dams have been planned along the river and will, if built, probably destroy the fast-flowing habitats that this species requires.

Lack of knowledge for the 39 species assessed as Data Deficient (Table 4.1) could hide the fact that several of these species might also be threatened. It is therefore important that initiatives be taken to improve knowledge on the inadequately known species of the southern African region.

4.5 Conservation recommendations

Industrial developments such as dune mining, and residential/recreational developments have become commonplace along much of the coastline of South Africa. Ecological impact studies, which are required before these developments can begin, must evaluate the potential impact on important mollusc habitats such as vleis, streams and lagoons. Brackish water species such as *Septaria* and other neritids, *Tomichia* spp. and the thiarid *Thiara amarula* (Linnaeus, 1758) are particularly

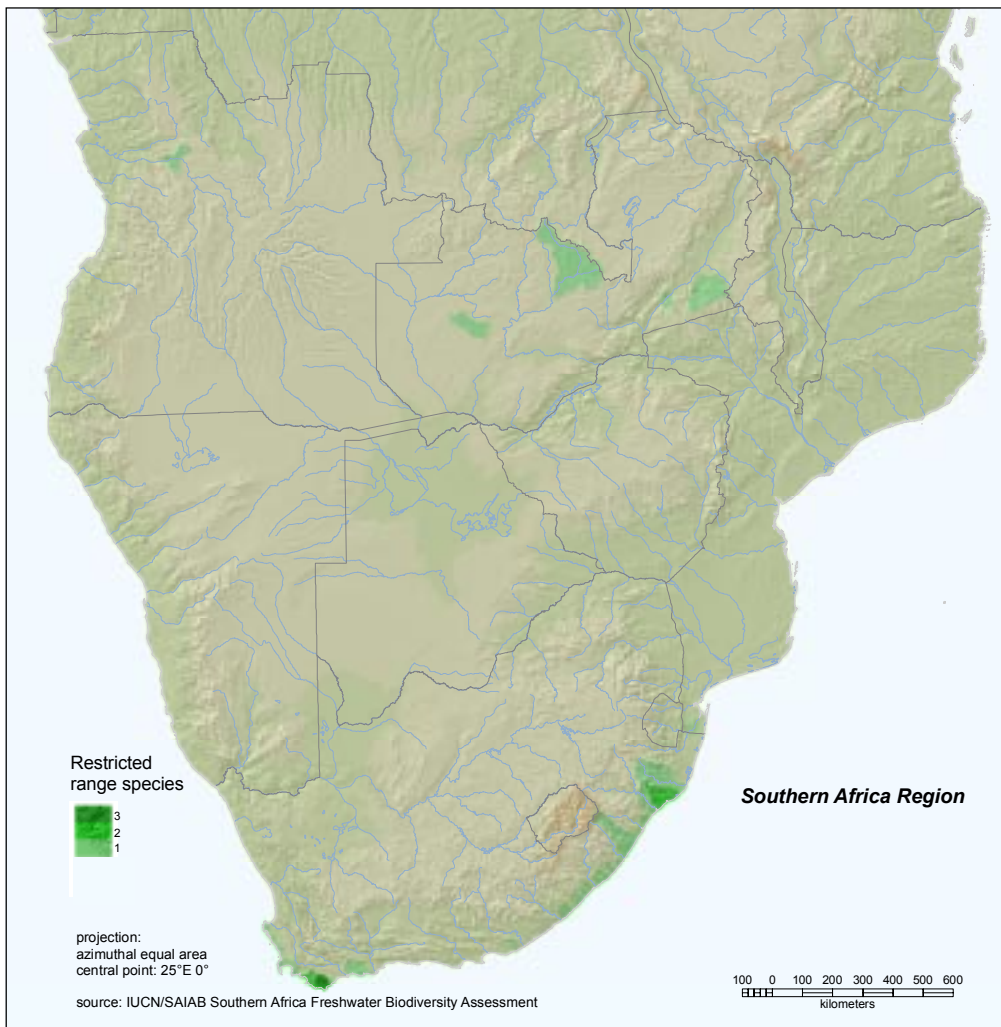


Figure 4.5 The distribution and number of restricted range freshwater mollusc species in southern Africa.

vulnerable to these developments. These species need to be monitored closely, not least because the level of threat to freshwater molluscs can change at short notice given the high degree of habitat specificity shown by many species. It is also recommended that research be carried out on all Data Deficient species that may be threatened. As far as the known threatened species are concerned, it is recommended that their occurrence and the status of their populations be checked regularly.

4.6 References

- Appleton, C.C. 1979. The Unionacea (Mollusca, Lamellibranchiata) of south-central Africa. *Annals of the South African Museum*, 77:151-174.
- Appleton, C.C. 2002. Mollusca. In: J.A. Day and I.J. de Moor (eds.), *Guides to the Freshwater Invertebrates of Southern Africa*, Volume 6: Arachnida and Mollusca: pp. 42-125, Water Research Commission, Pretoria.
- Appleton, C.C. 1996. *Freshwater Molluscs of Southern Africa, with a Chapter on Bilbarzia and its Snail Hosts*. University of Natal Press, Pietermaritzburg, South Africa.
- Appleton, C.C. and Curtis, B.A. 2007. Freshwater bivalves (Mollusca) of Namibia and Botswana. *Annals of the Eastern Cape Museums*, 6:45-71.
- Brown, D.S. 1994. *Freshwater Snails of Africa and their Medical Importance*. Taylor and Francis Ltd. London.
- Brown, D.S. and Kristensen, T.K., 1989. *A field guide to African freshwater snails*. DBL- Denmark.
- Brown, D.S., Curtis, B.A., Bethune, S. and Appleton, C.C. 1992. Freshwater snails of East Caprivi and the lower Okavango River Basin in Namibia and Botswana, *Hydrobiologia*, 246:9-40.
- Connolly, M. 1939. A monographic survey of the South African non-marine Mollusca, *Annals of the South African Museum*, 33:1-660.
- Curtis, B.A. 1991. Freshwater macro-invertebrates of Namibia, *Madoqua* 17:163-187.
- Davis, G.M. 1981. Different Modes of Evolution and Adaptive Radiation in the Pomatiopsidae, *Malacologia* 21, 209-262.
- Dos Santos, S.B. 2003. Estado atual do conhecimento dos ancilídeos na América do Sul (Mollusca: Gastropoda: Pulmonata: Basommatophora). *Revista de Biología Tropical* (suppl. 13): 191-224.
- Graf, D.L. and Cummings, K.S. 2006. Freshwater mussels (Mollusca: Bivalvia: Unionidae) of Angola, with description of a new species, *Mutela wistarmorrisi*. *Proceedings of the Academy of Natural Sciences of Philadelphia* 155:163-194.
- Mandahl-Barth, G. 1988. *Studies on African Freshwater Bivalves*, pp.147. Danisk Bilharziasis Laboratory, (DBL- Institute for Health Research and Development), Charlottenlund.
- Pilsbry, H.A. and Bequart, J. 1927. The aquatic mollusks of the Belgian Congo with a geographical and ecological account of Congo malacology, *Bulletin of the American Museum of Natural History* 53:69-602.
- Prinsloo, J.F. and van Eeden, J.A. 1973. The distribution of the freshwater molluscs in Lesotho with particular reference to the intermediate host of *Fasciola hepatica*, *Wetenskaplike Bydraes van die P.U. vir C.H.O. Reeks B: Naturwetenskappe*, 1-13.
- Schutte, C.H.J., Evans, A.C., Pammenter, M.D., Cooppan, R.M., Pretorius, S.J., Joubert, P.H., Gouws, E., Jooste, P.L., Badenhorst, C.J. and Joubert, J.J. 1995. Epidemiology and control of schistosomiasis mansoni in communities living on the Cuando River Floodplain of East Caprivi, Namibia. *Annals of Tropical Medicine and Parasitology*, 89:631-644.
- Thieme, M., Abell, R., Stiasny, M.L., Skelton, P., Lehner, B., Teugels, G.G., Dinerstein, E., Toham, A.K., Burgess, N. and Olson, D. (eds.) 2005. *Freshwater ecoregions of Africa and Madagascar: a conservation assessment*. Island Press, Washington DC, USA.

Chapter 5. The status and distribution of dragonflies (Odonata)

Suhling, F.¹, Samways, M.J.², Simaika, J.P.² and Kipping, J.³

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5.1 Overview of the regional fauna in relation to the freshwater ecoregions

The southern African region covered here contains 22 of the freshwater ecoregions defined by Thieme *et al.* (2005). These 22 ecoregions are categorized under six major habitat types, which are the basis for this report. The biological distinctiveness and current conservation status of each ecoregion, summarized from Appendix D of Thieme *et al.* (2005), is listed in Table 1.1 in Chapter 1 of this report. We comment here on the status of these ecoregions relative to the occurrence of endemic, rare and threatened dragonfly species.

5.1.1 Floodplains, Swamps, and Lakes

In general, this type of habitat contains a unique set of dragonflies and, with inclusion of the Lake Bangweulu-Mweru ecoregion just outside the southern Africa region as defined for this study, it supports a number of endemic or near-endemic species, such as *Anax bangweuluensis*

Kimmins, 1955, *Trithemis brydeni* Pinhey, 1970 and *Trithemis aequalis* Lieftinck, 1969. Very little information is available on these species and so their status has been assessed as Data Deficient (DD).

5.1.1.1 Kafue

The Kafue Floodplains have been inadequately surveyed for dragonflies. All historic data are single observations of dragonflies. It is expected that this ecoregion has a similar assemblage of Odonata species as the Okavango and Upper Zambezi Floodplains and serves as a stepping stone for several swamp species to the Lake Bangweulu ecoregion, but because of poor data, a final assessment is not yet possible. Further surveys are recommended.

5.1.1.2 Okavango Floodplains

The Okavango Floodplains are moderately well studied, due to recent studies particularly in the Delta and Panhandle (Kipping 2006, and unpublished data), where approximately 3,000 dragonfly records have been made at about 200 localities. The figures are lower

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in the middle section of the Okavango River, with around 1,000 records from less than 40 localities (Kipping and Suhling 2006). The large Angolan part of the ecoregion, with the two major tributaries Cubango and Cuito, has barely been surveyed; the 35 Odonata records from three localities date back 70 years. A diverse set of Odonata specialized for swamp conditions occur in other parts of the ecoregion, including *Agriocnemis ruberrima albifrons* Balinsky, 1961, *Ceriagrion katamborae* Pinhey, 1961, *Pseudagrion deningi* Pinhey, 1961, *P. fisheri* Pinhey, 1961, *P. helenae* Balinsky, 1964, *Ictinogomphus dundoensis* (Pinhey, 1961), *Anax bangweuluensis*, *Trithemis aequalis*, *T. brydeni*, and *Brachythemis wilsoni*, which are mainly confined to the Delta and Panhandle. In the more rapid-flowing middle course, a particularly high number of gomphids have been recorded, including two endemics and one near endemic, *Onychogomphus rossii* Pinhey, 1966, *Crenigomphus kavangoensis* Suhling and Marais, 2006, and *Lestinogomphus silkeae* Kipping, 2006, the latter two only recently having been detected. The rapids at Popa Falls are habitat of *Paragomphus cataractae* Pinhey, 1963.

5.1.1.3 Upper Zambezi Floodplains

The data quality for the floodplains of the Upper Zambezi is variable. Whereas the Kwando and Chobe Rivers including the Linyanti swamps, as well as the Zambezi



Brachythemis wilsoni (female) which has only recently been collected (2006) after 25 years of no records. The Okavango delta population is isolated from populations outside of the region, the main range being in western Africa, and there may be a need for taxonomic investigation. More data are needed to be able to assess this species in a category other than Data Deficient in southern Africa. Photo: © Jens Kipping.

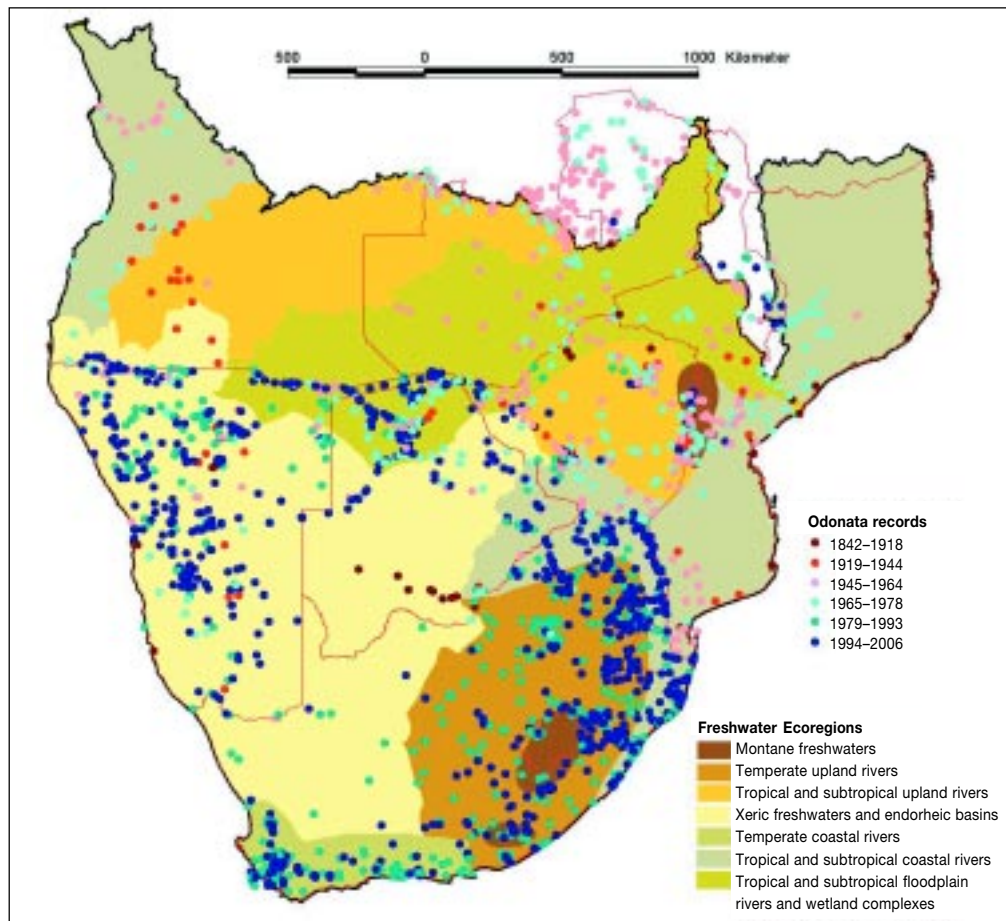


Figure 5.1 Distribution of dragonfly records in the southern African region made between 1842 and 2006. Note the major sampling gaps in eastern Angola and western Zambia, the southern Kalahari and Karoo, and in northern and central Mozambique.



Crenigomphus kavangoensis (female), Least Concern, is a recently detected endemic to the Okavango River system. It is so far only detected along the Namibian part of the river, where it is common in places, often even at degraded sites, so that it has been supposed that the species profits from a certain amount of degradation because the banks are less shaded. Photo: © Frank Suhling.

River downstream at Katima Mulilo in Namibia are moderately well studied. The remaining part of this ecoregion is almost unexplored. Only recently in 2007, J. Kipping made a brief survey to the Barotse Floodplains during the flooding period. The swampy Kwando River and the Linyanti swamps share several species with the Okavango swamps in the Delta, including *P. deningi*,

I. dundoensis, and *A. bangweuluensis*. The Zambezi River and the lower Chobe River are colonized by more riverine species, including *Paragomphus cataractae* at rapids. The Barotse Floodplains are occasionally characterized by seasonal swamp species, but they lack the diversity of the Okavango Floodplains due to a relatively short presence of floodwater and the marginal occurrence of permanent swamps along the Zambezi River bank. The Odonata fauna of the Zambezi River and its tributaries upstream of Katima Mulilo cannot be assessed because only single records are available. This part of the ecoregion needs to be surveyed.

5.1.2 Mediterranean Systems

5.1.2.1 Cape Fold

The Cape Fold ecoregion resembles, in many aspects, the Highland and Mountain Systems, being characterized by headwater streams. However, some larger rivers are also present, whose floodplains provide special habitats for Odonata. The dragonfly fauna of the ecoregion has the highest level of local endemism of all the southern African ecoregions. Endemic species are: *Chlorolestes conspicuus* Sélys, 1862, (LC), *C. umbratus* Hagen, 1862 (LC), *Ecchlorolestes nylephtha* (Barnard, 1937) (NT), *E. peringueyi* (Ris, 1921) (VU), *Metacnemis angusta*

The Okavango Delta in Botswana in early March 2006 after unusually heavy rains over the Kalahari basin, which caused an early flooding of the delta. The view shows papyrus swamps with streams and lagoons and some forest patches. Photo: © Frank Suhling.



Sélys, 1863 (VU), *Elatoneura frenulata* (Sélys, 1960) (LC), *Proischnura polychromatica* (Barnard, 1937) (CR), *Pseudagrion furcigerum* (Rambur, 1842) (LC), *Ceratogomphus triceraticus* Balinsky, 1963 (VU), *Syncordulia gracilis* (Burmeister, 1839) (VU), *S. venator* (Barnard, 1933) (VU), *S. legator* Dijkstra *et al.* 2007 (VU, new assessment not included in the current analysis), *S. serendipator* Dijkstra *et al.* 2007 (VU, new assessment not included in the current analysis), and *Orthetrum rubens* Barnard, 1937 (CR, new assessment not included in the current analysis). This ecoregion is also a stronghold for *Pseudagrion draconis* Barnard, 1937, which only occurs sporadically outside this area.

5.1.3 Highland and Mountain Systems

Such highlands are characterized by forested, swiftly flowing headwater streams, which are a major habitat for a number of endemic or rare dragonfly species. Typical species belong, for instance, to the family Synlestidae (genera *Chlorolestes* and *Ecchlorolestes*) and to the genera *Aeshna*, *Notogomphus*, and *Microgomphus*. All three highland ecoregions have populations of *Platycypha fitzsimonsi* (Pinhey, 1950), which they share with the Cape Fold ecoregion, demonstrating the similarity of these highlands and the Cape Fold.

5.1.3.1 Amatolo-Winterberg Highlands

This is an important ecoregion having forested headwaters that hold some South African dragonfly endemics, such as *Chlorolestes apricans* Wilmot, 1975 (EN), *C. tessellatus* (Burmeister, 1839) (LC) and *Metacnemis valida* Hagen, 1962) (EN).

5.1.3.2 Drakensberg-Maloti Highlands

The whole of this ecoregion is above 1,850 m asl in the Afromontane and Afroalpine ecoregions. It has many small streams, in which the endemic *Chlorolestes draconicus* (LC) occurs. Owing to the high elevation, the total species richness is relatively poor (23 species).

Pseudagrion rufostigma (male), Least Concern, is a fairly widespread species known from Angola, Zambia, Zimbabwe, Botswana and Namibia. It mainly occurs in the Zambezi and Okavango River systems. Photo: © Jens Kipping.



5.1.3.3 Eastern Zimbabwe Highlands

From the Eastern Zimbabwe Highlands, two endemics are known, *Africallagma cuneistigma* (Pinhey, 1969) from the Chimanimani Mountains and *Pseudagrion vumbaense* Balinsky, 1963 from the Vumba Mountains, both of which are listed as VU on the Red List. Other species such as *Chlorolestes elegans* Pinhey, 1950 (NT; also at Soutpansberg, South Africa, and Mount Mulanje, Malawi), *Notogomphus dendrobyrax* (Förster, 1906) (DD) and *N. zernyi* (St Quentin, 1942) (DD) all prefer small, forested streams as breeding habitats. The dragonfly record of these highlands is fair. However, there are only limited recent data, with most records dating back at least 30 years.

5.1.3.4 Other highlands

Some other highlands need to be mentioned here that appear to be similar in their characteristics e.g. the Angolan Highlands (Serra da Chela and others) and the Soutpansberg in South Africa, which all host typical forest stream species. In the Angolan Highlands, endemics or near endemics such as *Umma femina* Longfield, 1947 (VU) and *Chlorocypha crocea* Longfield, 1947 (DD) occur, as well as other rare or endemic species, including one still undescribed *Elatoneura* species and an *Aeshna* species that needs taxonomic attention. The Soutpansberg has a population of *Chlorolestes elegans*.

5.1.4 Savannah-Dry Forest Rivers

5.1.4.1 Kwanza

The coastal and escarpment rivers of western Angola are poorly studied with respect to dragonflies. They may have a high number of endemics and may contribute new species to the southern African region. There has been only one short survey around Luanda of less than a week in the 1960s. All other records date back almost 80 years. Nevertheless, there are already several species known that are endemic to the ecoregion or are otherwise rare in the southern African region, e.g. *Umma femina* (VU), *Platycypha rufitibia* (Pinhey, 1961) (DD), *Chlorocypha fabamacula* Pinhey, 1961 (DD), *Chlorocypha crocea* (DD), *Pseudagrion angolense* Sélys, 1875 (DD), and *Micromacromia flava* (Longfield, 1947) (DD).

5.1.4.2 Lower Zambezi

The Lower Zambezi ecoregion has been poorly explored for dragonflies. Relatively high diversity is to be expected in the floodplains of the lowland rivers.

5.1.4.3 Middle Zambezi/Luangwa

The Middle Zambezi River, downstream of Victoria Falls and its gorges is regulated by dams. In particular, Victoria Falls and its close surroundings are rich in dragonfly species, including *Neurogomphus cocytius* Cammaerts, 2004 (DD), *Paragomphus cataractae* (NT), *Lestinogomphus silkeae* (DD) and several other riverine

species. Downstream, *Paragomphus zambeziensis* Pinhey, 1961 (DD) and *Phyllomacromia congolica* (Fraser, 1955) (DD) occur, which may be influenced by the dams. The record of a “unique” dragonfly species called *Archaeopblebia victoriae* Pinhey, 1963 at Victoria Falls (Pinhey, 1963, Timberlake, 1997 in Thieme *et al.* 2005) was in fact the widespread *Tetrathemis polleni* (Sélys, 1869). The species numbers recorded from Victoria Falls by FitzPatrick (2000 in Thieme *et al.* 2005) also need clarification, as they appear to be underestimates.

5.1.4.4 Eastern Coastal Basins

The eastern coastal basins in the southern African region are almost unexplored by odonatologists. The split of this ecoregion between the project’s eastern and the southern African assessment regions does not fit the distribution of the Odonata fauna and represents a case where the project regional boundary, which is based on river catchment boundaries, does not well match the distribution patterns of Odonata species. For instance, *Coryphagrion grandis* Morton, 1924 occurs in coastal forest in the northern part yet there is no evidence that the species occurs in the southern part. This issue will be eliminated in the final stages of the project when the findings from all five of the assessment regions will be combined, thus eliminating any other such ecoregion splits.

5.1.4.5 Southern Temperate Highveld

This ecoregion is situated in the interior of South Africa, forming a grassy plateau. The Odonata fauna is well known in most areas, but with a lack of information towards the western parts. Four endemics, *Pseudagrion vaalense* Chutter, 1962, *P. citricola* Barnard, 1937, *Africallagma sapphirinum* (Pinhey, 1950) and *Proischnura rotundipennis* (Ris, 1921), are known from this ecoregion. Of importance are some separate mountains, such as the Soutpansberg, having a population of *Chlorolestes elegans* (NT), the Barberton Mountains with *Pseudagrion inopinatum* Balinsky, 1971 (EN), and the Pilaesberg and Waterberg with a wide variety of species.

5.1.4.6 Zambezian Headwaters

This ecoregion includes the headwaters of the Zambezi, Okavango and Kunene Rivers and their major tributaries, and thus spans a wide variety of habitats, from flooded riverine forest in the Upper Zambezi to extensive wet grasslands along the river courses in parts of the upper Cuito and Kavango Rivers and to small, forested headwaters in the Kunene. Most parts of the ecoregion, particularly those situated in Angola, are almost unexplored for dragonflies. No part of the ecoregion has been visited more than twice by odonatologists and no parts of Angola have ever been properly surveyed. The most recent collections of the region date back more than 30 years. However, the ecoregion hosts populations of several endemics or near-endemics, and of species

otherwise not represented in the southern African region; 28 of the Data Deficient species occur exclusively or mainly in this ecoregion. Owing to the inadequate surveys, the ecoregion is difficult to assess. Survey of the region is now required in order to locate and assess the status of the many Data Deficient species known to occur there.

5.1.4.7 Zambezian Lowveld

The southern part of this ecoregion, which is in South Africa, is well surveyed, whereas the northern part is poorly explored. The coastal area is of particular interest, as it has an endemic species, *Urothemis luciana* (DD). Two endemic subspecies occur that are widely separated from their other subspecies. *Agriocnemis ruberrima ruberrima* Balinsky, 1961 (EN) which also has a subspecies endemic to the Okavango Delta, and *Pseudagrion coeleste umzingaziense* Balinsky, 1963 (VU) which has its nominate form widespread in the northern, tropical perennial river systems.

5.1.4.8 Zambezian Highveld

The knowledge of the dragonflies of this ecoregion is moderately good. Although most records date back at least 20 years, wide areas of the ecoregion have been surveyed by Dr Elliot Pinhey. There is one endemic present, *Pseudagrion makabusiense* Pinhey, 1950.

5.1.5 Subterranean and Spring Systems

5.1.5.1 Karst Springholes

The Karst Springholes in northern Namibia host several endemics, including fish, frogs and amphipods. By contrast, their dragonfly fauna resembles that of other spring systems of the Namib coastal ecoregion of Namibia. There are no endemic dragonfly species or even species typical for this ecoregion. However, the spring systems form a rare kind of habitat in Namibia and need special consideration.

5.1.6 Xeric Systems

The Xeric Systems are characterized mainly by temporary water systems. The dragonflies occurring here need special traits to deal with such habitats, among them rapid development and high migration ability (Suhling *et al.* 2003, 2006). Most species living in the Xeric Systems are therefore widespread in major parts of the African savannah systems and often reach into Europe and Asia.

5.1.6.1 Etosha ecoregion

The Etosha ecoregion depends on rainwater mainly from the upper Cuvelai River system in Angola. During good rainy seasons numerous river channels, ponds and pans are filled with water for some months. Since most of the waters support abundant vegetation, the number of dragonflies occurring there is expected to be higher than the 28 species recorded so far, particularly in its northern

part, i.e. in Angola and northernmost Namibia. This area is poorly surveyed and needs more attention.

5.1.6.2 Kalahari and southern Kalahari

The Kalahari and the southern Kalahari both harbour numerous small and large temporary pans that may be colonized by 15–25 species of dragonflies, all having high re-colonization ability, some being true obligate migrants, such as *Pantala flavescens* (Fabricius, 1798), *Sympetrum fonscolombii* (Sélys, 1840) and *Anax ephippiger* (Burmeister, 1839). The southern Kalahari has lower species diversity than the northern part of the Kalahari, which receives species influx from the nearby floodplain systems of the Okavango and Zambezi Rivers. The pans rarely hold water for long periods due to the deep sands of the Kalahari. This requires short development times of less than 60 days for species that successfully breed there. The southern Kalahari is very poorly surveyed.

5.1.6.3 Karoo

The Karoo freshwater ecoregion is largely unexplored for dragonflies. The number of records from this ecoregion is so low that any assessment would likely be fruitless. Mountainous areas harbour climatic relict species such as isolated populations of *Chlorolestes fasciatus* (Burmeister, 1839) and *C. tessellates* (Burmeister, 1839).

5.1.6.4 Namib Coastal

Compared to the other xeric ecoregions the Namib Coastal ecoregion is most diverse in species due to its relative high diversity of freshwater habitats. The area is mainly characterized by the western flowing ephemeral rivers, which in their course provide major perennial wetlands as well as temporary waters. In addition, depending on the local geology, there are small perennial headwater streams, for example in the Naukluft and Tsaris Mountains, in the Damaraland, and in the Baynes Mountains. The spring systems in this area also host several species of Odonata (up to 25 species in each spring), including several rare species that do not occur in other Xeric

Systems. Among them is *Aeshna minuscula*, otherwise restricted to South Africa. The presence of this species together with a number of other species, such as *Pseudagrion kersteni* Gerstäcker, 1869 and *Trithemis stictica*, in widely isolated populations imply former connections to the Cape Fold ecoregion. The immediate coastal Namib is relatively poor in species. The deltas of some of the west-flowing ephemeral river systems, such as the Swakop, the Ugab, and the Uniab Rivers provide perennial wetlands which are reproduction habitats for about 10 species. Strong adiabatic winds may cause additional influx of several exotic species which otherwise can only be seen in more tropical regions and which do not breed in the Namib.

The lower Kunene River is the only perennial river in the ecoregion. Due to the arid surrounding landscape it exists mainly as the river course itself, including some major waterfalls and rapids, such as at Epupa Falls. There are no major floodplain wetlands. The riverine vegetation exists in the form of a narrow linear oasis along the river. Consequently, the river has a relatively diverse fauna of running water dragonflies, such as *Phaon iridipennis* (Burmeister, 1839), *Phyllogomphus selysii* Schouteden, 1933, *Phyllomacromia contumax* Sélys, 1879 and *Zygonyx torridus* (Kirby, 1889), but few typical backwater swamp species. Epupa Falls is one of only seven localities where *Paragomphus cataractae* has been recorded. In its dragonfly fauna, the river is more similar to the Okavango and Zambezi Rivers than the other habitats in this ecoregion.

5.1.6.5 Western Orange

The western Orange, although a perennial river, is poor in dragonfly species, with only 20 species having been recorded. There is no obvious explanation for this low species number although the absence of floodplain habitats in the arid environment and the limited floodplain vegetation reduce the number of potential dragonfly habitats and thus dragonfly diversity. The river system

Katambora rapids on the Zambezi River in Zambia. Photo: © Jens Kipping.



A temporary pan in the Kalahari. Species breeding in these habitats require a relatively short larval period, often less than 60 days. Photo: © Jens Kipping.





Trithemis kirbyi, Least Concern, is the typical desert dragonfly which can be found at all kinds of freshwater habitats in the Namib and Kalahari Deserts. Photo: © Frank Suhling.

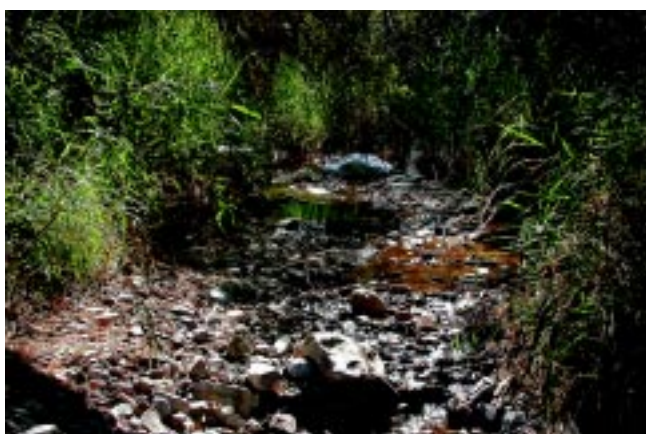
contains one regionally endemic species, *Pseudagrion vaalense*, which is, however, not endemic to the ecoregion, as it also occurs in the upper Orange system, including the Vaal River.

5.2 Conservation status (IUCN Red List Criteria: Regional Scale)

The summary presented here is based on an analysis of species regional Red List status following application of the IUCN Red List Criteria at the regional scale of southern Africa. The regional Red List status of any species which is endemic to southern Africa will be equivalent to its global Red List status.

Much of southern Africa is so far relatively lightly affected by industrial development and associated aquatic habitat

A shady stream in the Naukluft Mountains (Namib-Naukluft National Park). The stream is habitat for some species that are rare inhabitants of the Xeric Freshwater ecoregion, such as *Pseudagrion kersteni*, *Trithemis stictica*, and the southern African endemic *Aeshna minuscula*. Photo: © Frank Suhling.



degradation and pollution. As a result, the majority of species (about 76%) are classed as Least Concern (Table 5.1, Figure 5.2). Another 21 species were not assessed for the southern African region (Not Applicable) because more than 95% of their population is based outside the region, predominantly in the Central African region.

The high number of species in the Data Deficient category (ca. 18%), reflects mainly the low level of exploration of large areas of the region. Early records date back more than 30 years and many of these areas have not been revisited since that time. The early explorations resulted in several new records, often new to science. In many cases, where there are no more than a few records of the species, it is impossible to determine their true distributional ranges. In addition, the ecology is unknown in many cases. This applies particularly to several species occurring in the Zambebian Headwaters, as well as in the East Zimbabwe Highlands. Another factor producing some uncertainty is taxonomic changes and the recent description of some new species that are ecologically still unknown. These factors have created uncertainty about individual species distributions and as a result many of these species are also assessed as Data Deficient.

Thirteen species and two additional subspecies are in threatened categories, with a further three classed as Near Threatened (NT). These species are mainly concentrated in the Cape Fold ecoregion, while others occur mainly in highland ecoregions (Amatolo-Winterberg Highlands, two species; Eastern Zimbabwe Highlands, two species) or highlands spread over other ecoregions (Angolan highlands, one species). A few other threatened species occur in South African lowland regions. Most threatened species are South African endemics, which may reflect the relatively good ecological knowledge about the South African species compared to the more tropical parts of the region, such as Angola and Zambia (Samways, M.J.

Pseudagrion kersteni (male), Least Concern, feeding on a moth. The species is widespread throughout much of the region but has vanished from at least 50% of its localities in Namibia, mainly due to degradation of stream and spring habitats. Photo: © Frank Suhling.



Table 5.1 The number of dragonfly species, including two subspecies, in each Red List Category in the southern African region.

	Regional Red List Category	Number of Species	Number of regional endemics
Threatened Categories	Critically Endangered	1	1
	Endangered	4	4
	Vulnerable	10	10
	Near Threatened	3	2
	Least Concern	206	29
	Data Deficient	48	18
	Not Applicable	21	0
Total		293	64

Note: All species assessed as regionally threatened which are endemic to the region are also globally threatened.

2008). Three species are classified as NT, of which again one is a South African endemic, one is a more widespread highland species and one is restricted to cataracts of larger rivers.

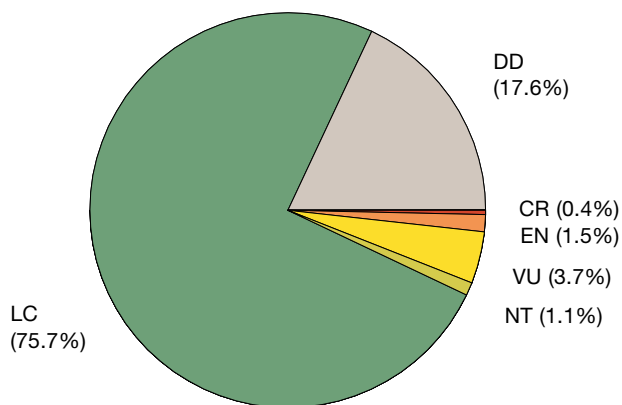
5.3 Patterns of species richness

5.3.1 All dragonfly species

The southern African region, as defined here, has a total of 293 species (plus the three species assessed since this analysis and two recently described new ones, which are not yet assessed). The highest species richness is in the northern parts of the region, particularly in north and north-west Zambia (Table 5.2). Most parts of Angola in the southern African region are likely to be highly diverse in dragonflies, but current knowledge is poor with only 450 records and about 160 species recorded so far. Other centres of diversity are the eastern coastal ecoregions and the Eastern Zimbabwe Highlands, but knowledge of Mozambique is not much better than Angola. Lowest dragonfly diversity occurs in the southern Kalahari, along the western Orange and in the Karoo ecoregions, with little more than 20 species of dragonflies recorded in each case. The patterns of species richness and of endemic species richness based on known and inferred species' distributions are shown in Figures 5.3 and 5.4. Highest number of species endemic to the southern African region occur in the northern parts, particularly in the Zambezian headwaters, such as in the Upper Zambezi (Mwinilunga district of Zambia). Other centres of diversity are found along the eastern and southern coast of the region, particularly in the Cape Fold ecoregion, which is a major centre of dragonfly endemism.

Endemism within an ecoregion is usually low since dragonflies have a high dispersal potential, and therefore

Figure 5.2 The proportions of dragonfly species, including two subspecies, in each regional Red List category in the southern African region.



many species easily spread over large distances (Figure 5.4). Exceptions are sometimes highland and small stream species, being trapped in insular conditions. Examples include *Zygoptera* living in high mountain headwater streams, such as *Pseudagrion vumbaense* from the Eastern Zimbabwe highlands or species of the synlestid family, which occur in all highland ecoregions. The highest levels of endemism are found in the Cape Fold ecoregion.

5.3.2 Threatened species

Most threatened species (nine) occur in the Cape Fold ecoregion (Table 5.2) because a major centre of endemism occurs in an area where there is intensive disturbance, including agriculture, urbanization and threats from invasive alien species, especially trees and fish

Neurogomphus zambeziensis, Least Concern, a species which may be endemic to the southern Africa region. It occurs in the river catchments of the Zambezi and the Limpopo (Botswana, Mozambique, Namibia, South Africa (Transvaal), Zambia, and Zimbabwe). However, there is also an unconfirmed record from Tanzania. Photo: © Jens Kipping.





Syncordulia legator, Vulnerable, a newly-discovered and extremely rare and threatened Cape endemic species. Photo: © Mike Samways.

Table 5.2 Recorded species diversity of dragonflies in the ecoregions of southern Africa. Data as of June 2007.

No.	Ecoregion name	Area [km ²]	No. of records	No. of localities	No. of recorded species	Red List Category of Threat							No. of endemic species
						LC	NA	DD	NT	VU	EN	CR	
Floodplains, Swamps and Lakes													
8	Kafue	105,474	48	17	33	31	-	2	-	-	-	-	1
12	Okavango Floodplains	179,148	4,565	293	111	97	-	13	1	-	-	-	9
16	Upper Zambezi Floodplains	243,789	1,864	138	120	113	-	6	1	-	-	-	8
Mediterranean Systems													
33	Cape Fold	132,487	1,427	248	83	71	-	2	1	7	1	1	24
Highland and Mountain Systems													
36	Amatolo-Winterberg Highlands	12,084	140	29	41	39	-	-	-	-	2	-	13
37	Drakensberg-Maloti Highlands	47,906	300	56	39	38	-	-	-	1	-	-	10
38	Eastern Zimbabwe Highlands	39,289	919	90	119	110	-	4	1	2	2	-	8
Savannah-Dry Forest Rivers													
63	Cuanza	332,729	164	33	72	65	-	6	-	1	-	-	2
66	Lower Zambezi	129,888	158	29	45	45	-	-	-	-	-	-	0
69	Middle Zambezi Luangwa	293,574	1,352	117	139	130	-	8	1	-	-	-	8
72	Eastern Coastal Basins	746,127	124	28	49	47	-	2	-	-	-	-	0
73	Southern Temperate Highveld	554,056	6,501	649	127	122	-	-	1	2	2	-	23
76	Zambezi Headwaters	562,924	1,210	72	183	135	20	28	-	-	-	-	11
77	Zambezi Lowveld	519,496	5,553	481	157	146	1	6	2	-	2	-	17
78	Zambezi Highveld	222,732	1,291	131	122	121	-	1	-	-	-	-	4
Subterranean and Spring Systems													
79	Karstveld Sinkholes	25,502	285	34	44	44	-	-	-	-	-	-	0
Xeric Systems													
82	Etosha (Cuvelai system)	130,963	170	62	50	50	-	-	-	-	-	-	1
84	Kalahari	445,256	507	97	59	59	-	-	-	-	-	-	2
85	Karoo	216,590	18	9	13	13	-	-	-	-	-	-	2
88	Namib Coastal	321,372	2,840	259	74	73	-	-	1	-	-	-	2
91	Southern Kalahari	456,400	387	62	32	32	-	-	-	-	-	-	1
93	Western Orange	54,264	149	24	29	29	-	-	-	-	-	-	2

(Figure 5.5). In other ecoregions, for instance in the Zambezan headwaters, 28 species occur that may be threatened, but current knowledge on the species' ecology is too poor to allow a reliable assessment of threat status. All these poorly known species had to be assessed as Data Deficient. The same is true for the species of most of the southern African ecoregions.

5.3.3 Restricted range species

Three main areas are highlighted as supporting two or more restricted range species (Figure 5.6). The first is in southern Angola where *Pseudagrion angolense* and *Elattonaura* sp. nov. are recorded from only a few locations. However, given the lack of field exploration in Angola it is possible that both species will be found to be more widespread. The second area is in northern KwaZulu-Natal and southern Mozambique where four species are thought to have restricted ranges. Two of these species are also assessed as Data Deficient and may yet prove to be more widespread but both *Pseudagrion inopinatum* (EN) and *Pseudagrion coeleste umsingaziense* (VU) are believed to have highly restricted

ranges within habitats which are declining. *P. inopinatum* is only known from two localities and there is only one recent record in 2002. Even at the type locality only one female has been found despite very intensive searches. The subspecies *P. coeleste umsingaziense* is a habitat specialist known only from the Richard's Bay area, South Africa. In wet years its range expands, and in dry years it retreats to its core area, mainly Lake Umsingazi. It occurs in ponds in peri-urban conditions, which are likely to exclude agriculture or heavy industry. However, habitat loss is still a potential threat. The third area is the Eastern Cape, South Africa, around the Kubusi river where there are two restricted range species, both assessed as Endangered. The first of these, *Metacnemis valida* which was never widespread has disappeared from some of its former known sites and is now known from only two sites on the Kubusi River in the vicinity of Stutterheim, both of which are threatened by ongoing habitat loss and degradation. The population decline seen in recent years is expected to continue. The second species, *Chlorolestes apricans*, has disappeared from much of its former range since 1975 and is currently known only from the Kubusi (near Stutterheim) and the Thorn Rivers.

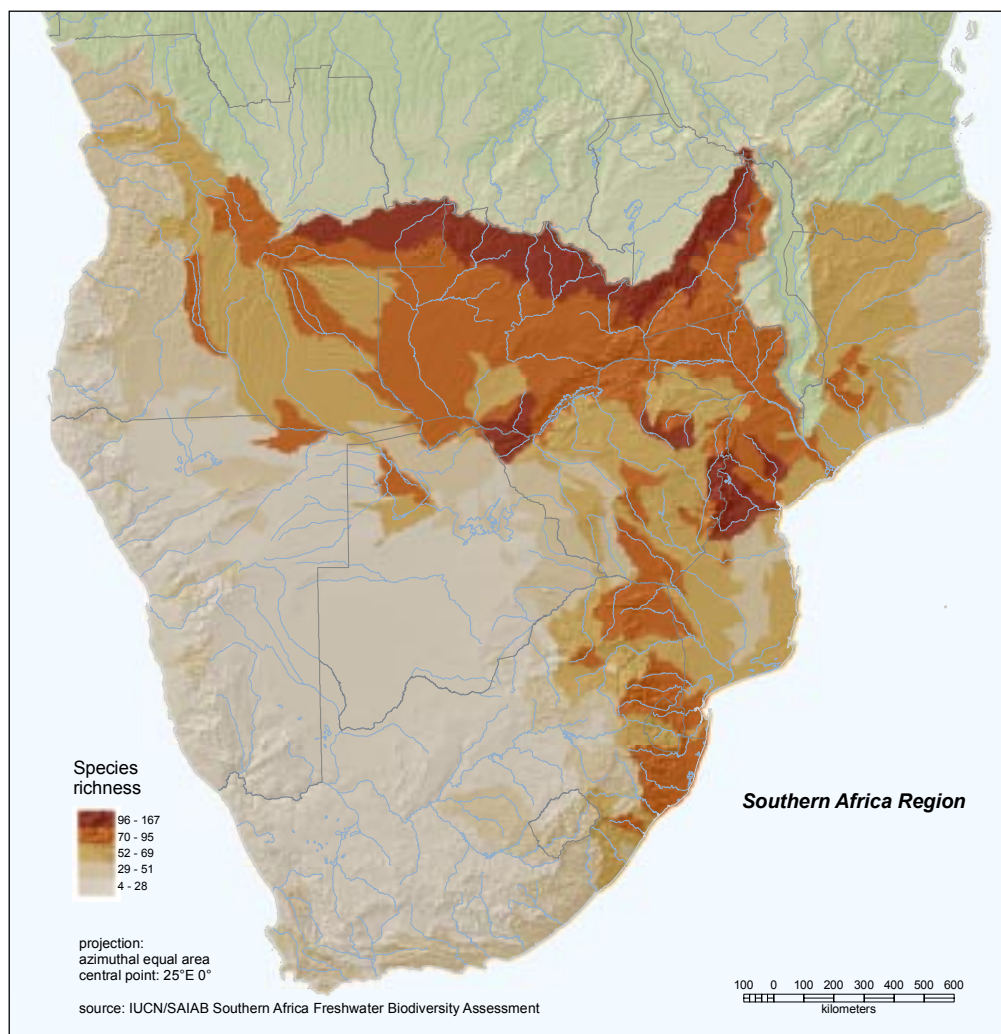


Figure 5.3 Dragonfly species richness in southern Africa based on known and inferred species' distributions mapped to river catchments.

5.3.4 Data Deficient species

The greatest number of Data Deficient species is in the northern part of the region along the border with the Democratic Republic of Congo, reflecting a lack of field survey in the area (Figure 5.7). In most cases information is lacking on species ranges, habitat requirements, and threats to the species. Clearly, this area is identified as a priority for future survey.

5.3.5 Extirpated species

No species are known to have been extirpated in the region. However, the status of a number of species is almost unknown and the degree of threat can only be inferred. For example, *Pseudagrion vumbaense* and *Africallagma cuneistigma*, endemics of the Eastern Zimbabwe Highlands, have not been recorded since their first collection more than 40 years ago. The habitats in these highlands are under threat due to release of alien fish species, deforestation and forestry using alien tree species. The same may be true for the west Angolan highlands where some endemics also occur (e.g. *Umma femina*). Thus, it is not known if these populations still

survive. These and some other highlands should be high priority for survey.

Globally, only two species of dragonflies are regarded as extinct. One of them is the St Helena Island endemic *Sympetrum dilatatum* (Calvert, 1892) (Odonata Specialist Group 1996). St Helena may be counted as part the southern African region, but in contrast to other islands, such as those in the Indian Ocean, it is not considered as an African freshwater ecoregion by Thieme *et al.* (2005). The reasons for this species extinction may include agricultural practices as well as the introduction of an alien frog.

5.4 Major threats to dragonflies

5.4.1 General

Wetlands are generally poorly protected and the important biological resources of these ecosystems are rapidly being lost through clearance and overuse. Some wetland areas, however, are situated in national parks and nature reserves, such as parts of the Okavango Delta in Botswana,

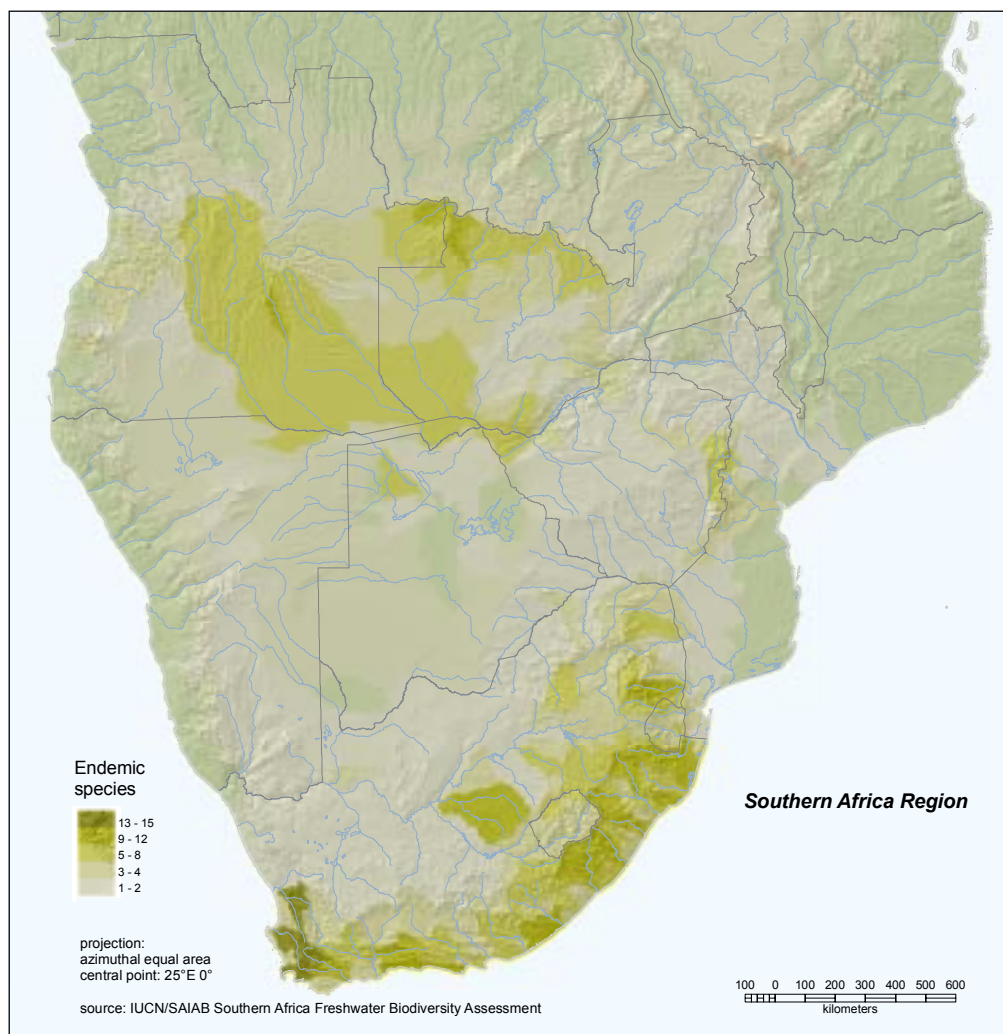


Figure 5.4 Richness of southern Africa's regionally endemic dragonfly species based on known and inferred species' distributions mapped to river catchments.



Degraded banks of the Okavango River in Namibia. During the civil war in Angola the human population on the Namibian side of the river increased dramatically leading to massive habitat destruction, mainly clear cutting of forest and following erosion, along some parts of that river section. Photo: © Frank Suhling.



Popa Falls on the Okavango River in Namibia. The remnants of pristine gallery forest at these rapids and to the north-west at Andara support more than 80 dragonfly species with many more yet to be recorded. Photo: © Frank Suhling.

parts of the Linyanti-Chobe and Okavango swamps in Namibia, and parts of the Zambezi and Kafue Floodplains in Zambia. Improved conservation through draft national policies on wetlands in Namibia and Botswana, as well as multinational basin management commissions (already established for the Okavango, Zambezi, Kunene, and Orange basins), can be expected in future.

5.4.1.1 Deforestation

Riverine forests are an important habitat for many odonate species that need shade, such as Calopterygidae: *Umma* spp., some Gomphidae: *Diastatomma* spp. and Libellulidae: *Eleuthemis* spp. In the middle courses of the Okavango, Chobe and Kunene, this type of forest is limited as extensive floodplains and swamps dominate. Where

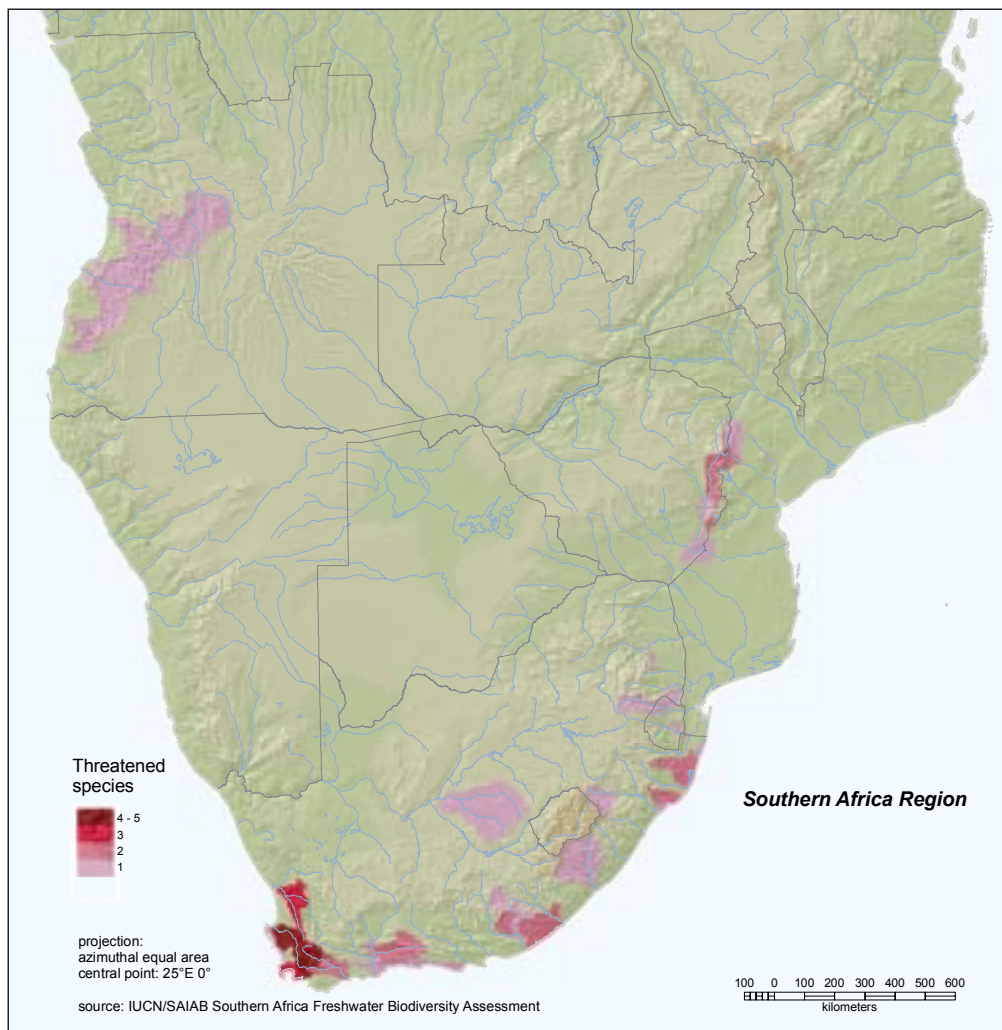


Figure 5.5 Richness of southern Africa's regionally threatened dragonfly species based on known and inferred species' distributions mapped to river catchments.

present, the riparian forests are under considerable pressure by people for wood and clearing of land for villages and agriculture. Deforestation along the rivers leads to habitat fragmentation, which is a severe problem as fragmented populations could possibly die out. The few remaining riparian forests are in urgent need of protection.

5.4.1.2 Damming large rivers

Rapids and waterfalls are under severe threat by plans to construct dams for electric power plants, such as at Epupa Falls on the Kunene River and at Popa Falls on the Okavango River. A major impact of dam construction is often the loss of riverine habitats, rapids, and waterfalls which will be flooded. Downstream flow regimes are also impacted and sedimentation patterns are altered. *Paragomphus cataractae* appears to be confined to rapids and waterfalls of large rivers. Additional dams for electricity generation and flow regulation, for example, in the Kunene, Orange, Okavango and Zambezi, are under discussion. The dam project at Epupa Falls has been finally cancelled in 2008.

5.4.1.3 Pollution

Chemical and organic water pollution is a local problem at present, except in more densely populated areas,

because the human population in most parts of the region is still low. However, pesticides used in agriculture and against human pest vectors (e.g. tsetse fly) are an emerging problem in the wetland areas. Currently little is known about the effects of these pesticides on Odonata in the region. Some stream species, namely *Pseudagrion kersteni*, *Crocothemis divisa* Baumann, 1898, *C. sanguinolenta* (Burmeister, 1839) and *Zygonyx torridus*, are highly susceptible to several pesticides tested (Muirhead-Thomson 1973, 1987). In contrast, *Aeshna* larvae in the Cape region (probably *A. subpupillata* McLachlan, 1895) did not suffer from organophosphate insecticides in microcosms (Schulz *et al.* 2001). River salination due to agriculture, as reported for South Africa, or flow limitations due to dam construction, may alter assemblages because many Odonata are not salt tolerant (Suhling *et al.* 2003).

5.4.1.4 Fish predation

Fish as main predators of larvae (e.g. Stoks and McPeck, 2003) affect Odonata assemblages in general. Although there are few such studies on African Odonata, the introduction of fish to wetlands, particularly of alien fish species, such as Nile Perch (*Oreochromis niloticus* (L., 1758)), rainbow trout (*Oncorhynchus mykiss* (Walbaum,

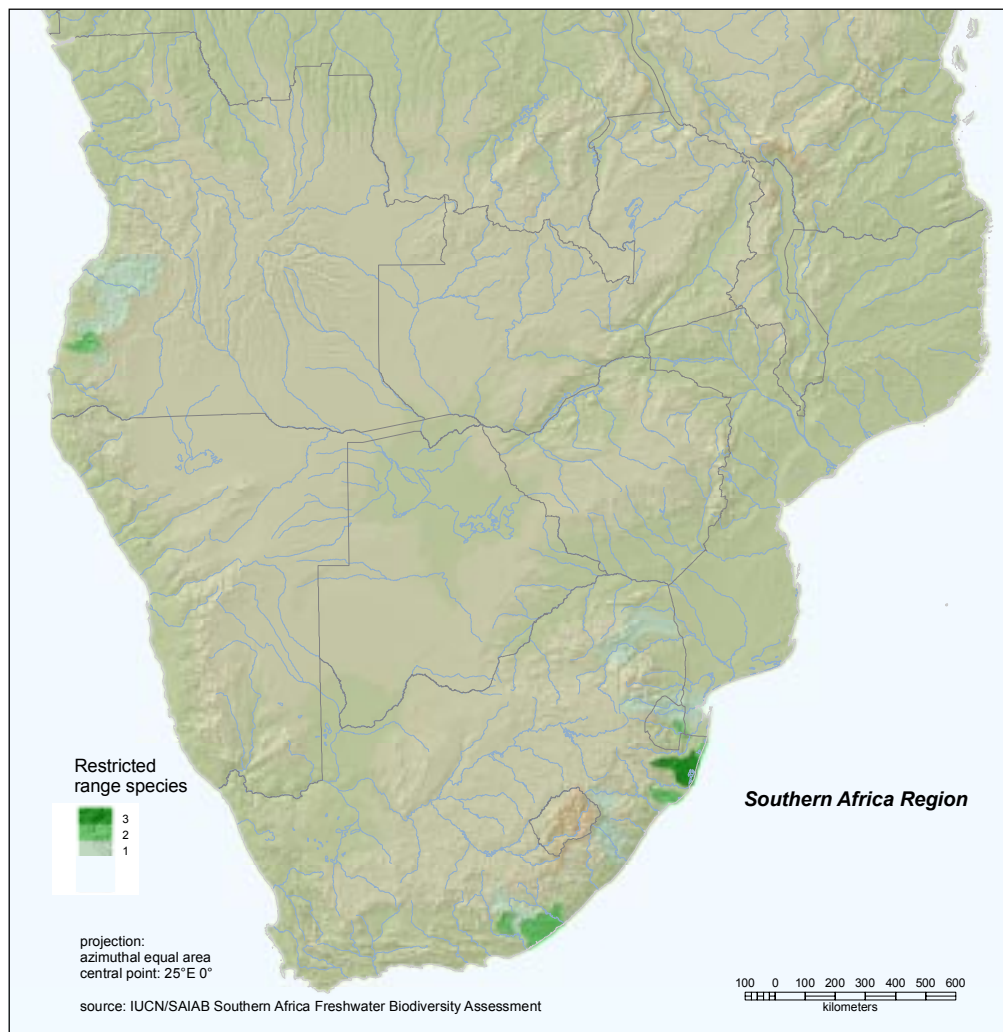


Figure 5.6 Richness of southern Africa's restricted range dragonfly species based on known and inferred species' distributions mapped to river catchments.



Ceriagrion katamborae (male). This species is known mainly from the Okavango Delta. It may be more widespread in southern Africa, but there are no data available to confirm this at present. More data are needed to be able to assess this beyond Data Deficient. Photo: © Jens Kipping.

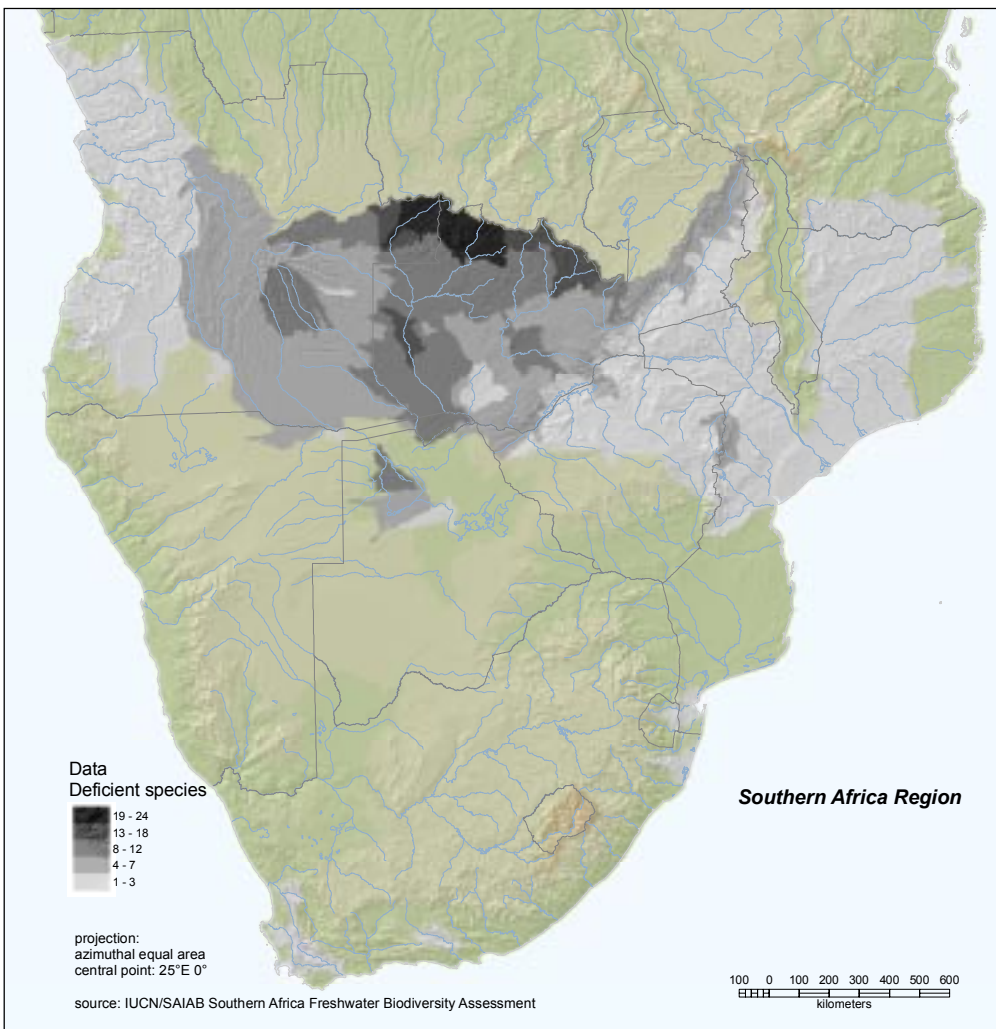


Figure 5.7 Richness of southern Africa's Data Deficient dragonfly species based on known and inferred species' distributions mapped to river catchments. It should be noted that the map is incomplete in that it fails to show those many species which could not be mapped due to lack of information on distribution ranges.



The picture shows the piped spring at the Bernabe de la Bat Restcamp at the Namibian Waterberg. Only 10 years previously this was the largest natural spring in the region with a population of *Pseudagrion kersteni* that is now extirpated. Photo: © Frank Suhling.

1792)) or bass (*Micropterus* spp.), may have major effects on Odonata assemblages. The introduction of brown trout (*Salmo trutta* L., 1758) to formerly fish-free headwaters (or those with indigenous specialized fish) risks causing rapid local extinction of dragonfly populations. There are, however, no studies so far quantifying such effects on southern African Odonata.

5.4.1.5 Alien plants

Invasive alien trees can be a key threat to some odonate species. For example, in South Africa, *Acacia mearnsii* De Wiild, overgrows the natural vegetation along streams and eliminates the natural habitats of certain species (Samways and Taylor 2004).

5.4.1.6 Water extraction

Abstraction of water for human use is an increasing problem all over Africa, particularly considering global climate change scenarios. Water abstraction may transform perennial rivers or streams to intermittent or even ephemeral streams. The example of Namibian springs shows that the whole spring is often piped instead of allowing for a continuous, though reduced flow. It can

be assumed that headwaters in particular will be used for abstraction owing to their good water quality. The consequences for dragonflies and other freshwater fauna are clear; assemblages of specialized, and often endemic, species will be replaced by ubiquitous species that are adapted to temporary waters.

5.4.2 Threats to specific ecoregions

5.4.2.1 Okavango Floodplains

The Okavango Delta is regularly sprayed by insecticides against tsetse fly. Effects on the freshwater fauna including dragonflies are difficult to assess. Most approaches using only monitoring methods are unlikely to reveal precise results, but a study very recently undertaken by Schuran and Kipping (in prep.) under semi-artificial conditions showed that the aerial spraying does have a serious effect on breeding success of Odonata. Despite intense dragonfly surveys in the delta *Pseudagrion fisberi* has not been recorded during recent surveys, although historically they seemed to be common. *Pseudagrion belenae*, another species not recorded for many years, was however rediscovered in December 2007. It is possible that insecticide spraying caused the decline of these species.

5.4.2.2 Cape Fold

Alien trees and shrubs overgrowing the headwater streams are a major threat to several endemics (Samways *et al.* 2005). Recent tree removal programmes through the South African Working for Water Programme have led to successful recovery of populations such as *Metacnemis angusta*, a species that was thought to have been extinct. In addition, many populations of other species have benefited from the programme.

Another specific threat is alien fish, especially rainbow trout, released in the Cape Fold streams. The highly localized Cape endemic *Ecchlorolestes peringueyi* today occurs mainly upstream of waterfalls and in small streams out of the reach of trout.

5.4.2.3 Highland and Mountain Systems

The major threats, alien plants and alien invasive fish, are the same as in the Mediterranean Systems. Another threat that is specific to the Eastern Zimbabwe Mountains is deforestation along the headwaters. Opening of the stream habitats has a negative effect on the shade-loving species in these systems, reducing the diversity and relative abundance species. Deforestation is likely to be a major threat to the more tropical highlands, such as in Angola.

5.4.2.4 Namib Coastal

Although the Xeric Systems do not have regionally or globally threatened species, they demonstrate possible future threats due to ongoing limitation of water resources.

A major problem for wetlands in the Xeric Systems of the region is overuse of water for drinking and for agriculture. In Namibia the natural dragonfly communities of most natural spring-fed streams have already been destroyed or they are currently under severe pressure by over-abstraction of water (Suhling *et al.* 2006). Many springs are piped directly at their outflow and thus no water is left in the natural bed. This has already caused local extinction of a number of habitat specialists among the dragonflies in the Otavi Mountains and at the Waterberg. Some of the ephemeral Namibian rivers contain large dams in the upper courses to supply water to nearby towns. On one hand, these reservoirs create new habitats for Odonata in the upper courses, but on the other they prevent water from reaching downstream habitats and result in a considerable increase in evaporation. This may lead to a reduced dispersal of Odonata into the desert habitats, but few data are available to evaluate the problem.

5.5 Conservation recommendations

Conservation measures have to be adapted to the specific requirements of species. Unfortunately, only a minority of the threatened or potentially threatened (DD) species are known well enough for specific conservation recommendations to be made. Thus, recommendations

on measures that can be taken are still quite general, but research on distribution, population biology and ecology of these species is strongly recommended.

5.5.1 Conservation measures

Protection of riverine forests

Forest removal should generally be avoided as many freshwater organisms, including dragonflies, require shade in their adult stages.

Alien tree/plant removal

Invasive alien trees should carefully be removed from the river courses where possible through the South African Working for Water Programme.

Protection of small streams against over-extraction of water

When using water from spring habitats, sufficient flow should remain to support the existing habitats instead of taking the entire flow for human use.

Avoiding introduction of invasive fish

Alien fish should generally not be released. The overall effects of such releases have not been assessed, but preliminary results suggest that alien fish have a negative impact.

Restored stream habitat on top of Table Mountain, South Africa, where several endemic species have returned after removal of alien tree species. Photo: © Mike Samways.



5.5.2 Research action required

5.5.2.1 Species-level research

Most of the species classified as Data Deficient (DD) need special research attention. In many cases even the distribution is poorly known especially due to a lack of surveys in Angola and Zambia. The highland endemics in the Eastern Zimbabwe Highlands need particular attention. In many cases it is necessary to confirm that populations even still exist.

Distribution ranges of the DD species as well as the threatened Eastern Zimbabwe Highlands and the Angolan Highland species should be clarified. Thereafter, the species need to be re-assessed in the light of their known distributions. For those species that remain DD or are classed as threatened, ecological and population biology studies are needed.

5.5.2.2 Regional/ecoregion-level research

Sites should be selected for long-term monitoring of assemblages and populations in those ecoregions that have already good or moderately good datasets to enable tracking of future trends, such as in the Cape Fold Mountains, the Okavango Delta and the Namib Coastal ecoregion.

5.5.2.3 Country-level research

Angola

There are no recent collections of dragonflies from Angola. The most recent work was conducted 30 years ago, and most records date back 70 years to the Swiss Angola expedition lead by Monard. Elliot Pinhey, the only odonatologist who ever visited Angola spent less than one week in the country during two visits. All other records are by non-odonatologists. The small collections of Angolan dragonflies, which do not exceed 450 specimens/records, are based in Switzerland (Musée d'Histoire Naturelle de la Ville de la Chaux-de-Fonds, MHNC) and Zimbabwe (Bulawayo). The Zambezian headwaters in Angola need particular attention. Even short surveys by odonatologists would dramatically improve the current state of knowledge.

Mozambique

Mozambique has been poorly explored. All knowledge of Odonata of Mozambique has been summarized by Pinhey (1981) and dates back more than 25 years. Major parts of the country, such as the eastern coastal basins, remain unexplored for Odonata.

NW Zambia

Numerous records made by Pinhey (1984) in the Lutchigena Province are the major source of information on the species of this area. These records, however,

provide only a preliminary checklist as they did not cover all seasons of the year. A survey of the Upper Zambezi River would be fruitful.

Kafue

The Kafue swamps are almost unsurveyed. Similar assemblages as in the Okavango Floodplains are to be expected.

Eastern Zimbabwe Highlands

The data record for this ecoregion is moderately good, but most records date back 30 years or more. The endemics have not been recorded again since their first sighting and their precise habitat is mostly unknown. Considering the high level of threat facing the highland dragonfly habitats, the ecoregion should be surveyed and populations of the endemics recorded.

Karoo

Although the Karoo ecoregion is not expected to have high species numbers or endemism, the isolated mountains should be surveyed in search of populations of Cape Fold endemics.

5.6 References

- Kipping, J. 2006. The Odonata of Botswana – an annotated checklist. *Cimbebasia Memoirs* 10.
- Kipping, J. and Suhling, F. 2006. Dragonflies of the Okavango River system. *Cimbebasia Memoirs* 10.
- Muirhead-Thomson, R.C. 1973. Laboratory evaluation of pesticide impact on stream macroinvertebrates. *Freshwater Biology* 3: 479–498.
- Muirhead-Thomson, R.C. 1987. *Pesticide impact on stream fauna: with special reference to macroinvertebrates*. Cambridge University Press, Cambridge.
- Odonata Specialist Group 1996. *Sympetrum dilatatum*. In: IUCN 2006. 2006 IUCN Red List of Threatened Species. <www.iucnredlist.org>. Downloaded on 5 July 2007.
- Pinhey, E. 1963. A remarkable new primitive dragonfly (Odonata) from the Victoria Falls. *Novos Taxa Entomológicos Supplement* 32:3–5.
- Pinhey, E. 1965. Odonata from Luanda and the Lucala River, Angola. *Revista de Biologia, Lisboa* 5: 159–164.
- Pinhey, E. 1981. Checklist of the Odonata of Mozambique. *Occasional Papers of the National Museums and Monuments of Rhodesia, Series B* 6:557–631.
- Pinhey, E. 1984. A check-list of the Odonata of Zimbabwe and Zambia. *Smithersia* 3:1–64.
- Samways, M.J. 2008. *Dragonflies and Damselflies of South Africa*. Pensoft, Sophia, Bulgaria.
- Samways, M.J. and Taylor, S. 2004. Impacts of invasive alien plants on Red-Listed South African dragonflies

- (Odonata). *South African Journal of Science* **100**:78–80.
- Samways, M.J., Taylor, S. and Tarboton, W. 2005. Extinction reprieve following alien removal. *Conservation Biology* **19**:1329–1330.
- Stoks, R. and McPeck, M.A. 2003. Predators and life histories shape *Lestes* damselfly assemblages along a freshwater habitat gradient. *Ecology* **84**:1576–1587.
- Suhling, F., Jödicke, R. and Schneider, W. 2003. Odonata of African arid regions – are there desert species? *Cimbebasia* **18**:207–224.
- Suhling, F., Sahlén, G., Martens, A., Marais, E. and Schütte, C. 2006. Dragonfly assemblages in arid tropical environments: a case study from western Namibia. *Biodiversity and Conservation* **15**:311–332.
- Suhling, F., Martens, A., Schmalstieg, K., Schütte, C. and Richter, O. (in press). Biodiversity patterns of freshwaters in an arid country: distribution atlas and updated checklist of the Odonata of Namibia. *Cimbebasia Memoirs* **10**.
- Thieme, M.L., Abell, R., Stiassny, M.L.J., Skelton, P., Lehner, B., Teugels, G.G., Dinerstein, E., Toham, A.K., Burgess, N.D. and Olson, D.M. 2005. *Freshwater ecoregions of Africa and Madagascar: a conservation assessment*. Island Press, Washington DC, USA.

Chapter 6. The status and distribution of freshwater crabs

Cumberlidge, N.¹ and Daniels, S.R.²

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Freshwater crabs (Potamonautidae, Potamoidea) are among the most important invertebrates inhabiting African fresh waters, but until recently were poorly known due to a general lack of interest and insufficient taxonomic knowledge (Cumberlidge 1999). These large and conspicuous crustaceans are present in almost all freshwater habitats in southern Africa from rugged montane habitats with torrential streams and waterfalls to large lowland rivers and small water bodies (Daniels *et al.* 2001; Cumberlidge and Tavares 2006). In addition, species that live in seasonally arid areas tend to be semi-terrestrial, live in burrows, and move about on land at night (Reed and Cumberlidge 2004). Isolation related to complicated topography and the fragmentary nature of wetland habitats (such as small lowland water bodies or highland streams) in much of southern Africa, and limited dispersal abilities due to reproduction by direct development, are probably responsible for much of the diversity and endemism of these crabs. Distributional ranges include point endemics (such as *Potamonautes kensleyi* and *P. macrobrachii* from Angola), localized taxa (such as *P. brincki*, *P. parvispina*, *P. parvicorpus* and *P. granulatus* from the

Cape Fold Mountains), and wide ranging species (such as *P. bayonianus* from Angola, Zambia, Zimbabwe, and Mozambique, plus the DRC).

6.1 Overview of the regional fauna

Southern Africa includes only 19 of the estimated 137 known species of freshwater crabs in the Afrotropical region, a fauna that comprises 20 genera in two families: Potamonautidae Bott, 1970, and Potamidae Ortmann, 1896 (Cumberlidge 1999; Cumberlidge and Sternberg 2002; Daniels *et al.* 2006; Cumberlidge *et al.* 2008; Yeo *et al.* 2008). All of the 134 species of potamonautids are endemic to the Afrotropical region while only three out of the more than 520 species of potamids worldwide are Afrotropical (Yeo *et al.* 2008). The 19 species of freshwater crabs found in the southern African region belong to a single genus, *Potamonautes* MacLeay, 1837 (Cumberlidge and Daniels 2008, Table 1). This genus has a wide distribution elsewhere in continental Africa but is absent in North Africa north of the Sahara (excepting the Nile basin) (Bott 1955;

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Cumberlidge 1999) and Madagascar (Cumberlidge and Sternberg 2002). Southern Africa's freshwater crab fauna is relatively impoverished in comparison to other areas of the Afrotropical region such as East Africa (35 species, three genera) (Bott 1955; Cumberlidge 1997, 1998; Corace *et al.* 2001; Cumberlidge and Vannini 2004; Reed and Cumberlidge 2004, 2006a), Central Africa (24 species, five genera) (Bott 1955; Cumberlidge *et al.* 2002; Cumberlidge and Boyko 2000; Cumberlidge and Reed 2004), West Africa (33 species, seven genera) (Cumberlidge 1999) and Madagascar (only 14 species, but seven genera) (Cumberlidge and Sternberg 2002; Reed and Cumberlidge 2006b; Cumberlidge *et al.* 2008).

Freshwater crab distribution patterns in southern Africa do not coincide well with the 22 ecoregions defined by Thieme *et al.* (2005). Instead their distributions show more correspondence with the six major aquatic ecoregions recognised by Skelton (2001) as shown in Figure 3.1 (Chapter 3 this volume). These are:

1. **The tropical east coast ecoregion** that includes parts of South Africa (coastal KwaZulu-Natal Province and the Limpopo valley in Northern Province), most of Mozambique, and the Zambezi valley in Zimbabwe and eastern Zambia. The rivers in this region are low gradient with wide floodplains, and there are also coastal lakes, swamps, and temporary rain-filled pans. Six species of freshwater crabs are found here: *P. unispinatus*, *P. bayonianus*, *P. calcaratus*, *P. warreni*, *P. sidneyi* and *P. lividus*.
2. **The tropical interior ecoregion** that includes the eastern highlands of Angola and western Zambia that are drained by rivers with distinct seasonal annual floods and extensive flood-plain swamps. Only one species of freshwater crab (*P. bayonianus*) is known to occur in this aquatic ecoregion.
3. **The highveld (temperate) ecoregion** consists of two separate subregions: the interior plateau in Zimbabwe (where *P. unispinatus* and *P. obesus* occur), and the Transvaal-Free State Province of South Africa (where *P. warreni* and *P. unispinatus* occur). The latter subregion extends south into the Midlands of KwaZulu-Natal Province and the Transkei (where *P. dentatus* and *P. sidneyi* occur), and west along the Orange River to the Atlantic coast (where *P. warreni* and *P. perlatus* are found).
4. **The montane-escarpment ecoregion** includes the Drakensberg Mountains in Lesotho and South Africa (Free State and KwaZulu-Natal Provinces) and is characterized by cool-temperature high-gradient streams that have low or moderate concentrations of dissolved solids. The freshwater crab fauna here includes three species: *P. clarus*, *P. depressus*, and *P. sidneyi*, the first two of which are endemic to this region.
5. **The Cape Fold Mountains ecoregion** in the Western Cape Province of South Africa is characterized by clear,

cool streams with acid water. This region has a rich freshwater crab fauna that is highly endemic and distinct (*P. parvicorpus*, *P. parvispina*, *P. brincki*, *P. granularis*, and *P. perlatus*). Four of these species are restricted range endemics, while the fifth, *P. perlatus*, has a wide distribution well beyond the Cape Fold Mountains.

6. **The Kalahari-Karoo-Namib ecoregion** includes most of Namibia and Botswana, plus the Karoo in the Northern Cape Province of South Africa. This vast ecoregion is mostly arid and has only intermittent rivers, temporary pans, isolated permanent springs, and sinkholes. No crabs are found in the Kalahari, Namib, and the Great Karoo, but *P. dubius* and *P. bayonianus* are found in the Kunene and Okavango Rivers that form the northern borders of the arid zone, and *P. warreni* and *P. perlatus* are found in the Orange River that flows between the Namib desert in Namibia and the Karoo in South Africa.

6.2 Conservation status (IUCN Red List Criteria: Regional Scale)

The summary presented here is based on an analysis of species regional Red List status following application of the IUCN Red List Criteria at the regional scale of southern Africa (Cumberlidge and Daniels 2008). The regional Red List status of any species that is endemic to southern Africa is equivalent to its global Red List status.

The conservation status of southern Africa's freshwater crab species was assessed using the IUCN Red List Criteria (IUCN, 2003) (Cumberlidge and Daniels 2008). Although there is a need to collect more comprehensive information, the available data were sufficient to make valid assessments for the conservation status of most species. Of the 19 species of freshwater crabs found in the southern African region, three (*P. kensleyi*, *P. dubius*, and *P. macrobrachii*, 16%) from Angola and Namibia had insufficient data to complete a Red List assessment (Data Deficient, DD, Table 6.1). Of the remaining 16 non-DD species in southern Africa, only one (*P. lividus*) (5%) (Figure 6.1 and Table 6.1) is listed in a threatened category (Vulnerable, VU) (Table 6.1). Encouragingly, 94% of all species that could be assigned conservation status were assessed as Least Concern (LC). The majority of these LC species live in rivers, marshy lowlands, or mountain streams (Cumberlidge and Daniels 2008). The high proportion of species found to be LC is due to much of southern Africa being relatively lightly affected by industrial development and the associated aquatic habitat degradation and pollution. Data Deficient species are found only in Angola and Namibia reflecting the lack of material from these countries, a scarcity that continues to fuel uncertainty about the distribution of little-known species (Bott 1955;

Cumberlidge and Tavares 2006). The presence of DD species can lead to underestimations of the proportion of threatened species in a fauna as, when more information becomes available, it may be found that these species are also threatened. This effect is expected to have the greatest impact in Angola and Namibia. No species of freshwater crabs could be confirmed Extinct (EX) or Extinct in the Wild (EW), although extinctions are difficult to confirm. Of great concern are those DD species that have not been found in recent years (*P. macrobrachii* and *P. dubius*) but cannot be formally classified as Extinct until exhaustive surveys probing their disappearance have been carried out.

The main threats to freshwater crabs are listed in Table 6.2 and include the loss and degradation of habitat, and water pollution.

Given the relatively low number of crab species found within southern Africa compared to the other taxonomic groups covered in this report, the conservation status for each species of freshwater crab is dealt with below in some detail.

Figure 6.1 The proportion (%) of freshwater crab species in each regional Red List Category in southern Africa. DD = Data Deficient, VU = Vulnerable, LC = Least Concern.

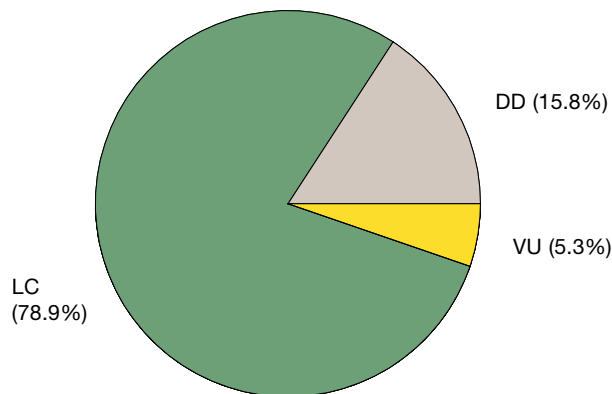


Table 6.1 The number of crab species in each regional Red List Category in the southern African region.

	Regional Red List Category	Number of Species	Number of regional endemics
Threatened Categories	Critically Endangered	0	0
	Endangered	0	0
	Vulnerable	1	1
	Near Threatened	0	0
	Least Concern	15	12
	Data Deficient	3	3
Total		19	16

Note: All species assessed as regionally threatened which are endemic to the region are also globally threatened.

Table 6.2 Summary of the most important threats to freshwater crab species in the southern African region.

Species of <i>Potamonautes</i>	Main threats	Conservation Status
<i>P. ancbetiae</i>	3	LC
<i>P. bayonianus</i>	3	LC
<i>P. brincki</i>	1,2	LC
<i>P. calcaratus</i>	1,2	LC
<i>P. clarus</i>	1,2	LC
<i>P. dentatus</i>	1,2	LC
<i>P. depressus</i>	1,2	LC
<i>P. dubius</i>	1,2	DD
<i>P. granulatus</i>	1,2	LC
<i>P. kensleyi</i>	1	DD
<i>P. lividus</i>	1,2	VU, B1ab(iii)+2ab(iii)
<i>P. macrobrachii</i>	1,2	DD
<i>P. obesus</i>	1,2	LC
<i>P. parvicorpus</i>	1,2	LC
<i>P. parvispina</i>	1,2	LC
<i>P. perlatus</i>	2	LC
<i>P. sidneyi</i>	3	LC
<i>P. unispinus</i>	3	LC
<i>P. warreni</i>	2	LC

1 - Habitat destruction; 2 - Pollution; 3 - No major threats identified.

6.2.1 Species assessed as Vulnerable

Potamonautes lividus Gouws, Stewart, and Reavell, 2001

This medium-sized crab is coloured orange/red with a faint blue sheen, and is endemic to swamp forests in north-eastern KwaZulu-Natal Province in South Africa in the tropical east coast aquatic ecoregion. These swamp forests are dominated by *Barringtonia racemosa* (L.) Spreng. 1826, *Ficus trichopoda* Baker, 1883, and *Syzgium cordatum* Hochst. Ex Krauss. Individual crabs inhabit u-shaped burrows dug into spongy hydromorphic peat soil among vegetation that are sited some distance from the main seepage channels. This is a semi-terrestrial air-breathing, burrow-living crab that divides its time between water and land. It is terrestrial at night and during rainstorms when it leaves its burrow to feed on land, and during the wet season when crabs migrate to higher elevations as the water table rises. *Potamonautes lividus* is only known from seven localities. It is assessed as Vulnerable because it is an endemic species with a restricted distribution that lives in a fragile and isolated wetland habitat threatened by development throughout many parts of its range (see Section 6.4.6 below for more detail). The population size is thought to be low based on the density of burrows occupied and the relatively few specimens found.



Potamonautes lividus (VU) is endemic to swamp forests in north-eastern KwaZulu-Natal Province in South Africa. This is the only species of freshwater crab found in southern Africa that is assessed as threatened, the main threats being the loss, fragmentation, and/or degradation of its wetland habitat. Photo: © Winks Emmerson.

6.2.2 Species Assessed as Least Concern

***Potamonautes anchietae* (Brito-Capello, 1871)**

This widespread and abundant large-bodied riverine species is common in the north-western part of Angola and has a distributional range that extends outside the southern African region into the neighbouring provinces of the DRC. In Angola, *P. anchietae* is found in the western and north-western Provinces of Benguela, Kwanza Norte, Kwanza Sul, Malanje, and Huila (and probably also in Uige and Bié Provinces). In the DRC, *P. anchietae* is found in the tributaries of the Congo River in the Provinces of Bas-Congo, Bandundo, and Kasai Occidental that share a border with the northern provinces of Angola. The distributional range includes the Kwanza River in the Kwanza ecoregion in central Angola (Thieme *et al.* 2005) that flows west from the savannah woodlands of the escarpment. Other localities where *P. anchietae* has been collected include the forests in the north of Angola and a number of other sites in the lower Congo River basin in the DRC (Bott 1953). Interestingly, there are no records of this species from the lowland coastal plain of Angola that stretches from the Provinces of Namibe in the south to Zaire in the north. In addition, this species has not been recorded from the Zambezi River drainage in the savannah region of eastern and south-eastern Angola. There are also no records of *P. anchietae* from the south-west of Angola in the drainage basin of the Kunene River and in the desert that borders with the Kaokoveld of northern Namibia. *Potamonautes anchietae* is listed as Least Concern because it is reasonably abundant, widely distributed, and there are no known widespread threats. Estimates of the abundance and population size of

P. anchietae are based on recent collections from new localities made in the past five years, coupled with its representation in museum collections dating back more than 130 years.

***Potamonautes bayonianus* (Brito-Capello, 1864)**

This common large-bodied riverine species is found in the tropical interior aquatic ecoregion in eastern Angola, northern Botswana, Namibia, and the Zambezi River valley in Zambia and Zimbabwe, plus the Katanga Province of the DRC. *Potamonautes bayonianus* has the widest distribution of any species found in the region and is found in seven countries associated with the Zambezi, Kunene, and Congo River drainage systems. In Angola, this species occurs in the vast region that is drained by the Cubango and Cuito Rivers that flow south-east to the Okavango delta in Botswana, as well as in tributaries of the Zambezi River. *Potamonautes bayonianus* is listed as Least Concern in view of its wide distribution, relative abundance, and the lack of known threats. Estimates of a stable population size and abundance of *P. bayonianus* are based on recent collections from new localities made in the past five years coupled with its strong representation in museum collections dating back more than 140 years.

***Potamonautes brincki* (Bott, 1960)**

This small-bodied species is found only in the Cape Fold Mountains ecoregion of the Western Cape Province of South Africa. It occurs in the upper reaches of the rivers draining the slopes of Table Mountain, the Cape Peninsula, Hottentot's Holland Mountains, and the Klein River Mountains, and it is also found in the lower reaches of the Steenbras, Palmiet, and Rooiels Rivers near Cape Agulhas, Grabouw, and Hermanus (Stewart 1997a). This species is known from fewer than 10 localities across a relatively restricted range. It is assessed as Least Concern, however, due to its presence in quite large numbers in all parts of its range, because it is found in a protected area (the Fernkloof Nature Reserve), and because there are currently no known major widespread threats.

***Potamonautes calcaratus* (Gordon, 1929)**

These semi-terrestrial, burrow-living crabs occur in South Africa (in Mpumalanga and Northern Provinces) and in Mozambique. They feed at night either in water or on land, and are common in seasonal marshy wet ground in savannah country, living in colonies either in temporary rain-filled pans (in the dry season) or in open water (in the rainy season). *Potamonautes calcaratus* is listed as Least Concern in view of its wide distribution, lack of known widespread major threats, and its occurrence in a protected area (the Kruger National Park). Estimates of abundance and population size of *P. calcaratus* are based on recent collections from new localities made in the past five years coupled with a strong representation in museum collections dating back more than 70 years.

***Potamonautes clarus* Gouws, Stewart, and Cook, 2000**

These small-bodied orange-coloured crabs are known only from the montane-escarpment region of the Drakensberg-Maloti Highlands ecoregion in Lesotho and South Africa (in Free State and KwaZulu-Natal Provinces). This species occurs in the upper tributaries of the Tugela River that rises on the 3,050 m-high Mont-aux-Sources plateau near the Free State Province/Lesotho border in the Royal Natal National Park. This species is also found in the vicinity of Oliviershoek Pass, in Sterkfontein Reservoir near the summit of Van Reenan's Pass, and Cathedral Peak. The range of the species may extend further south into KwaZulu-Natal Province, and further north into other parts of the Free State, and possibly into Mpumalanga Province. In the pristine rocky headwaters of the Tugela River *P. clarus* is found under rocks and boulders in cold fast-flowing mountain streams that have moderate concentrations of dissolved solids. It is presently known from six localities across a relatively wide area. This species is assessed as Least Concern because it currently has no known widespread threats and is found in a protected area.

***Potamonautes dentatus* Stewart, Coke, and Cook, 1995**

This small-bodied riverine species is endemic to the low-gradient mature river systems in the highveld aquatic ecoregion of KwaZulu-Natal Province, South Africa. It occurs in the middle reaches of the Mgeni River near Pietermaritzburg from below the Nagle Dam to the Howick Falls and the Albert Falls Dam. It is also found in the tributaries of the Tugela River including Bushman's River near Estcourt, the Mooi River, and the Inyamvubu River, but has not been recorded from the Msunduzi (Dusi) River, a tributary of the Mgeni River. *Potamonautes dentatus* prefers medium to large rivers where it shelters under rocks in places where the water velocity is fast enough to prevent silting up of the rocky substrate. This species is presently known from only eight localities across a relatively restricted range but was assessed as Least Concern because there are currently no known major widespread threats.

***Potamonautes depressus* (Krauss, 1843)**

This medium-sized brown-green coloured crab is known only from the montane-escarpment region of the Drakensberg-Maloti Highlands ecoregion in KwaZulu-Natal Province, South Africa. It is found in the faster flowing tributaries of the Drakensberg and the higher altitude areas of the Midlands in the Mzimvubu, Mzimkulu, Mkomasi, and Mgeni Rivers, as well as the Mooi River in the Tugela River system. The species is widespread in the Drakensberg range and in the foothills south of Giants Castle as far south as the headwaters of the Mzimkulu River (possibly extending into the Eastern Cape Province), and as far north as the Highland Nature Reserve. *Potamonautes*

depressus occurs in pristine cool temperature, high gradient, fast-flowing mountain streams that drain the Drakensberg Mountains and the higher altitude areas of the Midlands where the streams have moderate concentrations of dissolved solids. This species has been known for over 150 years, has been collected recently, is known from more than 15 different localities, and has a relatively wide distribution. It is found in a protected area (the Highland Nature Reserve), and there are no known widespread major threats so it was assessed as Least Concern.

***Potamonautes granularis* Daniels, Stewart, and Gibbons, 1998**

These large-bodied orange-coloured riverine crabs are endemic to the Cape Fold Mountains in the Western Cape Province of South Africa. This species lives in boulder-strewn stream beds in the middle and lower reaches of the Olifants River system from Citrusdal to Lutzville. *Potamonautes granularis* is known from fewer than 10 localities all in a relatively restricted area, but the lack of widespread major threats to this species resulted in its assessment as Least Concern.

***Potamonautes obesus* (A. Milne-Edwards, 1868)**

The distribution of this widespread species includes a large area of East Africa (Somalia, Kenya and Tanzania) and recent collections have extended its known range southward into Zimbabwe (Reed and Cumberland 2004). Its preferred habitat is seasonal marshy wet ground in savannah country. This burrowing species feeds at night either in water or on land, and moves into more open waters during the rainy season. Although there have been no studies of population size and trends, or of the number of mature individuals, recent collections indicate that this species is locally abundant and that it may be found in a larger number of localities than are presently known. *Potamonautes obesus* is known from more than 20 localities, has a wide distribution and there are no known widespread major threats, and so is assessed as Least Concern.

Potamonautes granularis (LC), an endemic species of freshwater crab found in South Africa. Photo: © Michelle van der Merwe.



***Potamonautes parvicorpus* Daniels, Stewart, and Burmeister, 2001**

This small-bodied species is found only in the Cape Fold Mountains of the Western Cape Province in South Africa where it occurs in the headwaters (mountain stream zone) of the Liesbeek River system of Table Mountain near Cape Town. The high altitude upper reaches of the Liesbeek River have a steep gradient, a high-energy flow, and pure water quality. *Potamonautes parvicorpus* also occurs in the high mountain streams on the Cape Peninsula where it prefers unpolluted streams with small boulders that are shaded by leaf cover. This species has a relatively restricted distribution in upland streams in two adjacent mountain ranges of the Western Cape Province. However, it is found in a protected area and there are currently no obvious widespread major threats, so it is assessed as Least Concern. Recent collections further indicate that *P. parvicorpus* is locally abundant and may be found in a large number of localities that are mainly in protected areas high up on the mountains that are thought unlikely to be developed in the near future. The headwaters where this species lives are relatively undisturbed and in a good ecological state, but are potentially sensitive to anthropogenic disturbance.

***Potamonautes parvispina* Stewart, 1997b**

This small-bodied species is found only in the Cape Fold Mountains of the Western Cape Province of South Africa in the headwaters of the Berg and Olifants River systems. It is presently known from more than 10 localities but has a relatively restricted distribution in mountain streams. Although there have been no studies of population size and trends, or on the number of mature individuals, recent collections indicate that this species is locally abundant mostly in protected areas high up in mountain streams that are thought unlikely to be developed in the near future. So despite its relatively restricted distribution the lack of obvious widespread major threats to this species means that it was assessed as Least Concern.

***Potamonautes perlatus* (H. Milne Edwards, 1837)**

This large-bodied riverine species has been recorded from large rivers (as opposed to small mountain streams) in the Western Cape, Eastern Cape, and Northern Cape Provinces of South Africa. In the Western Cape Province it is common in the Olifants, Berg, Bree, and Gamtoos River systems, and in the upper, middle and lower reaches of rivers from Clanwilliam in the Western Cape, to Port Elizabeth in the Eastern Cape. There are unconfirmed records of this species from Namibia (Balss 1922; Barnard 1935). *Potamonautes perlatus* is listed as Least Concern in view of its wide distribution, the lack of any known widespread major threats to the species, and its residence in protected areas in parts of its range. Estimates of a stable population size and abundance are based on recent collections from new localities made in the past five years coupled with a

strong representation in museum collections dating back to over 160 years.

***Potamonautes sidneyi* (Rathbun, 1904)**

This large-bodied species is found in South Africa, Swaziland, and Mozambique in the tropical east coast aquatic ecoregion. In South Africa *P. sidneyi* occurs in Northern Cape, Mpumalanga, Northern, Gauteng, North-west, Free State, Eastern Cape, and KwaZulu-Natal Provinces. In KwaZulu-Natal Province it is common throughout the low-lying Midlands region between the foothills of the Drakensberg range to the coast, and from Lake Sibayi in the north to Port Shepstone in the south. The species lives in a variety of aquatic habitats including major rivers, small pristine mountain streams, reservoirs, lakes, and swamps, and is tolerant of moderate to high levels of organic pollution. In KwaZulu-Natal Province it is typically found in the slower-flowing middle and lower reaches of rivers, and has not been recorded from the upper reaches and faster flowing tributaries of the Mzimkulu, Mzimvubu, and Mkomasi Rivers. It is also found in the faster-flowing streams and upper tributaries of the Tugela and Mgeni Rivers that drain the foothills of the Drakensberg Mountains where it lives sympatrically with *P. clarus* and *P. depressus*. The presence of *P. sidneyi* in the upper drainages may have been assisted by impoundments such as the Woodstock, Kilburn, Driel, and Spionkop reservoirs in the Tugela River system and the Albert Falls and Midmar reservoirs in the Mgeni River system (Gouws and Stewart 2001). It commonly shelters in burrows dug into the side of muddy riverbanks or under large boulders in rivers with boulder-strewn or sediment-covered beds, and it usually feeds at night. *Potamonautes sidneyi* is listed as Least Concern in view of its very wide distribution, the lack of known widespread major threats, and its presence in protected areas in parts of its range. Estimates of a stable population size and abundance are based on recent collections from new localities made in the past five years coupled with a strong representation in museum collections dating back over 100 years.

***Potamonautes unispinatus* Stewart and Cook, 1998**

This species is found in Zimbabwe in the highveldt aquatic ecoregion of the interior plateau, and in South Africa in the highveldt of the Transvaal-Free State in Mpumalanga, Northern, Gauteng, North-west, and Free State Provinces. In Zimbabwe it occurs in streamless, grassy depressions in low-lying, gently sloping treeless areas that are seasonally waterlogged by seepage from the surrounding high ground as well as by rainfall (Butler and Marshall 1996). During the dry season when surface water is lacking, crabs migrate overland to perennial streams (Gratwicke 2004). This species has not been recorded from other parts of the highveldt region in KwaZulu-Natal, Eastern Cape, Western Cape, and Northern Cape Provinces. In South Africa, it is common in the middle and lower reaches of the Limpopo

River system where it shelters under boulders and submerged vegetation. The species is known to be able to tolerate high levels of organic pollution (Stewart and Cook 1998). *Potamonautes unispinatus* has a very wide distribution and is assessed as Least Concern on account of the lack of immediate human impact on the health of its habitat. Recent collections from new localities made in the past 10 years suggest it has a stable population size and is quite abundant.

***Potamonautes warreni* (Calman, 1918)**

This large riverine species is common in the Orange and Vaal River systems in Mpumalanga, Gauteng, North-west, Free State, and Northern Cape Provinces in South Africa, and in the middle and lower reaches of the Orange River in Namibia where it is found under boulders. The habitat of this river-living species includes the biologically distinct but endangered xeric vegetation typical of the Western Orange ecoregion. *Potamonautes warreni* has a very wide distribution and is assessed as Least Concern on account of the lack of immediate human impact on the health of its habitat. Recent collections from new localities made in the past five years coupled with a strong representation in museums dating back more than 80 years suggest it has a stable population size and is quite abundant.

6.2.3 Species assessed as Data Deficient

***Potamonautes dubius* (Brito-Capello, 1873)**

This riverine species is endemic to the Kunene River and its tributaries in south-western Angola and northern Namibia. Although *P. dubius* has been known to science for over 130 years, it is still known from only a few specimens from less than five localities and it has not been represented in any of the material collected in the past 25 years in the vicinity of the Kunene River. The species is assessed as Data Deficient due to this lack of recent material and the taxonomic uncertainty that surrounds it. This species needs further study because it is possible that it might be synonymous with other more widespread species.

***Potamonautes kensleyi* Cumberlidge and Tavares, 2006**

This large-bodied riverine species is known only from a single locality in the Kwanza River in Kwanza Sul Province, in the savannah region of the Kwanza ecoregion of central Angola, where it was collected from a rocky river bed with no ciliary vegetation. The distributional range of *P. kensleyi* is probably much wider than presently recorded, but it is likely that this species will still prove to be endemic to Angola. More field surveys are needed to establish the true distributional range of this species and to identify the nature of any threats to its long-term survival. The species is currently assessed as Data Deficient.

***Potamonautes macrobrachii* Bott, 1955**

This large-bodied riverine species is found on the inland plateau of Angola in the savannah/dry forest river system of the Kwanza ecoregion. It is known from only a few specimens from two localities in Huambo and Bié Provinces in central Angola and it is likely that it will prove to be endemic to this country. However, no new specimens have been collected for over 50 years and there is little information on population size and trends and on the number of mature individuals. Additional survey is recommended to establish the true distributional range of this species and to identify the nature of any possible threats. The species is assessed as Data Deficient.

6.3 Patterns of species richness

The general pattern of species richness shown by freshwater fish distributions in southern Africa is one where there are rich tropical faunas in the north of the region that decline southwards towards the temperate parts of the region. However, this trend does not appear to apply to the distribution patterns of the freshwater crabs in this region (Cumberlidge and Daniels 2008).

6.3.1 All freshwater crab species

The southern African region has a distinctly recognisable freshwater crab fauna, whereby only three species (*P. bayonianus*, *P. anchetiae* and *P. obesus*) have distributions extending outside of the region (Cumberlidge and Daniels 2008). The river systems of the Cape Fold Mountains and of KwaZulu-Natal Provinces in South Africa, together with the central highlands of Angola support the most diverse freshwater crab faunas in the region (Figure 6.2).

The distributional data indicate that there is a high degree of endemism in southern Africa's freshwater crab fauna at the species level (16 out of 19 species, 84%), but not at the genus or family levels. The majority of species (14 out of 19 species, 74%) occur in South Africa, of which 50% (seven out of 14 species) are endemic to that country. Four South African endemics (*P. brincki*, *P. granularis*, *P. parvicorpus*, and *P. parvispina*) are found in the mountain streams and rivers associated with the fynbos vegetation zone of the Western Cape Province. This endemism may reflect the isolation of the Cape Fold Mountains region, and the relatively easy isolation of crab populations in the rivers that drain these mountain ranges. Other South African endemic species, such as *P. clarus*, are associated with the cold headwater streams draining the high Drakensberg Mountains, or with the middle stretches of the major rivers in the highveldt of the Midlands of KwaZulu-Natal (*P. dentatus*), or with the marshy wetlands of the low lying areas of the tropical

east coastal ecoregion of KwaZulu-Natal (*P. lividus*). Angola is the second most speciose country in the southern African region (with five out of 19 species, 26%) and with a rate of endemism of 40% (two out of five species). The lowest species richness (one to three species) is found in a vast area of the region that includes Botswana, Lesotho, Mozambique, Namibia, Swaziland, Zambia, and Zimbabwe, none of which have any endemic species of freshwater crabs. Species diversity is unexpectedly low in the major aquatic ecosystems of the region such as the Orange, Limpopo, Kunene, Okavango, and Zambezi River basins where only common widespread species (*P. bayonianus* and *P. warreni*) are found and there are no endemics. Species diversity is, as might be expected, lowest in the Namib and Kalahari deserts in Namibia, Botswana, and South Africa where there are also no endemic species, and where crabs are restricted to permanent water sources (such as the Kunene, Okavango, and Orange River basins) on the margins of these arid lands (Cumberlidge and Daniels 2008).

In summary, by far the most diverse freshwater crab faunas of the southern African region are found in South Africa

and Angola, although the sampling intensity in this part of Africa is very uneven. South Africa is by far the most thoroughly surveyed country in the region, which no doubt accounts for the recent increase in species descriptions and new distribution records, while the freshwater crab faunas of Namibia, Angola, Botswana, Zimbabwe, Zambia, and Mozambique have only been lightly sampled by comparison. Nevertheless, the general pattern of species-rich faunas in Angola and South Africa and low species richness in Botswana, Lesotho, Mozambique, Namibia, Swaziland, Zambia, and Zimbabwe is probably real, rather than an artefact resulting from under-collection. The low species richness in Botswana and Namibia is not entirely unexpected because these countries include vast areas of arid land, but it is harder to explain the low number of species in the better-watered areas of Zambia, Zimbabwe, and Mozambique, although it is likely that at least some of this may be due to under-sampling. Further exploration is needed throughout southern Africa where it is probable that the species-count for the freshwater crab fauna of the region will increase substantially as taxonomic discrimination improves and collection efforts intensify.

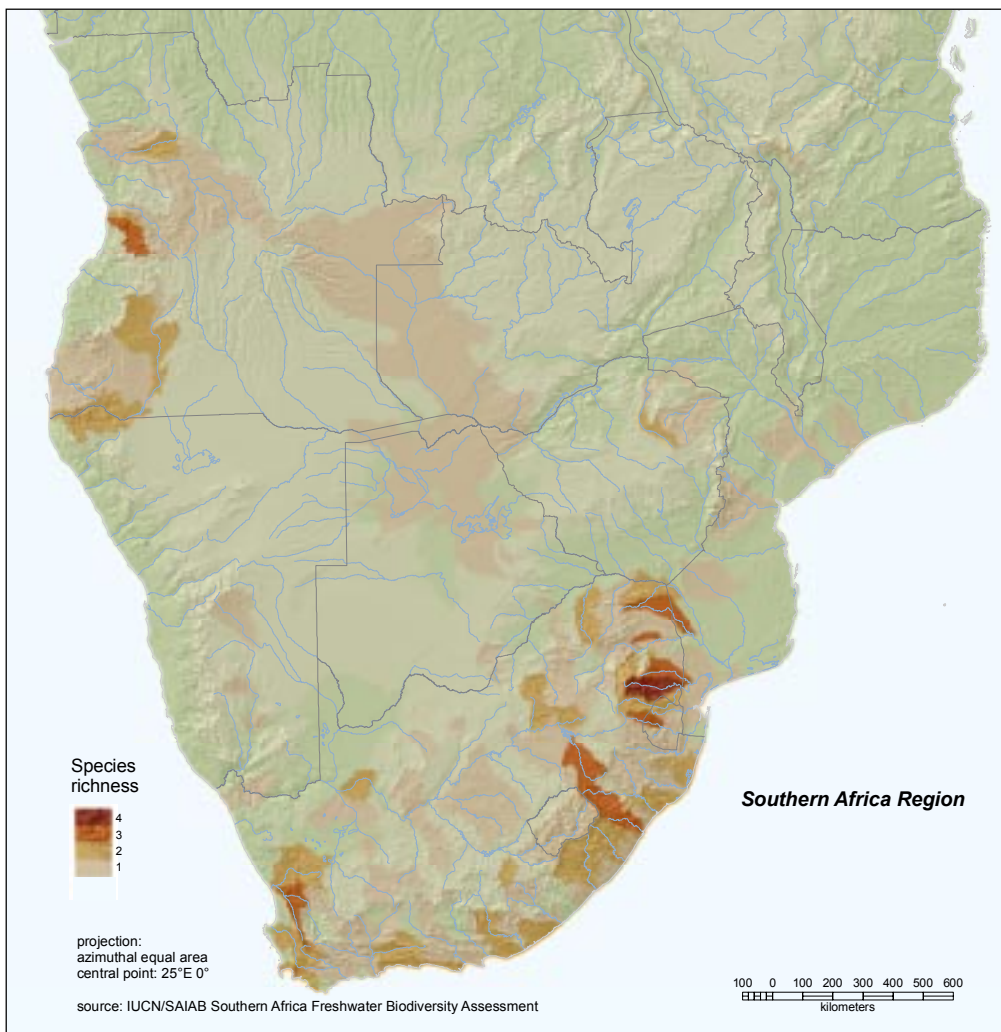


Figure 6.2 Distribution of freshwater crab species in the southern African region, showing the highest species numbers in South Africa and Angola, and lowest species numbers in the better-watered, warmer savannahs of the eastern part of the region.

6.3.2 Threatened species

The only threatened species of freshwater crab (*Potamonautes lividus*), assessed as Vulnerable, is from the tropical east coast freshwater ecoregion of KwaZulu-Natal Province in South Africa (Figure 6.3).

6.3.3 Restricted range species

Species with restricted ranges are irregularly distributed in the region (Figure 6.4 and Table 6.3). Excluding Data Deficient species, eight species of freshwater crab from southern Africa have a restricted range (of <20,000 km²), and all of these are found in South Africa (Table 6.3). They fall into two groups: (1) four endemic species from the Cape Fold Mountains ecoregion (*P. brincki*, *P. granularis*, *P. parvicorpus*, and *P. parvispina*), and (2) four species from KwaZulu-Natal Province: *P. clarus* and *P. depressus* (in the Drakensberg-Maloti Highlands ecoregion), *P. dentatus* (in the highveldt ecoregion), and *P. lividus* (in the tropical east coast aquatic ecoregion). The limited distribution of these species is likely not an anomaly. *Potamonautes brincki* for example, is only known from the southern part of the Hottentots Holland Mountains and has not been recorded elsewhere despite a great deal

Table 6.3 Species of freshwater crabs of southern Africa restricted to single river basins, excluding those considered to be Data Deficient.

Species of <i>Potamonautes</i>	RL Category	Range (km ²)	#Loc	PA
<i>P. brincki</i>	LC	<20,000	10	N
<i>P. clarus</i>	LC	<20,000	6	Y
<i>P. dentatus</i>	LC	<5,000	8	N
<i>P. depressus</i>	LC	<20,000	5	Y
<i>P. granularis</i>	LC	<20,000	12	N
<i>P. lividus</i>	VU	<20,000	9	Y
<i>P. parvicorpus</i>	LC	<20,000	9	N
<i>P. parvispina</i>	LC	<20,000	8	N

RL = Red List status; LC = Least Concern, VU = Vulnerable; Range = estimation of species distribution range based on distribution polygon of all known specimens; #Loc = Number of discontinuous localities from which the species was collected; PA = found in a protected area; Y = yes, N = no. See text for taxonomic authorities.

of collecting throughout the Western Cape Province and beyond. Similarly, *P. parvicorpus* occurs only on the Cape Peninsula and parts of the Hottentots Holland Mountains, and there seems to be no overlap in the distribution of

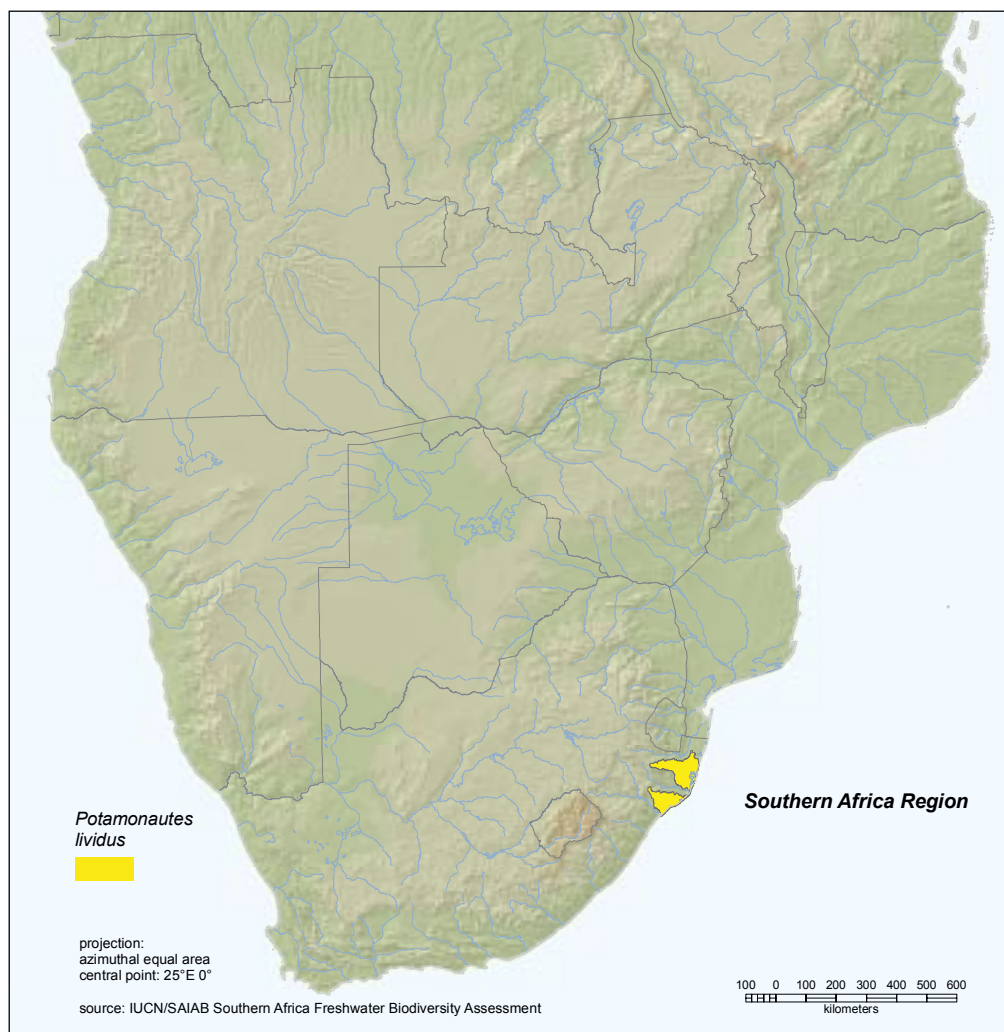


Figure 6.3 The distribution of *Potamonautes lividus* from Kwa-Zulu Natal, South Africa, the only threatened species of freshwater crab from southern Africa.

these two sister taxa. Any development of the hills around Cape Town could thus potentially impact species such as *P. parvicarpus* and *P. brincki*. Only one of the restricted range species (*P. lividus*) was assessed as threatened, with the other seven highland species being Least Concern despite their narrow distributions. This assessment is attributed to the low levels of threat related to the relative inaccessibility of their habitat, because these mountainous areas are generally less disturbed, and most include protected areas that are not scheduled for development. Nevertheless, species with a restricted range are vulnerable to extreme population fragmentation and could suffer a rapid decline and even extinction in a relatively short time should dramatic changes in land-use suddenly affect their habitat. It is therefore of immediate concern that eight (42%) of the region's 19 crab species are known from distribution ranges of less than 2,000 km² (three of which have an estimated range of less than 500 km²). Despite the danger of population fragmentation, the current population levels of those stenotopic species assessed as Least Concern are estimated to be stable, many are found in at least one protected area, and there are no identifiable immediate threats that would impact the health of those streams and endanger their long-term existence. The

reasons for the restricted ranges of these species are largely unknown, but it is thought to be more likely that they have speciated relatively recently in response to isolation in a specialized (marginal) habitat, rather than their being the remnant populations of formerly widespread species now in decline.

6.3.4 Data Deficient species

The three species of freshwater crabs from the southern African region assessed as Data Deficient are all from Angola (Figure 6.5). This status is due to insufficient information either on their taxonomic distinction (for example, *P. dubius*), or because they are known from only one or a few localities (*P. kensleyi* and *P. macrobrachii*). Further research is needed on all of these species that may prove to be restricted range endemics that are vulnerable to habitat loss.

6.3.5 Extirpated species

No species of freshwater crab from the southern African region is known to have been extirpated and none are Extinct (EX) or Extinct in the Wild (EW).

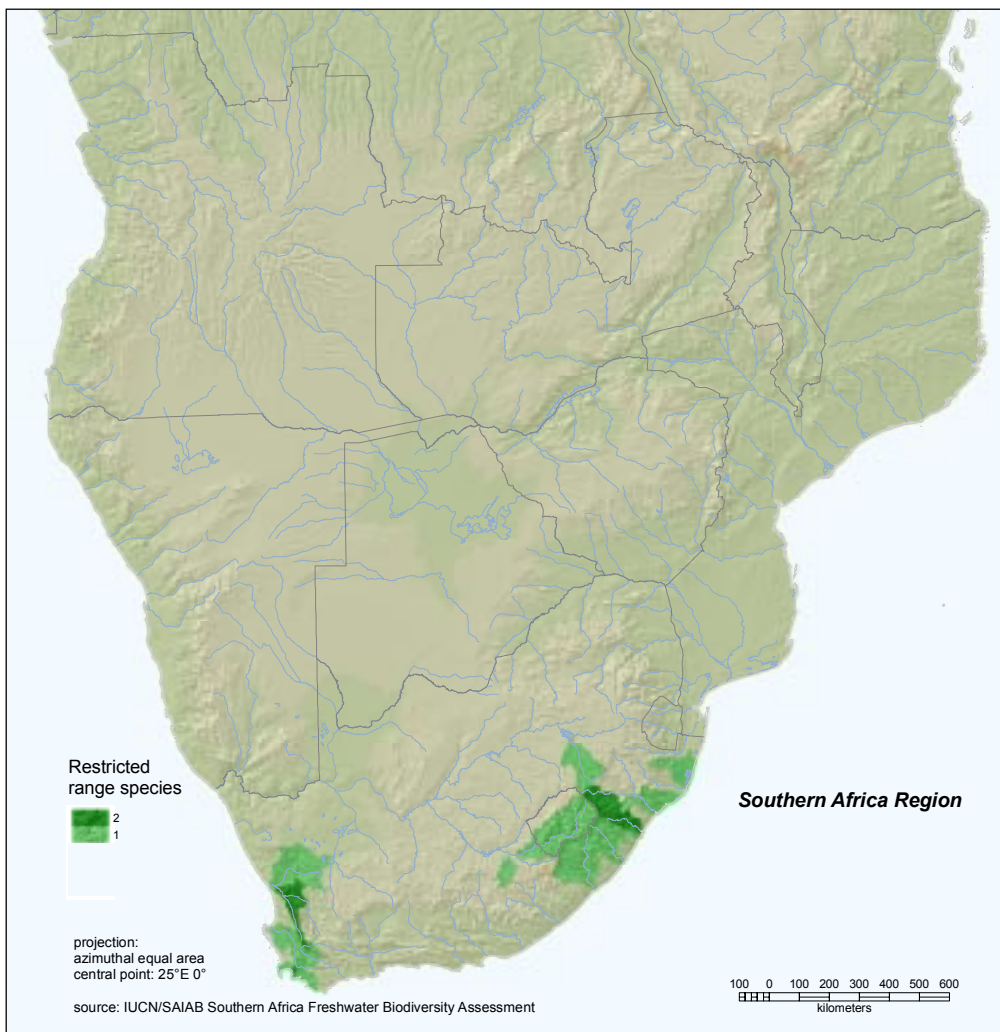


Figure 6.4 Distribution of freshwater crab species with severely restricted distributional ranges, illustrating the high endemism of species in the Western Cape and in the rivers of KwaZulu-Natal Provinces of southern Africa.

6.4 Major threats to freshwater crabs

6.4.1 Natural predators

Freshwater crabs are the largest of the macro-invertebrates in African aquatic ecosystems and when conditions are right can dominate benthic invertebrate communities. Crabs are omnivores with a preference for herbivory over carnivory, and typically consume plant matter and scavenge detritus, making them important detritivores (Dobson 2002, 2004; Dobson *et al.* 2007a, b). Freshwater crabs also form an integral part of the food chain in the river systems of southern Africa because they are vital components of the diet of a number of natural mammalian and avian predators. For example, freshwater crabs represent a common food resource for the Cape clawless otter, the yellow-necked otter, the water mongoose, and the African civet, as well as of kites, egrets, herons, and the giant kingfisher (Turnbull-Kemp 1960; Rowe-Rowe 1977; Hill and O'Keeffe 1992; Purves *et al.* 1994; Butler and Marshall 1996). Other animals that prey on crabs include the African mottled eel (*Anguilla bengalensis labiata* Peters, 1852), bullfrogs (*Pyxicephalus adspersus* Tschudi, 1838), toads, monitor lizards (*Varanus niloticus* L., 1758) and crocodiles (*Crocodylus niloticus* (Laurenti,

1768)) (Butler and Marshall 1996). In many rural parts of southern Africa freshwater crabs (e.g., *P. warreni*, in the Klip River, Gauteng Province, South Africa) form an important part of the diet of humans (de Kock 2001). Most of the natural predators of freshwater crabs avoid competition by feeding at different times of day, at different depths, and by selecting prey of different sizes. For example, large African mottled eels are nocturnal and feed on the river bed in deep water where they select medium-sized crabs, while clawless otters are also nocturnal benthic feeders, but they use their fingered forefeet to catch crabs of all sizes hidden under rocks at all depths, but mostly in shallow water (Rowe-Rowe 1977; Butler and Marshall 1996). It is clear that freshwater crabs are important members of freshwater communities in the aquatic ecosystems of southern Africa, and it is vital to the health of these ecosystems that fishery managers consider measures that specifically include the conservation of local populations of river crabs.

6.4.2 Introduced predators

In well-aerated shallow water in cold headwater streams in the upland parts of South Africa and Zimbabwe freshwater crabs are eaten by introduced predators such

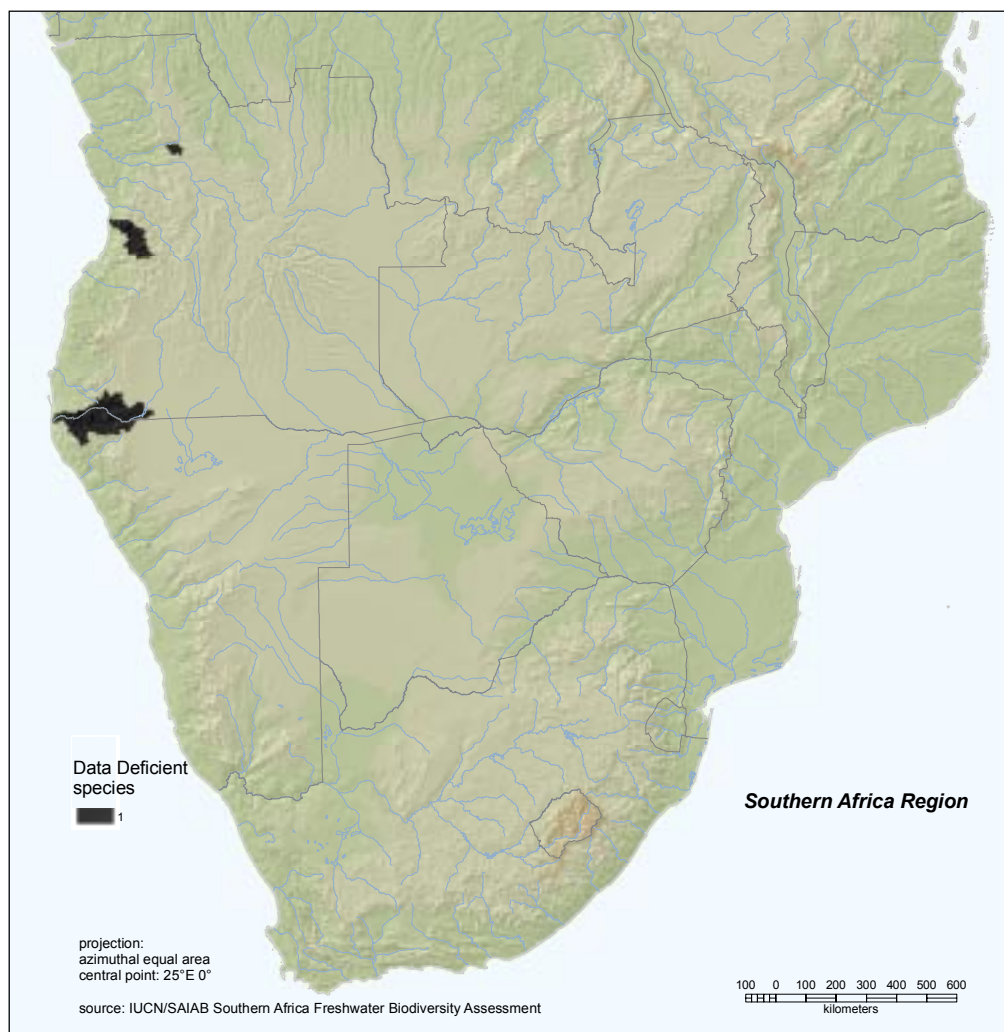


Figure 6.5 Distribution of the species of freshwater crabs assessed as Data Deficient. All are found in Angola, but this pattern may be an artefact of insufficient field surveys in other parts of this vast region.

as rainbow trout (*Oncorhynchus mykiss* (Walbaum, 1792)). These fish prefer to feed most actively in the mornings and evenings, and select mostly small-sized and juvenile crabs that comprise about 13% of their diet (Turnbull-Kemp 1960; Butler and Marshall 1996). However, their impact may be greater than this because rivers in East Africa that had a dense populations of crabs suffered immediate declines in crab numbers after the introduction of trout which fed intensively on crabs until prey population levels declined (Williams *et al.* 1964). On Mt Elgon in eastern Uganda and on Mt Kenya and the Aberdares in the eastern highlands of Kenya introduced rainbow trout predation significantly impacted crab population levels to the point where today freshwater crabs are rare in those rivers that have been stocked with rainbow trout, and abundant in adjacent rivers in which there are no trout (Hynes *et al.* 1961; Williams *et al.* 1964).

6.4.3 Introduced competitors

Like freshwater crabs, crayfish (Astacoidea) are large dominant macro-invertebrates found in fresh water habitats, and both of these crustaceans are potential niche competitors. In Africa, crabs and crayfish are not in competition because there are no crayfish found naturally in any part of this continent (although there are seven endemic species of crayfish on Madagascar (Hobbs 1987; Boyko *et al.* 2005)). However, the potential for competition between crayfish and freshwater crabs in Africa does in fact arise, because four species of crayfish have been introduced there for aquaculture, which is practiced on a small scale in South Africa and elsewhere. Although there is little direct evidence to date, all four exotic species of crayfish are thought to have the potential for a large impact on southern African freshwater ecosystems in general, including negatively affecting freshwater crab populations (de Moor 2002). Species of southern crayfish (Parastacidae) from Australia that are used commercially in South Africa include the marron

Crab remains (possibly *Potamonautes perlatus*) in an otter spraint at a reservoir near Ceres, South Africa. Freshwater crabs form a key component of the diet of otters. Photo: © William Darwall.



(*Cherax tenuimanus* (Smith, 1912)), the yabbie (*C. destructor* (Clark, 1936)) and the red claw (*C. quadricarinatus* (von Martens, 1868)). In addition, the Louisiana red swamp crayfish (*Procambarus clarkii* (Girard, 1852)) (Cambaridae) from North America has had a major impact on aquatic ecosystems in East Africa wherever it has been introduced. For example, in Lake Naivasha, Kenya, *P. clarkii* has caused the almost complete disappearance of native floating-leaved and submerged plants, and has had a large impact on native invertebrate communities, including freshwater crabs (Foster and Harper 2006a,b; Lodge *et al.* 2005). Alien crayfish that colonize the aquatic ecosystems of Africa could well put globally important freshwater biodiversity resources at risk (de Moor and Holden 1997; de Moor 2002).

6.4.4 Pollution

Pollutants from mining activities (such as lead, cadmium, iron, and copper) and organic wastes from leaking sewage systems can accumulate in rivers and other freshwater bodies and affect crab populations (van Eeden and Schoonbee, 1991; Reinecke *et al.* 2003; Snyman *et al.* 2002; Steenkamp *et al.* 1993; Steenkamp *et al.* 1994; de Kock 2001). These pollutants impact freshwater crabs because they are benthic feeders ingesting invertebrates and detritus that have high levels of contaminants. Perhaps not surprisingly, in heavily polluted areas (such as the mining districts of Gauteng Province in South Africa) crab population densities are low, and here crabs grow to smaller sizes compared to those living in non-impacted sites (de Kock 2001). Immediate attention should be given to the improvement of the water quality in these areas not least because the bioaccumulation of metals in crabs could pose an increasing problem for people that may eat them.

6.4.5 Threats in the Cape Floristic Region (CFR)

Threats to the endemic species in the CFR (*P. parvicorpus*, *P. parvispinata*, *P. brincki*, and *P. granularis*) include habitat destruction driven by increasing agriculture, the demands of increasing industrial development, the alteration of fast flowing rivers for the creation of hydroelectric power, and the drainage of wetlands for farming and other uses. In addition, excessive water abstraction leaves rivers with little or no flow in the drier months, and sedimentation associated with farming activities further decreases habitat quality. Potential future threats to aquatic communities in freshwaters (especially in the Cape Town area) include the over-use of aquifers that feed the base flow of rivers, and the destruction of wetlands and streams with associated wetland-adapted fynbos vegetation. In addition, rivers associated with cities and towns tend to be polluted by sewage and industrial and general waste, and agricultural pesticides used by

farmers may prove to be lethal to freshwater crabs once more research has been carried out. All of the above combine to increase the overall level of threat to range-restricted endemic species of freshwater crabs found in the CFR, and the careful management of water resources in the future will have the biggest impact on their survival.

6.4.6 Threats to *Potamonautes lividus* in the Tropical East Coast region

This burrow-living specialist is a semi-terrestrial obligate wetland species endemic to swamp forests in north-eastern KwaZulu-Natal Province in South Africa. It is known from localities in the University of Zululand near Empangani, the Mdibi swamp forest near Richards Bay, and wetlands in the Mapelane Nature Reserve. It also occurs in north-eastern KwaZulu-Natal Province in the Mkuze Game Reserve, False Bay Park, Ntambanana, Mtubatuba, St Lucia, and Hluhluwe Game Reserve. An unconfirmed locality in the Amatikulu River would represent the southernmost limit of this species.

The major present and future threats to *P. lividus* include habitat loss/degradation resulting from human population increase throughout most of its range. The type locality is in disturbed marshy ground close to residences on the campus of the University of Zululand near Empangani. This habitat is at risk of pollution from household detergents and waste and from physical disturbance. Although there are no known conservation measures in place specifically for *P. lividus* it is found in three protected areas in north-eastern KwaZulu-Natal Province: the Mapelane Nature Reserve, the Mkuze Game Reserve, and the Hluhluwe Game Reserve.

6.4.7 Taxonomic issues

The evolving taxonomy of freshwater crabs may prove a challenge for conservation planning in the future as some taxa currently assumed to be widespread and common may prove to be complexes of several distinct cryptic taxa, each with specific ecologies and distributions requiring directed conservation action. One such possibility is *P. perlatus* that is currently assessed as Least Concern primarily on account of its wide distributional range throughout the Western Cape Province. However this range consists of many pockets of relatively isolated subpopulations that show a great deal of morphological and genetic variation, and further investigations may show *P. perlatus* to be a species complex (Daniels *et al.* 2002).

6.5 Conservation recommendations

As the biology and distribution patterns of the freshwater crabs of southern Africa become better known, so are the

potential threats to their long-term survival. With only one of the 19 species of freshwater crabs from the southern African region currently assessed as being at risk of global extinction the region's largely endemic freshwater crab fauna does not appear at first sight to be in immediate trouble when compared with other assessed freshwater groups, such as fishes, molluscs, and dragonflies, found in the same freshwater habitats. Nevertheless it is hoped that conservation recovery plans for threatened species will be developed for those species identified to be in need of conservation action through the Red List assessment process.

The conservation of many species of freshwater crabs depends primarily on the preservation of patches of natural habitat large enough to maintain the water quality of the upper catchment streams. Although it is not yet known exactly how sensitive freshwater crabs in Africa are to polluted or silted waters, there is evidence from Asia that crabs are not likely to survive when exposed to these factors (Ng and Yeo 2007). Development, agriculture and exploitation of natural resources are necessary realities in developing economies, but compromises may have to be made if freshwater crab species are not to be extirpated in the future. Judicious and careful use of resources is unlikely to cause species extinctions as long as water drainages are not heavily polluted or redirected, sufficient forest and vegetation cover is maintained, and protected areas are respected.

Common species of southern African freshwater crabs assessed as Least Concern (*P. anchetiae*, *P. bayonianus*, *P. calcaratus*, *P. obesus*, *P. perlatus*, *P. sidneyi*, *P. warreni*, and *P. unispinatus*) have a wide distribution in the rivers, lakes, and mountain streams of the region and so far have proved to be relatively tolerant of changes in land-use affecting wetland ecosystems. The persistence of these more adaptable species in lowland rivers and streams that are already disturbed and visibly polluted in parts is encouraging. Loss of natural vegetation and pollution as a result of land development and agriculture is, however, likely to affect the lowland rivers, and many of the wholly aquatic species that live here could be vulnerable. Even species assessed as Least Concern could suffer catastrophic declines should there be abrupt changes in land development, hydrology, or pesticide-use regimes. It is not known how the highland taxa will cope with habitat disturbance and pollution, but considering their specialized habitat requirements it is likely that most of these species will not adapt as readily as the more widespread lowland species. In many countries with a rapid pace of development often only a fine line separates a species assessed as Least Concern from one assessed as Vulnerable, or a Vulnerable species from an Endangered species. The numerous development projects in place or in planning could have a dramatic impact on species of freshwater crabs that have specific habitat requirements

and a restricted distribution. Conservation activities should therefore be aimed primarily at preserving the integrity of sites and habitats while at the same time closely monitoring key freshwater crab populations.

The Data Deficient status of the three species of freshwater crabs from Angola (*P. dubius*, *P. macrobrachii*, and *P. kensleyi*) is primarily a product of insufficient field survey. The scarcity of available specimens is in large part due to the long-term poor security situation in that country, and little is known of the habitat needs, population trends, or threats to these species. For example, *P. kensleyi* came to light only recently during construction of a hydroelectric dam across the river where this species occurs. All three DD species will probably prove to have a relatively restricted distribution and all will likely prove to be endemic to Angola, when more information has been gathered.

The conservation assessment of freshwater crabs of southern Africa represents a first step toward the identification of threatened species within the region and toward the development of a conservation strategy for endemic species. The restricted range of many species of *Potamonautes* from southern Africa, together with the on-going human-induced loss of habitat in many parts of the region are primary causes for concern for the long-term survival of this fauna.

Southern Africa's freshwater crabs have a high degree of endemism with many species living in specialized habitats such as highland streams and lowland marshes. Although many species live in a protected area and may not be under immediate threat, their inherent fragility and their specific habitat requirements support the need to establish reserves specifically aimed at the inclusion and protection of freshwater aquatic ecosystems. Additional research is recommended to determine the minimum effective size and design of protected areas for freshwater species such as crabs. Finally, watershed conservation, in particular the upper catchment areas, is an immediate priority.

Significant areas of this vast region still remain insufficiently explored and new species of freshwater crabs are sure to be discovered as collection efforts in the remote areas intensify and as taxonomic skills become more refined. Although taxonomic knowledge has advanced considerably in recent years and museum collections of freshwater crabs have improved, a great deal of work still needs to be done. There is a need for new surveys to discover new species, refine species distributions, define specific habitat requirements, describe population levels and trends, and identify specific threats to southern Africa's important and unique freshwater crab fauna.

6.6 References

- Balss, H. 1922. Crustacea Decapoda. In: Beiträge zur Kenntnis der Land-und Süßwasserfauna Deutsch-Südwestafrikas, herausgegeben von W. Michaelson. *Ergebnisse der Hamburger Deutsch S-W-Afrikanischen Studienreise* 2:71-72.
- Barnard, K.H. 1935. Scientific Results of the Vernay-Lang Kalahari Expedition, March to September 1930, Crustacea. *Annals of the Transvaal Museum* 16:481-492.
- Bott, R. 1953. Potamoniden (Crust. Decap.) von Angola. *Publicações culturais da Companhia de Diamantes de Angola, Lisboa* 16:133-148.
- Bott, R. 1955. Die Süßwasserkrabben von Afrika (Crust., Decap.) und ihre Stammesgeschichte. *Annales du Musée du Congo belge (Tervuren, Belgique) C-Zool. Sér.* 3(III):209-352.
- Bott, R. 1960. Crustacea (Decapoda): Potamonidae. In: *South African Animal Life* (eds. Hansström B and others). Results of the Lund University Expedition in 1950-1952 7:13-18.
- Bott, R. 1970. Betrachtungen über die Entwicklungsgeschichte und Verbreitung der Süßwasser-Krabben nach der Sammlung des Naturhistorischen Museums in Genf/Schweiz. *Revue suisse de Zoologie* 77:327-344.
- Boyko, C.B., Ravoahangimalala, R.O., Randriamasimanana, D. and Razafindrazaka, T.H. 2005. *Astacoides hobbsi*, a new crayfish (Crustacea: Decapoda: Parastacidae) from Madagascar. *Zootaxa* 1091:41-51.
- Brito-capello, F.De. 1864. Descrição de tres especies novas de Crustaceos da Africa occidentale. Observações acerca do *Penaeus bocagei* Johnson, especie nova dos mares de Portugal. *Memorias da Academia Real Sciencias de Lisboa* 3(II):1-11.
- Brito-capello, F.De. 1871. Algumas especies novas ou pouco conhecidas de crustaceos pertencentes dos generos *Calappa* e *Telphusa*. *Jornal de Sciencias Mathematicas, Physica e Naturaes Lisboa* 3: 128-134.
- Brito-capello, F.De. 1873. Descrição d'uma nova specie de *Telphusa* d' Africa occidental. *Jornal de Sciencias Mathematicas, Physica e Naturaes Lisboa* 4:254-257.
- Butler, J.R.A. and Marshall B.E. 1996. Resource use within the crab-eating guild of the Upper Kairezi River, Zimbabwe. *Journal of Tropical Ecology* 12(4):475-490.
- Calman, W.T. 1918. A new river crab from Transvaal. *Annals of the Magazine of Natural History* 9(1):234-236.
- Corace, R.G., Cumberlidge, N. and Garms, R. 2001. A new species of freshwater crab from Rukwanzi, East Africa. *Proceedings of the Biological Society of Washington* 114:178-187.

- Cumberlidge, N. 1997. The African and Madagascan freshwater crabs in the Museum of Natural History, Vienna (Crustacea: Decapoda: Brachyura: Potamoidea). *Annalen des Naturhistorischen Museums in Wien* **99B**:571–589.
- Cumberlidge, N. 1998. The African and Madagascan freshwater crabs in the Zoologische Staatssammlung, Munich (Crustacea: Decapoda: Brachyura: Potamoidea). *Spixiana* **21**:193–214.
- Cumberlidge, N. 1999. *The freshwater crabs of West Africa. Family Potamonautidae*. Faune et Flore Tropicales 35, Institut de recherche pour le développement (IRD, ex-ORSTOM), Paris, pp. 382.
- Cumberlidge, N. and Boyko, C.B. 2000. Freshwater crabs (Brachyura: Potamoidea: Potamonautidae) from the rainforests of the Central African Republic. *Proceedings of the Biological Society of Washington* **3(2)**:406–419.
- Cumberlidge, N. and Daniels, S.R. 2008. A conservation assessment of the freshwater crabs of southern Africa (Brachyura: Potamonautidae). *African Journal of Ecology* **46**:74–79.
- Cumberlidge, N. and Reed, S.K. 2004. *Erimetopus vandenbrandeni* (Balss, 1936) n. comb., with notes on the taxonomy of the genus *Erimetopus* Rathbun, 1894 (Brachyura: Potamoidea: Potamonautidae) from Central Africa. *Zootaxa* **422**:1–27.
- Cumberlidge, N. and Sternberg, Rv. 2002. The freshwater crabs of Madagascar (Crustacea, Decapoda, Potamoidea). *Zoosystema* **24**:41–79.
- Cumberlidge, N. and Tavares, M. 2006. Remarks on the freshwater crabs of Angola, south-western Africa, with the description of *Potamonautes kensleyi*, new species (Brachyura: Potamoidea: Potamonautidae). *Journal of Crustacean Biology* **26**:248–257.
- Cumberlidge, N. and Vannini, M. 2004. Ecology and taxonomy of a tree living freshwater crab (Brachyura: Potamoidea: Potamonautidae) from Kenya and Tanzania, East Africa. *Journal of Natural History* **38**:681–693.
- Cumberlidge, N., Clark, P.F. and Baillie, J. 2002. A new species of freshwater crab (Brachyura: Potamoidea: Potamonautidae) from Príncipe, Gulf of Guinea, Central Africa. *Bulletin of the British Museum of Natural History (Zoology), London* **68(1)**:13–18.
- Cumberlidge, N., Daniels, S.R. and Sternberg, Rv. 2008. A revision of the higher taxonomy of the Afrotropical freshwater crabs (Decapoda: Brachyura) with a discussion of their biogeography. *Biological Journal of the Linnean Society* **93**:399–413.
- Cumberlidge, N., Marijnissen, S.A.E. and Thompson, J. 2007. *Hydrothelphusa vencesi*, a new species of freshwater crab (Brachyura: Potamoidea: Potamonautidae) from south-eastern Madagascar. *Zootaxa* **1524**:61–68.
- Daniels S.R., Stewart, B.A. and Gibbons, M.J. 1998. *Potamonautes granularis* sp. nov. (Brachyura: Potamonautidae), a new cryptic species of river crab from the Olifants river system, South Africa. *Crustaceana* **71**:885–903.
- Daniels, S.R., Stewart, B.A. and Burmeister, L. 2001. Geographic patterns of genetic and morphological divergence amongst populations of a river crab (Decapoda, Potamonautidae) with the description of a new species from mountain streams in the Western Cape, South Africa. *Zoologia Scripta* **30**:181–197.
- Daniels, S.R., Stewart, B.A., Gouws, G., Cunningham, M. and Matthee, C.A. 2002. Phylogenetic relationships of the southern African freshwater crab fauna (Decapoda: Potamonautidae: *Potamonautes*) derived from multiple data sets reveal biogeographic patterning. *Molecular Phylogenetics and Evolution* **25**:511–523.
- Daniels, S.R., Cumberlidge, N., Pérez-Losada, M., Marijnissen, S.A.E. and Crandall, K.A. 2006. Evolution of Afrotropical freshwater crab lineages obscured by morphological convergence. *Molecular Phylogenetics and Evolution* **40**:225–235.
- De Kock, E. 2001. Aspects of the general biology and bioaccumulation of metals in the freshwater crab, *Potamonautes warreni*. MSc Thesis, Rand Afrikaans University, South Africa.
- De Moor, I.J. 2002. Potential impacts of alien freshwater crayfish in South Africa. *African Journal of Aquatic Science* **27(2)**:125–139.
- De Moor, I.J. and Holden, K. 1997. Literature study on the exotic freshwater crayfish species of the genera *Cherax* and *Procambarus* which are of aquacultural significance. Consultancy report to the Agricultural Research Council, J.L.B. Smith Institute of Ichthyology.
- Dobson, M. 2002. Detritivores in Kenyan highland streams: more evidence for the paucity of shredders in the tropics? *Freshwater Biology* **47**:909–919.
- Dobson, M. 2004. Freshwater crabs in Africa. *Freshwater Forum* **21**:3–26.
- Dobson, M., Magana, A., Lancaster, J. and Mathooko, J.M. 2007a. Aseasonality in the abundance and life history of an ecologically dominant freshwater crab in the Rift Valley, Kenya. *Freshwater Biology* **52**:215–225.
- Dobson, M., Magana, A., Mathooko, J.M. and Ndegwa, F.K. 2007b. Distribution and abundance of freshwater crabs (*Potamonautes* spp.) in rivers draining Mt Kenya, East Africa. *Fundamental Applied Limnology* **168**:271–279.
- van Eeden, P.H. and Schoonbee, H.J. 1991. Bioaccumulation of heavy metals by the freshwater crab *Potamonautes warreni* from a polluted wetland. *South African Journal of Wildlife Research* **21(4)**:103–108.
- Foster J. and Harper, D. 2006a. Status of the Alien Louisianan Red Swamp Crayfish *Procambarus clarkii* Girard and the Native African Freshwater

- Crab *Potamonautes loveni* in Rivers of the Lake Naivasha Catchment, Kenya. *Freshwater Crayfish* **15**, 189–194.
- Foster, J. and Harper, D. 2006b. The Alien Louisianan Red Swamp Crayfish *Procambarus clarkii* Girard in Lake Naivasha, Kenya 1999–2003. *Freshwater Crayfish* **15**, 195–202.
- Gratwicke, B. 2004. Migration of the freshwater crab *Potamonautes unispinus* in a seasonal stream, Zimbabwe. *African Zoology* **39**:25–29.
- Gordon, I. 1929. A new river-crab of the subgenus *Potamonautes* from Portuguese East Africa. *Annals of the Magazine of Natural History* **3**(10):405–411.
- Gouws, G., Stewart, B.A. and Coke, M. 2000. Evidence for a new species of river crab (Decapoda, Brachyura, Potamonautidae) from the Drakensberg, South Africa. *Journal of Crustacean Biology* **20**:743–758.
- Gouws, G., Stewart, B.A. and Reavell, P. 2001. A new species of freshwater crab (Decapoda, Potamonautidae) from the swamp forests of Kwazulu-Natal, South Africa: biochemical and morphological evidence. *Crustaceana* **74**:137–160.
- Hill, M.P. and O’Keeffe, J.H. 1992. Some aspects of the ecology of the freshwater crab (*Potamonautes perlatus* Milne Edwards) in the upper reaches of the Buffalo River, Eastern Cape Province, South Africa. *South Africa Journal of Aquatic Science* **18**:42–50.
- Hobbs, H.H.Jr. 1987. A review of the crayfish genus *Astacoides* (Decapoda: Parastacidae). *Smithsonian Contributions to Zoology* **443**:1–50.
- Hynes, H.B.N., Williams, T.R. and Kershaw, W.E. 1961. Freshwater crabs and *Simulium neavei* in East Africa. I. – Preliminary observations made on the slopes of Mt Elgon in December, 1960, and January, 1961. *Annals of Tropical Medicine and Parasitology* **55**(2):197.
- IUCN 2003. Guidelines for Application of IUCN Red List Criteria at Regional Levels: Version 3.0. IUCN Species Survival Commission. IUCN, Gland, Switzerland and Cambridge, UK.
- Krauss, F.F. 1843. Die Sudafrikaoischen Crustaceen. Stuttgart.
- Lodge, D.M., Rosenthal, S.K., Mavuti, K.M., Muohi, W., Ochieng, P., Stevens, S.S., Mungai, B.N. and Mkoji, G.M. 2005. Louisiana crayfish (*Procambarus clarkii*) (Crustacea: Cambaridae) in Kenyan ponds: non-target effects of a potential biological control agent for schistosomiasis. *African Journal of Aquatic Science* **30**(2):119–124.
- Macleay, W.S. 1838. Brachyurous Decapod Crustacea. Illustrations of the Zoology of South Africa 5; being a Portion of the Objects of Natural History Chiefly Collected during an Expedition into the Interior of South Africa, under the Direction of Dr Andrew Smith, in the Years 1834, 1835, and 1836; Fitted Out by “The Cape of Good Hope Association for Exploring Central Africa.” In: A. Smith, *Illustrations of the Zoology of South Africa; Consisting Chiefly of Figures and Descriptions of the Objects of Natural History Collected During an Expedition into the Interior of South Africa, in the Years 1834, 1835, and 1836; Fitted Out by “The Cape of Good Hope Association for Exploring Central Africa.”* (Invertebrates), pp. 1–75.
- Marijnissen, S.A.E., Schram, F., Cumberlidge, N. and Michel, A.E. 2004. Two new species of Platythelphusa A. Milne-Edwards, 1887 (Decapoda, Potamoidea, Platythelphusidae) and comments on the taxonomic position of *P. denticulata* Capart, 1952 from Lake Tanganyika, East Africa. *Crustaceana* **77**:513–532.
- Marijnissen, S.A.E., Lange, F. and Cumberlidge, N. 2005. Revised distribution of the African freshwater crab genus *Deckenia* Hilgendorf, 1868 (Brachyura, Potamoidea, Deckeniidae). *Crustaceana* **78**:889–896.
- Milne-Edwards, A. 1868. Description de quelques Crustacés nouveaux. *Nouvelles Archives du Muséum d’Histoire naturelle, Paris* **4**:69–92.
- Milne Edwards, H. 1837. Histoires naturelles des Crustacés, comprenant l’anatomie, la physiologie et la classification de ces animaux **2**:1–532.
- Purves, M.G., Kruuk, H. and Nel, J.A.J. 1994. Crabs *Potamonautes perlatus* in the diet of otter *Aonyx capensis* and water mongoose *Atilax paludinosus* in a freshwater habitat in South Africa. *Zeitschrift für Säugetierkunde* **59**(6):332–341.
- Rathbun, M.J. 1904. Les crabes d’eau douce (Potamonidae). *Nouvelles Archives du Muséum d’Histoire naturelle, Paris* **6**:255–312.
- Reed, S.K. and Cumberlidge N. 2004. Notes on the taxonomy of *Potamonautes obesus* (A Milne-Edwards, 1868) and *Potamonautes calcaratus* (Gordon, 1929) (Brachyura: Potamoidea: Potamonautidae) from eastern and southern Africa. *Zootaxa* **1262**:1–139.
- Reed, S.K. and Cumberlidge, N. 2006a. Taxonomy and biogeography of the freshwater crabs of Tanzania, East Africa (Brachyura: Potamoidea: Potamonautidae, Platythelphusidae, Deckeniidae). *Zootaxa* **418**:1–137.
- Reed, S.K. and Cumberlidge N. 2006b. *Foza raimundi*, a new genus and species of potamonautid freshwater crab (Crustacea: Decapoda: Potamoidea) from northern Madagascar. *Proceedings of the Biological Society of Washington* **119**:58–66.
- Reinecke, A.J., Snyman, R.G. and Nel, J.A.J. 2003. Uptake and distribution of lead (Pb) and cadmium (Cd) in the freshwater crab, *Potamonautes perlatus* (Crustacea) in the Eerste River, South Africa. *Water, Air and Soil Pollution* **145**:395–408.
- Rowe-Rowe, D.T. 1977. Food ecology of otters in Natal, South Africa. *Oikos*, **28**:210–219.
- Skelton, P.A. 2001. *A Complete Guide to the Freshwater Fishes of Southern Africa*. Cape Town, Struik Publishers.

- Snyman, R.G., Reinecke, A.J. and Nel, J.A.J. 2002. Uptake and distribution of copper in the freshwater crab *Potamonautes perlatus* (Crustacea) in the Eerste River, South Africa. *African Zoology* **37**(1):81-89.
- Steenkamp, V.E., Du Preez, H.H., Schoonbee, H.J., Wiid, A.J.B. and Bester, M.M. 1993. Bioaccumulation of iron in the freshwater crab (*Potamonautes warreni*) from three industrial, mine and sewage polluted freshwater ecosystems in the Transvaal. *Water South Africa* **19**(4):281-290.
- Steenkamp, V.E., Du Preez, H.H. and Schoonbee, H.J. 1994. Bioaccumulation of copper in the tissues of *Potamonautes warreni* (Calman) (Crustacea, Decapoda, Brachyura), from industrial, mine and sewage-polluted freshwater ecosystems. *South African Journal of Zoology* **29**(2):152-161.
- Stewart, B.A. 1997a. Morphological and genetic differentiation between populations of river crabs (Decapoda: Potamonautidae) from the Western Cape, South Africa, with a taxonomic re-examination of *Gecarcinautes brincki*. *Zoological Journal of the Linnean Society* **99**:1-21.
- Stewart, B.A. 1997b. Biochemical and morphological evidence for a new species of river crab *Potamonautes parvispina* (Decapoda: Potamonautidae). *Crustaceana* **70**:737-753.
- Stewart, B.A. and Cook, P.A. 1998. Identification of a new species of river crab (Decapoda: Brachyura: Potamonautidae) from South Africa using morphological and genetic data. *Journal of Crustacean Biology* **18**:556-571.
- Stewart, B.A., Coke, M. and Cook, P.A. 1995. *Potamonautes dentatus*, new species, a fresh-water crab (Brachyura: Potamoidea: Potamonautidae) from KwaZulu-Natal, South Africa. *Journal of Crustacean Biology* **15**:558-568.
- Turnbull-Kemp, P.St.J. 1960. Quantitative estimations of populations of the river crab, *Potamon (Potamonautes) perlatus* (M. Edw.), in Rhodesian trout streams. *Nature* **185**:481.
- Thieme, M.L., Abell, R.A., Stiassny, M.J.L., Skelton, P.A. and Lehner, B. 2005. *Freshwater ecoregions of Africa and Madagascar: A conservation assessment*. Island Press, Washington DC, USA.
- Williams, T.R., Hynes, H.B.N. and Kershaw, W.E. 1964. Freshwater crabs and *Simulium neavei* in East Africa II. Further observations made during a second visit to East Africa in February-April 1962. *Annals of Tropical Medicine and Parasitology*, **58**:159-168.
- Yeo, D.C.J., Ng, P.K.L., Cumberlidge, N., Magalhaes, C., Daniels, S.R. and Campos, M. 2008. Global diversity of crabs (Crustacea: Decapoda: Brachyura) in freshwater. In: *Freshwater Animal Diversity Assessment. Hydrobiologia* **595**:275-286.

Chapter 7. The status and distribution of vascular plants (Magnoliophyta, Lycopphyta, Pteridophyta)

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7.1 Overview of the regional flora

There is a large number of vascular plants from the phyla Magnoliophyta, Pteridophyta and Lycopphyta growing in wetlands and aquatic habitats. In addition to the difficulties in dealing with a group of this size, it is often difficult to distinguish between wetland and upland plants. Wetland plants do not form a distinct phylogenetic grouping and there are many families that contain some wetland species and some terrestrial species. Vascular plants cover the entire gradient from the aquatic zone right up to the uplands and many species can occur coincidentally in a wet area (Cronk and Fennessey 2000). For this reason it is quite rare that wetland and aquatic plants have been studied separately from other species in national herbaria. However, Glen (in prep.) has recently compiled a complete list of wetland plants for South Africa, Namibia and Botswana, based on herbarium material. This list also includes an assessment of whether these are facultative or obligate wetland plants. A large number of families contain species that are adapted to the wetland environment, and there are a small number of families that entirely consist of wetland plants. Most

vegetation studies focus on the terrestrial (zonal) vegetation, while wetlands, as isolated patches in the landscape, have been studied to a lesser extent.

For the current assessment we have confined ourselves to the list of aquatic plants published in Cook (2004). This book deals mostly with real aquatic species (hydrophytes) and a large part of the helophytes and is restricted to those species that occur within South Africa, Namibia and Botswana. From this work, a list of 565 vascular plant species has been derived and forms the basis of this current assessment. The SABONET working group (Phiri 2005; Mapaura and Timberlake 2004; Da Silva *et al.* 2004) has collated material from herbaria in Angola, Zambia, Zimbabwe and Mozambique, but the material in these herbaria is rather scarce and large parts of these countries have not been investigated properly. In particular, Zambia and Mozambique require further survey, being very rich in wetlands thought likely to contain rare wetland species. In Cook (2004), a total of 36 species are presented that are not native to the region, but that commonly occur in wetlands as introduced species or alien invaders. In a few cases, the indigenous

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status of plants is not known very well, since many aquatic plants have dispersal mechanisms that allow them to be transported over large distances (for example by migrating birds). It is therefore strongly recommended that efforts be taken to expand the current species list of wetland plants in southern Africa as distributions of tropical species from Zambia, Angola, Mozambique and Zimbabwe become better known and as the ecological requirements of many species inhabiting the land/water interface become established.

The occurrence of wetland plants within each of the 22 freshwater ecoregions of southern Africa (Thieme *et al.* 2005) will be dealt with in detail. These ecoregions are predominantly based on faunal distribution and thus may not be the most suitable divisions for explaining the distributions of plants because wetland plants are not one distinct phylogenetic grouping and may be affiliated to species of terrestrial or aquatic origins. The distribution of wetland plants is often correlated to the terrestrial ecoregions as closely as it is to aquatic ecoregions. Examples of some important centres of endemism for wetland plants, not recognised by Thieme *et al.* (2005), include Namaqualand and the KwaZulu-Natal coastline. Cowan (1997) subdivides South Africa into several wetland ecoregions, based on hydrology, geomorphology and climate, and these better reflect the distributions of wetland plants, as does the vegetation map of southern Africa (Mucina *et al.* 2006). However, to enable comparison with other taxa assessed in this study, plant distributions and status will be reviewed on the basis of the ecoregion definitions given in Thieme *et al.* (2005).

7.1.1 Floodplains, Swamps and Lakes

The central plateau of Zambia and adjacent Namibia, Angola and Botswana contains several extremely large wetland areas supporting a large number of wetland plants, especially helophytic grasses and sedges, most of which are quite widespread, often extending north into the Congo and East Africa. Very little is known about the distribution of these species within the various wetlands in Zambia.

Kafue: The Kafue Floodplains have been inadequately surveyed for wetland vegetation, although Ellenbroek conducted a study of the area (Ellenbroek 1987). It is expected that this ecoregion supports similar species to those reported in the Okavango and Upper Zambezi Floodplains and may serve as a stepping-stone for several swamp species of the Lake Bangweulu ecoregion. However, because of poor data, a more detailed assessment is not yet possible. Further surveys are recommended.

Okavango Floodplains: The Okavango Floodplains have been reasonably well studied and many specimens of

wetland plants from the Delta are found in the South African National Herbarium in Pretoria. Many typical marshland species, rare elsewhere, are quite common in the Okavango Delta, such as *Cyperus pectinatus* Vahl, *Vossia cuspidata* (Roxb.) Griff., *Paspalidium obtusifolium* (Delile) N.D. Simpson, and *Oxycaryum cubense* (Poepp. and Kunth) Lye. The Delta also contains a range of more specialized species such as the aquatic sedges *Websteria confervoides* (Poir.) S.S. Hooper, *Eleocharis naumanniana* Boeck., and *E. decorigulumis* Berhaut, the amphibious herb *Limnophila bangweolensis* (R.E.Fr.) Verdc. and the grass *Leersia tisserantii* (A.Chev.) Launert. A special vegetation type, which is quite rare elsewhere in the mostly arid subcontinent, is the sudd vegetation, floating mats of aquatic sedges (*Cyperus papyrus* L., *C. pectinatus* or *Oxycaryum cubense*). The sudd vegetation is of particular interest in that pieces may break away to be carried off by the river and possibly block downstream channels where they are finally deposited. There are more data available for the Okavango Delta than for many of the other large swamps in Southern Africa, mainly due to the work of Ellery and Ellery (1997) and the AquaRAP Report in the Delta (Alonso and Nordin 2003).

Upper Zambezi Floodplains: Information for the region in Western Zambia, the Caprivi Strip and bordering Botswana is quite limited. Many of the permanent wetlands are probably quite similar to those in the Okavango Delta, but most are only seasonally inundated. In fact, for many of the tropical permanent wetland species that are found in the Okavango Delta, the first place to the north where they have been collected again is the Bangweulu Swamps in Northern Zambia, skipping the Zambezi Floodplains and the Kafue Flats. Whether

Cyperus papyrus L., a perennial Sudd hydrophyte found in water in lakes and along rivers or forming floating mats or islands. The species is widespread throughout southern Africa and beyond where it is widely utilized in the production of parchment, as a fuel, in construction of boats, and as a medicine. In southern Africa the rhizomes and culms are eaten raw or cooked, with the culms also being used for construction materials. Photo: © William Darwall.



this is because the intervening permanent swamps are relatively small, or because they have been less thoroughly investigated, is unclear. Species occurring here that are in common with the Okavango Delta include: *Cyperus pectinatus* Vahl, *Rotala fluitans* Pohnert, *Nymphoides rautanenii* (N.E.Br.) A. Raynal, and *Elytrophorus globularis* Hack. Some species with a patchy distribution in southern Africa and that are absent from the Okavango Delta have been found here, such as *Enydra fluctuans* Lour., and the grass *Paratheria prostrata* Griseb.

7.1.2 Mediterranean Systems

Cape Fold: The Cape Fold ecoregion is a mountainous area with extensive lowlands supporting an extremely high variety of wetlands ranging from mountain springs to temporary pans. The area contains a number of endemic plant species, a product of the unique geology of Table Mountain Sandstone and the winter rainfall climate that results in a different hydrological regime for most wetlands.

Many rare and endemic wetland plants are found in this area. The wetlands on Table Mountain Sandstone contain many fynbos species from the families Restionaceae and Ericaceae, but these are largely neglected by Cook (2004) and most of the wetland species assessed here are from families more typical of the lowland pans and riverine wetlands. One of the most typical fynbos riverine wetland species is Palmiet (*Prionium serratum* (L.f) Drège ex E.Mey.), which occurs extensively in wetlands where river water is seeping through a broad valley bottom, often on peat. Large stands of this species are now quite rare, but the species itself is quite common.

The wetlands of the West Coast experience extreme levels of water fluctuation as they only receive winter rainfall and suffer from high evaporation in summer. These wetlands are often referred to as ‘vernal pools’ (Mucina

An example of a Palmiet wetland in Pondoland in the Eastern Cape, South Africa. Photo: © Caitlin von Witt.



Cotula myriophylloides, a Critically Endangered species endemic to the Cape Peninsula in the Western Cape, South Africa. The species had not been collected for the past 30 years and was thought possibly extinct until this population was discovered at Kleinmond in October 2008. Its main current threats are urbanisation and invasive alien species. Photo: © Nick Helme.

et al. 2006) since plants mainly grow here in the spring and die back in summer when the wetlands shrink and become quite saline. Many of the endemic wetland plants in these areas are annuals and bulbous species, such as *Romulea aquatica* G.J. Lewis, *Spiloxene aquatica* (L.f.) Fourc., and *Crassula natans* Thunb.

Some rare and endemic species common to this area include: *Aponogeton angustifolius* Aiton, *Cotula vulgaris* Levyns, *C. myriophylloides* Harv., *Oxalis natans* L., *O. uliginosa* Schltr., *Cadiscus aquaticus* E. Mey, *Isoetes capensis* A.V. Duthie, and *Isoetes stephansenii* A.V. Duthie.

Cadiscus aquaticus, a Critically Endangered species which is endemic to the Western Cape between Groenekloof and Saldanha Bay. It is restricted to vernal pools where it is threatened through overgrazing by livestock, infilling of wetlands, invasion by alien grasses and eutrophication. The species is severely fragmented and has declined by more than 70% in the past 100 years. Photo: © Nick Helme.





Aponogeton distachyos L.f., an edible aquatic plant native to the Western Cape in South Africa where it is used to prepare a local dish. It is widely cultivated throughout South Africa. Photo: © Craig Hilton-Taylor.



Lindernia conferta (Hiern) Philcox is a widespread species found in seasonal pools and is a typical plant of rock pools in the Drakensberg. This specimen is growing on the top of Baker's Kop in the eastern Free State, South Africa. Photo: © Erwin Sieben.

7.1.3 Highland and Mountain Systems

Amatolo-Winterberg Highlands: This is a 'transitional area' for most wetland plant species since the climate is switching between a winter-rainfall to a summer-rainfall climate. Some of the typical fynbos elements such as *P. serratum* may be present, whereas other species from the eastern seaboard of South Africa also appear in these wetlands. There are only a few species endemic to this ecoregion.

Drakensberg-Maloti Highlands: The KwaZulu-Natal Drakensberg is one of the wettest areas in southern Africa and many peatlands exist at altitudes above 2,800 m. Most endemic species in this area are associated with these high-altitude bogs or slow-flowing mountain streams, whereas most of the species in lower-altitude riverine wetlands are more widespread across the eastern seaboard. These peatland endemic species include *Lobelia galpini* Schltr., *Cotula paludosa* Hilliard, *Carex subinflata* Nelmes, and the rare grass *Colpodium drakensbergense* Hedberg and I. Hedberg. The high-altitude mires in Lesotho are described in detail by Backeus and Grab (1995).

Eastern Zimbabwe Highlands: Not much is known about wetland plants occurring in the Eastern Zimbabwe Highlands. Since it is a mountainous region with high rainfall, like the Maloti-Drakensberg area, it probably has a few endemics, but these were not dealt with by Cook (2004) and have therefore not been addressed specifically through this assessment.

7.1.4 Savannah-Dry Forest Rivers

Kwanza: The wetland plants of the lower-lying coastal regions of western Angola are poorly studied. The area is

well-known for its high levels of endemism for other taxa so it is possible that there are also many endemic plants. These are, however, not dealt with in Cook (2004) so have not been addressed specifically through this assessment.

Lower Zambezi: The Lower Zambezi ecoregion has been poorly explored for wetland plants and it is still not known how species recorded from neighbouring ecoregions are distributed within the Lower Zambezi area.

Middle Zambezi/Luangwa: The Middle Zambezi area around the Victoria Falls, Lake Kariba and the Mana Pools National Park in Zimbabwe supports many wetlands similar to those found in the Upper Zambezi, but the distribution of species is even less well-known than for the Upper Zambezi. Various tropical wetland grasses like *Oryzidium barnardii* C.E. Hubb. and Schweick., *Leersia friesii* Melderis, and *Entolasia imbricata* Stapf have been recorded here. *Aponogeton afroviolaceus* Lye is an extremely rare species that may be restricted to the area, but the species has not been recorded in recent times.

Eastern Coastal Basins: The eastern coastal basins of northern Mozambique are among the most poorly studied in the entire region. Not much is known about the distribution of wetlands let alone the plant species within them. It is, however, thought that the area is rich in wetlands and probably shares many species known from southern Mozambique.

Southern Temperate Highveld: This area contains many pans, a large proportion of which become saline in the dry season, as well as a few river-associated wetlands. The wetlands are rich in species, but there are few rare or endemic species present. The eastern wetlands, which contain many riverine and valley wetlands dominated by *Carex acutiformis* Ehrh. and *Cyperus fastigiatus* Rottb.,

remain fresh throughout the year, whereas the wetlands in the western part tend to become saline.

Zambezi Headwaters: This area is poorly known botanically, and much of it is located in very inaccessible areas in Angola. It is expected that many species with a more tropical distribution occur here but not many are included in the species list of Cook (2004).

Zambezi Lowveld: The vegetation in this area is very heterogeneous and may be split into several climatic zones. The coastal areas in particular contain many wetlands with their own unique combination of species. Common and widespread species in this region include *Cyperus dives* Delile, *C. prolifer* Lam. and *Eleocharis limosa* (Schrad.) Schult. Locally, an area such as Lake St Lucia and neighbouring Maputaland may harbour specialists such as *Restio zuluensis* H.P. Linder and *Scleria poiformis* Retz. In the Albany region there are a few regional endemics including *Marsilea schelpeana* Launert, *Crinum campanulatum* Herb. and *Isoetes wormaldii* Sim. A few rare wetland species, such as *Bacopa monnieri* (L.) Pennell and *Eriocaulon schlechteri* Ruhland, are distributed along the coast of Kwazulu-Natal possibly extending into Mozambique. There are also a number of species with patchy distributions in South

A stand of *Carex subinflata* (Vulnerable) in the high mountains around Naudés Nek in the Eastern Cape. This sedge is endemic in the Maloti-Drakensberg region and is only known from a few localities. Photo: © Erwin Seiben.



Africa, including *Fimbristylis aphylla* Steud. and *Enydra fluctuans*. The inland areas support fewer wetlands but a very rare species, *Monochoria africana* (Solms) N.E.Br., is found in the Kruger National Park.

Zambezi Highveld: This area in central Zimbabwe is reasonably well known botanically and one rare species, *Aponogeton afroviolaceus* Lye, was first recorded here but has not been recorded again for more than 50 years.

7.1.5 Xeric Systems

The Xeric Systems are characterized mainly by temporary water systems. Most of these have a fairly depauperate flora, with some hardy and widespread species, such as *Schoenoplectus decipiens* (Nees) J. Raynal, dominant. Locally, however, in Namibia and in Namaqualand in South Africa, a few rare and endemic species are present.

Etosha ecoregion: This area in northern Namibia and southern Angola contains a few rare and endemic xeric species. The many temporary wetlands in northern Ovamboland contain species such as *Aponogeton azureus* H. Bruggen, which is known only from a single locality. Two other species that are confined to this region are *Ledermannia warmingiana* (Gilg) C. Cusset, a haptophyte growing on rocks in fast-flowing rivers, and *Marsilea unicornis* Launert.

Kalahari and southern Kalahari: The Kalahari and the southern Kalahari both harbour numerous small and large temporary pans, which drain quickly due to the Kalahari sands. The flora is quite depauperate, but the northern parts may contain some elements of the Zambezi and Okavango Floodplains. Both are poorly studied when it comes to wetland vegetation.

Karoo: The Karoo contains several temporary wetlands, of which the largest combine to form the Bushmanland Vloere (Mucina *et al.* 2006). Most species in these wetlands are salt-tolerant members of the genus *Sarcocornia*, but these species are not dealt with here. The coastal area of Namaqualand has a few rare and endemic species, such as *Moraea stagnalis* (Goldblatt) Goldblatt.

Namib Coastal: Compared to the other xeric ecoregions the Namib Coastal area is relatively rich in wetlands due to the presence of western flowing ephemeral rivers, but these are not particularly rich in plant species. An interesting wetland plant from this region is the aquatic resurrection plant *Chamaegigas intrepidus* Dinter ex Heil, which can become dormant in the dry period and start growing again when the plant is inundated.

Western Orange: The lower Orange River is not particularly rich in aquatic and wetland species. The



Sarcocornia sp. in the Swakop River, Namibia. This is a salt tolerant succulent species typical of the ephemeral rivers of the Namib coastal region. Photo: © William Darwall.

largest wetland in the area is the Orange River mouth and this area will most likely contain a large range of estuarine species.

7.2 Conservation status (IUCN Red List Criteria: Regional Scale)

The summary presented here is based on an analysis of species regional Red List status following application of the IUCN Red List Criteria at the regional scale of southern Africa. The regional Red List status of any species endemic to southern Africa will be equivalent to its global Red List status.

Southern Africa is for the largest part unaffected by industrialization, intensive agriculture and other threats to wetland habitats, so many plant species may maintain viable populations in the wetland areas that exist in the subcontinent. Within South Africa, however, the National Spatial Biodiversity Assessment (NSBA) report (Driver *et al.* 2005) states that 82% of all river signatures are threatened in the country, 44% of which are critically endangered. Among estuaries, 10 out of 13 estuary types are considered threatened. The NSBA report does not focus on wetlands but among all terrestrial vegetation types that were included in the analysis, there were 19 wetland vegetation types included. Of these, seven were categorized as threatened. Many areas in South Africa face serious threats from overgrazing, while containing large numbers of endemic species.

Of the 547 species assessed in this current study, 87% fall into the Red List Category of Least Concern (LC) (Table 7.1). Those species that are alien to the subcontinent derived from Cook (2004) have been assessed as Not Applicable and these account for 6% of the species. The only area where wetland plants are



Myriophyllum aquaticum (Vell.) Verdc., is one of the species introduced to the region and not therefore evaluated for the Red List. It is native to subtropical south-east America and has been introduced to Europe, Asia, and Africa. It was first recorded in southern Africa in 1919 from the Western Cape. Only female plants have been recorded in Africa so the plant currently spreads by fragmentation of the stem. It has become a pest in some regions and should male plants be imported it could become a more serious problem. Photo: © William Darwall.

currently known well enough to make a reasonable assessment of the threat status is South Africa, and to a lesser extent Namibia. Most of the tropical species have been assessed as Least Concern (LC), but some of the tropical species are known only from a few records in the subcontinent. These species have been mostly listed as Data Deficient (DD) and only one of them had sufficient information to complete a useful assessment of its Red List status. In effect, almost all the tropical species, from the northern part of the subregion, can be regarded as Data Deficient.

A total of 28 species (5%) are in regionally threatened categories, with a further five assessed as Near Threatened (NT) (Table 7.1 and Figure 7.1). These species are mainly

Table 7.1 The number of wetland species from Cook (2004) in each regional Red List Category in the southern African region.

	Regional Red List Category	Number of Species	Number of regional endemics
Threatened Categories	Critically Endangered	8	7
	Endangered	4	4
	Vulnerable	16	14
	Near Threatened	5	3
	Least Concern	450	105
	Data Deficient	34	23
	Not Applicable	29	0
Total		546	156

Note: All species assessed as regionally threatened which are endemic to the region are also globally threatened.

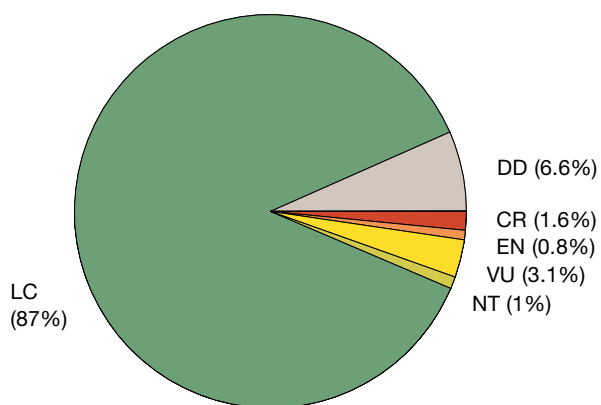


Figure 7.1 The proportion of wetland plant species in each regional Red List Category in the southern African region. CR: Critically Endangered, EN: Endangered, VU: Vulnerable, NT: Near Threatened, DD: Data Deficient, LC: Least Concern.

restricted to a small number of ecoregions with most found in the mountainous regions where both endemism and threats are high, such as the Western Cape Province of South Africa and the Maloti-Drakensberg Mountains. A number of threatened species also occur on the KwaZulu-Natal coastline and in the Okavango Delta. Many of the species confined to the Okavango Delta have been listed as NT because of the pending decision to be made by the Namibian government to build a dam on the Kavango River. Should the dam construction go ahead it is likely to have significant impacts on these aquatic plants due to changes in the sediment load and hydrology of the ecosystem downstream.

Figure 7.2 indicates the proportion of species in each family assessed as regionally threatened. The families Iridaceae and Oxalidaceae have a particularly high proportion of species listed as threatened. The family Asteraceae, a very big family of mostly dryland species, also has a large number of threatened wetland species.

The percentage of species assessed as Data Deficient (6.6%) reflects the low level of knowledge of many wetland plants in the southern Africa region. The species assessed here also represent only a small sample of the total wetland species found throughout the region. Should an attempt have been made to assess all known aquatic plants then the proportion of species assessed as Data Deficient would undoubtedly have been significantly higher than recorded here. Systematic sampling of wetland plants has not often occurred in southern Africa, and many species have a very poor collection record. Finally, it is not always clear whether the lack of collection

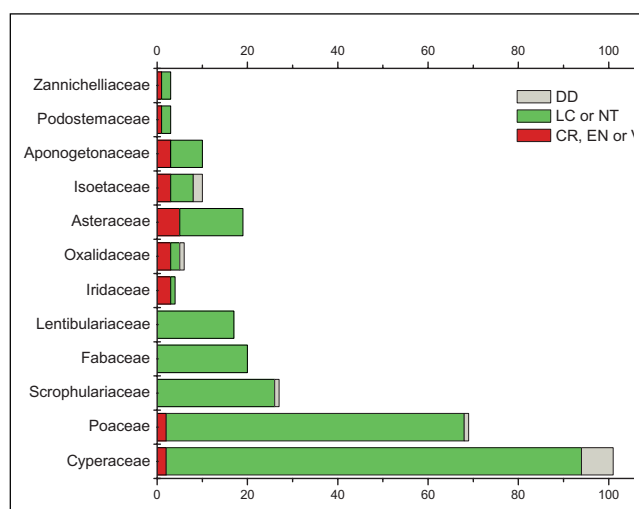


Figure 7.2 The number of species in each family listed as threatened (CR, EN or VU); Near Threatened (NT) or Least Concern (LC); and Data Deficient (DD). It is notable that some of the larger families include no threatened species and that some of the smaller families are over-represented with many threatened (often localized) species.

records reflects species rarity or simply the lack of sampling effort because wetland areas are often neglected by botanists.

7.3 Patterns of species richness

7.3.1 All mapped wetland plants

Only 475 of the wetland plant species assessed from the southern Africa region, as defined here, have been mapped. Future research will certainly reveal the presence of many more species, especially in 'marginal wetlands' like the salt pans in the Karoo and Kalahari, or species-rich environments, such as the Cape Fold Belt. This overview of species distributions can therefore only be taken as a preliminary assessment based on limited and somewhat regionally biased data. The 475 species that could be mapped occur in Namibia, Botswana and South Africa, the countries with the most comprehensive data sets. The tropical or endemic species restricted to the northern parts of the subregion have not been mapped or assessed. So while interpreting the maps (Figures 7.2 to 7.5) and tables below it is important to realize that a fully comprehensive assessment would include many more species in the northern parts of the region.

Most tropical wetland species are widespread with distributions also extending across eastern and central Africa, but their distribution in southern Africa may be quite restricted due to the scarcity of certain wetland habitats, especially sudd (floating vegetation) and peatlands (Figure 7.3).

The apparent low diversity of species in the more tropical regions (Figure 7.3) reflects the lack of focus by this assessment on tropical species (for the reasons given above). Many wetland-rich areas such as Zambia and Northern Mozambique are expected to support a high diversity of aquatic plants species with a total species richness at least as high as that observed here in the Okavango Delta. The Western Cape is also extremely rich in wetland plants in a large variety of habitats, but as most of the typical fynbos wetland species (Restionaceae, Ericaceae, Iridaceae) were not included in Cook's assessment (Cook 2006) this region is also portrayed as being less species-rich than it really is. The portrayal of South Africa as being species-poor in the west and species-rich in the east does, however, correctly reflect the number of wetlands and diversity of wetland types and wetland habitats, which will be closely correlated with the number of wetland plant species.

The highest number of endemic species (Figure 7.4) occurs in the Western Cape, and this is still under-estimated as many other wetland species in the Western Cape have not been included in the assessment. Other concentrations of endemic species include the other mountain regions, the KwaZulu-Natal coast and northern Namibia.



Oxalis dregei Sond., a species endemic to South Africa where it is confined to the Cape region (Northern and Western Cape provinces). It is found in seasonal ponds, wet marshy places and along streams. Photo: © Erwin Seiben.

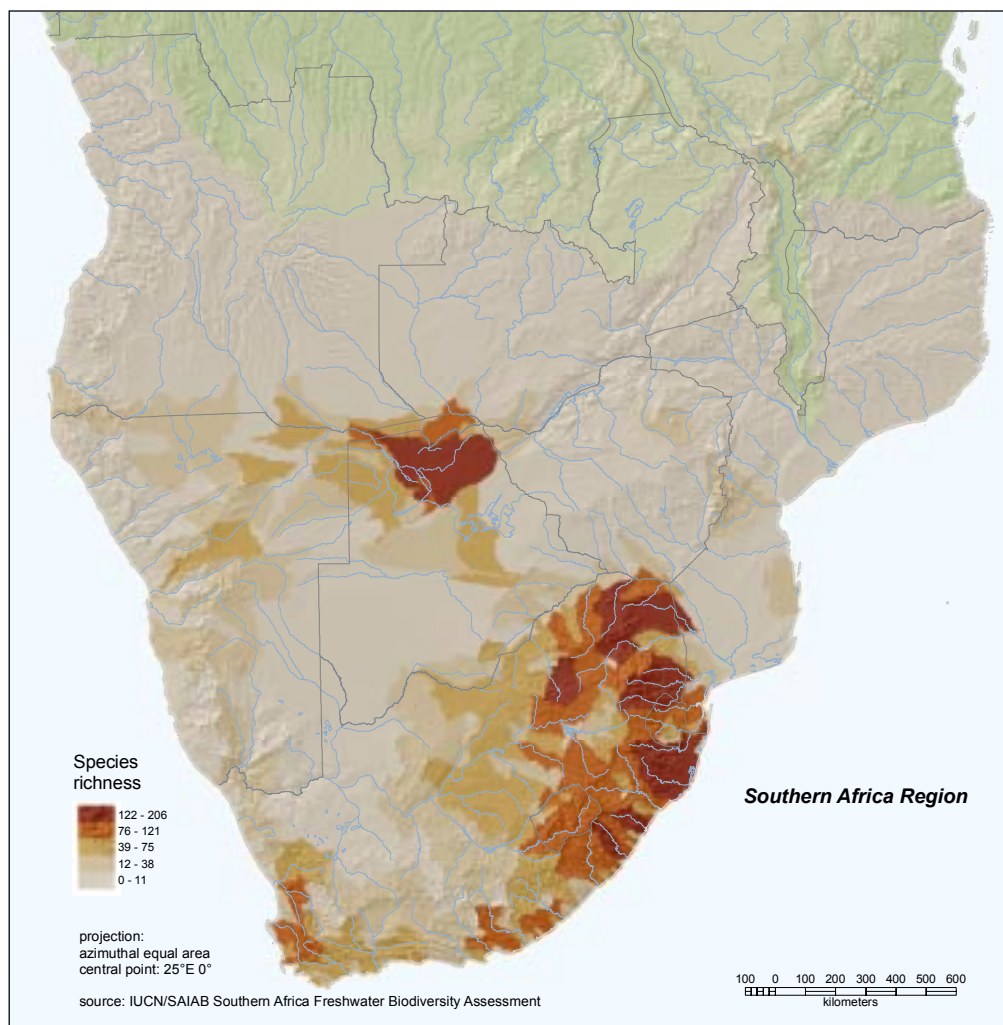


Figure 7.3 The distribution of wetland plant species in southern Africa based on known and inferred species' distributions mapped to river catchments. Analysis is based mainly on data sets for South Africa, Botswana, and Namibia.



Trapa natans L., a floating plant typically found on the fringes of channels and lagoons. This species is widespread and common throughout the Okavango Delta. Photo: © William Darwall.

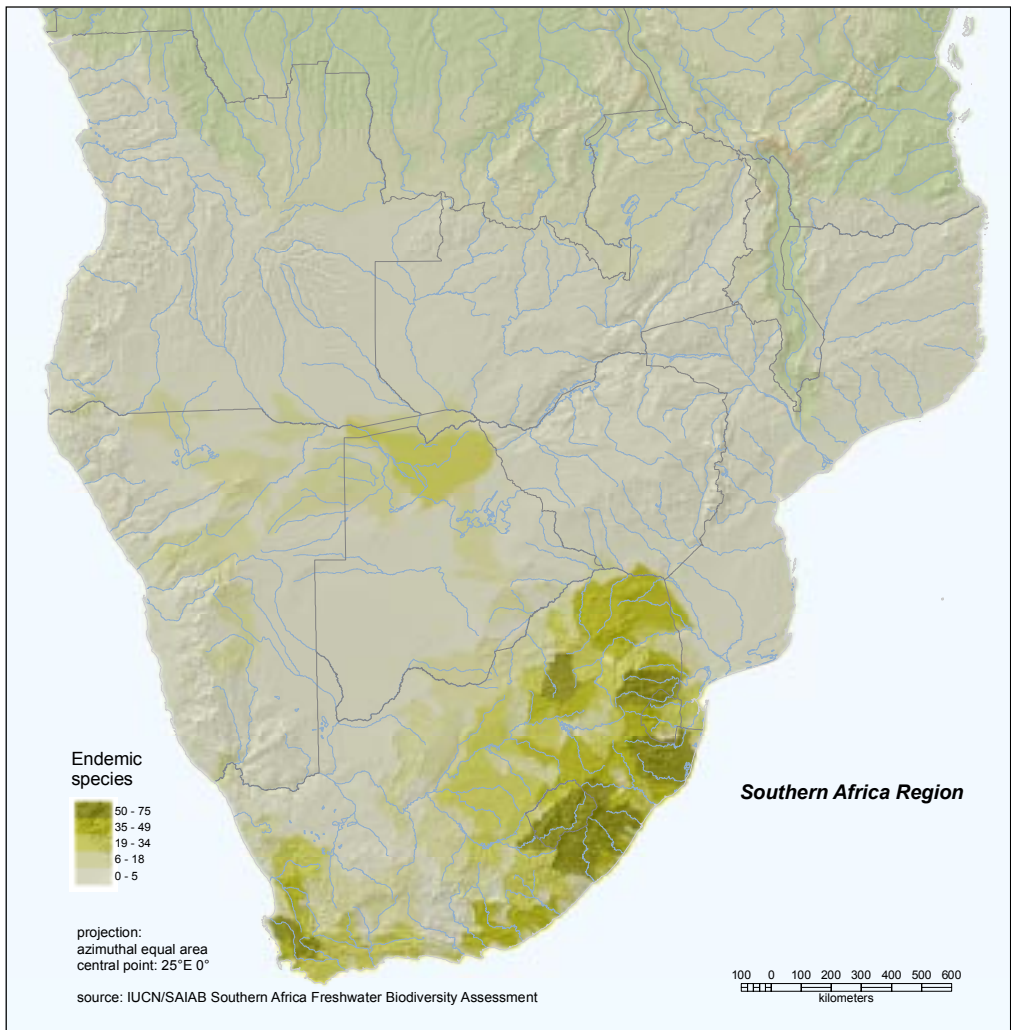


Figure 7.4 The distribution of southern Africa's endemic wetland plant species based on known and inferred species' distributions mapped to river catchments. Analysis is based mainly on data sets for South Africa and Namibia.

The highest concentration of Data Deficient species is in the Okavango (Figure 7.5) but note that many other poorly known species from other parts of the region were not included in this assessment.

7.3.2 Threatened species

Most threatened species (nine) occur in the Cape Fold ecoregion (Figure 7.6) where a major centre of endemism is subject to intensive disturbance, including from agriculture, urbanization and threats from invasive alien organisms, especially trees and fish.

7.3.3 Extirpated species

Some species, such as *Limnophila bangweolensis* and *Aponogeton afroviolaceus*, are known from only a few historical collections and their threat status can only be inferred. In the Western Cape, there are a few species, such as *Lobelia limosa* (Adamson) E. Wimm. and several members of the genus *Riella* that grow in wetlands on the Cape Flats, which are under threat from rapid urbanization, but for which only a few old distribution records are available. *Pseudalthenia aschersoniana* (Graebn.) Hartog, which grows in estuarine systems on

the West Coast, is also poorly known, but is probably under threat. These species have been listed as Data Deficient, but further systematic survey is likely to confirm that they are declining and are severely threatened or possibly extinct.

7.4 Major threats to wetlands and wetland plants

7.4.1 General threats

Even though southern Africa is not heavily industrialized and urbanized there is tremendous pressure on its freshwater resources (Breen and Begg 1989). Wetlands in South Africa have recently enjoyed more attention and this will probably have an impact on their historically poor conservation status. Wetlands are no longer regarded as ‘wastelands’ and incentives are being developed for farmers and communities to take care of wetlands, for example in the Working for Wetlands Programme. Some large wetland areas are situated in national parks and nature reserves, for example parts of the Okavango Delta in Botswana, parts of the Zambezi, Luangwa and Kafue Floodplains in Zambia, the Etosha Pan in Namibia, the

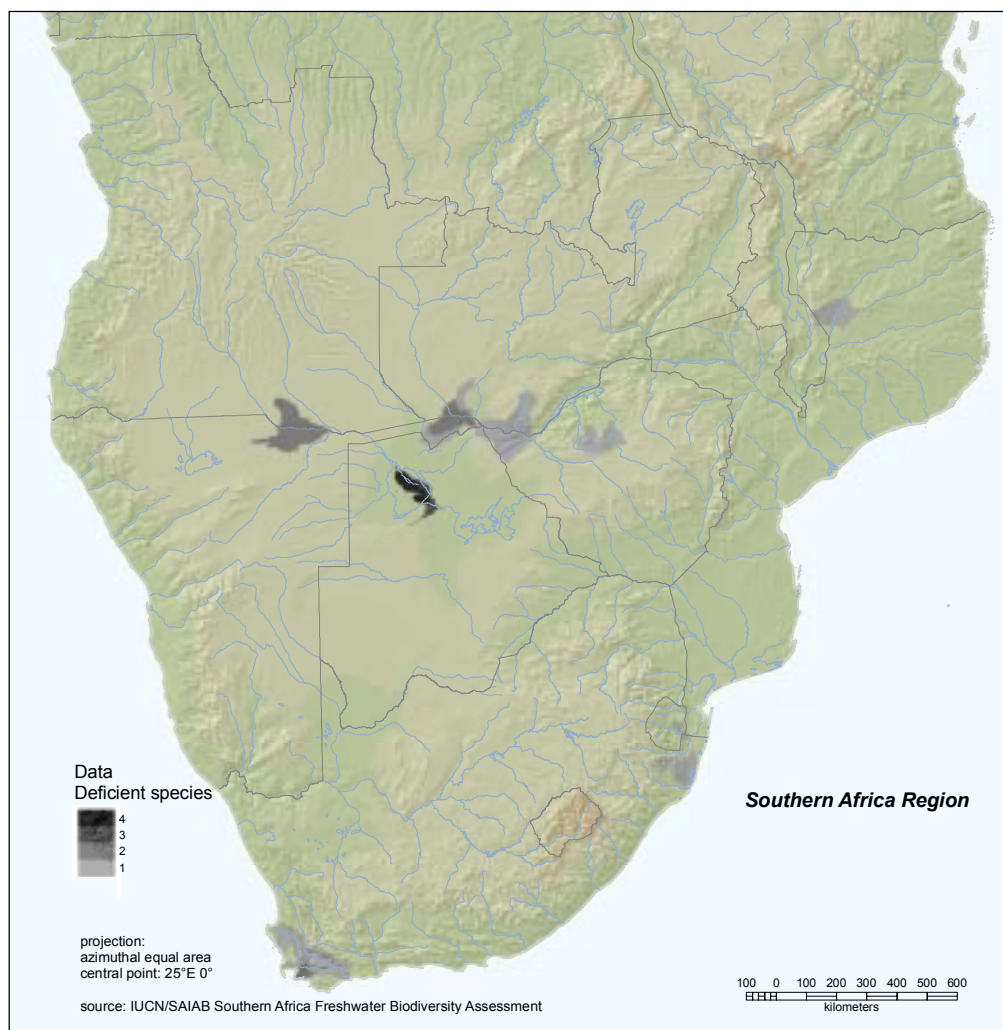


Figure 7.5 The distribution of southern Africa’s Data Deficient wetland plant species based on known and inferred species’ distributions mapped to river catchments. Analysis is based mainly on data sets for South Africa and Namibia. It should be noted that the map is incomplete in that it fails to show the many species that could not be mapped due to lack of information on distribution ranges.

Greater St Lucia Wetland Park in KwaZulu-Natal and the Agulhas National Park in the Western Cape. However, it is still critical that wetland conservation is based on catchment management, as impacts outside protected areas will spread rapidly downstream, or even upstream in the case of invasive species, into those parks or reserves thus offering little effective protection to wetland species. Improved conservation through draft national policies on wetlands in Namibia and Botswana, as well as multinational basin management commissions (already established for the Okavango, Zambezi, Kunene, and Orange basins), can be expected in future.

The main habitats in which species were assessed are shown in Figure 7.7. In many cases species have been listed under more than one habitat whereas others only occur in specialist habitats such as waterfalls. Seepages and springs are under-represented because Cook (2004) does not list many seepage species in his book. In reality, this is probably a much more important habitat for wetland plants with many rare and endemic species.

Seasonal pools and estuaries are over-represented when it comes to habitats of threatened species. These are indeed often very fragile ecosystems, especially

the seasonal pools on the Cape Flats, that require attention.

The main threats identified are shown in Figure 7.8. In many cases species were reported subject to a number of different threats. The main threats are overgrazing, agriculture and urbanization. Urbanization is mainly a threat to the many species of the Cape Flats. The most significant potential threat to species currently assessed as Least Concern is construction of dams. In particular this is considered important for those species that would probably be impacted should a dam be built on the Kavango River in Namibia.

7.4.1.1 Agriculture

Agriculture is a major threat to wetland species because farmers often drain wetlands where they feel the land would be more productive under agriculture. In other cases crops, such as the Amadumbe ('African potatoes') (*Colocasia esculenta* (L.) Schott.) or sugarcane (*Saccharum officinarum* L.), are planted directly in the existing wetland and the native vegetation is either removed or it dies off as the water is used by these water hungry crops. There are two types of land users: subsistence farmers and commercial farmers. Even though

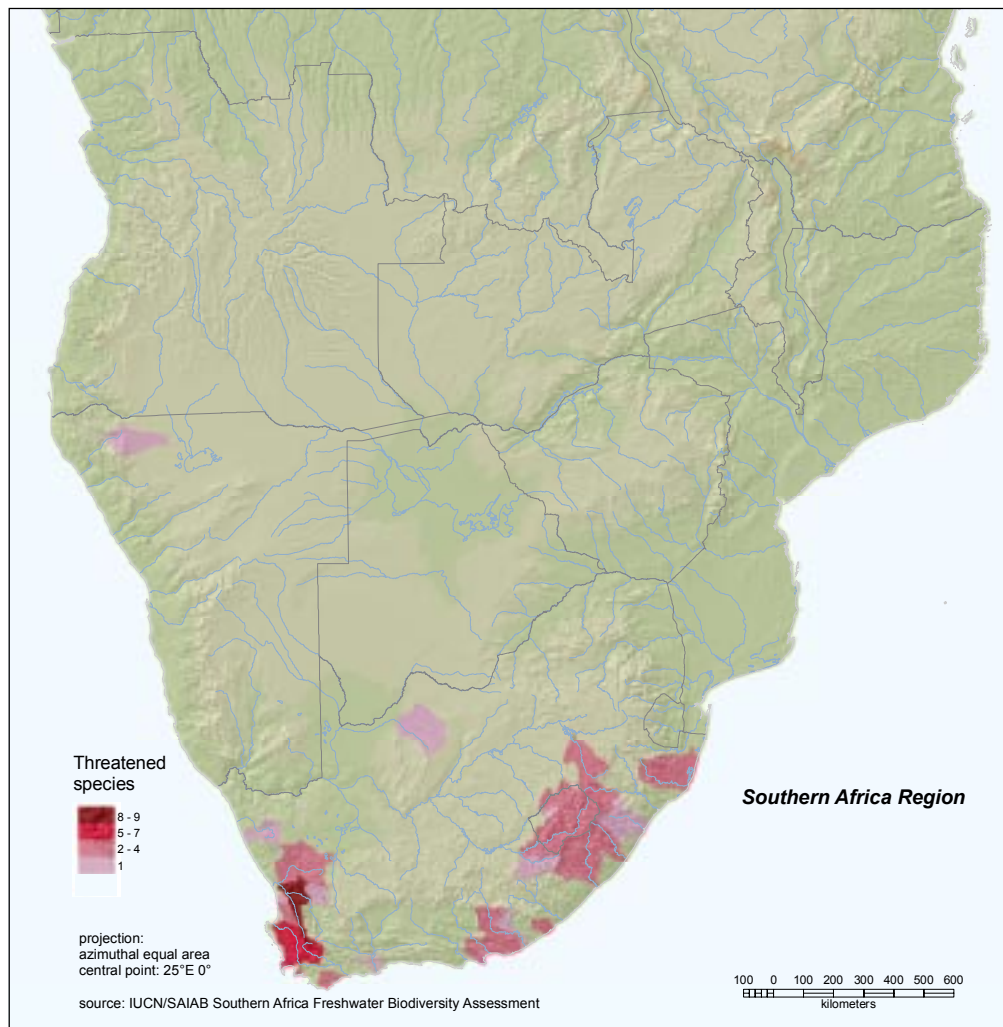


Figure 7.6 The distribution of southern Africa's regionally threatened wetland plant species based on known and inferred species' distributions mapped to river catchments. Analysis is based mainly on data sets for South Africa and Namibia.

commercial farmers are often more 'effective' in draining wetlands, large numbers of subsistence farmers can be a considerable threat, especially in an area like Maputaland. The areas most threatened by commercial agriculture are the Western Cape and the Bokkeveld Plateau.

7.1.4.2 Erosion/overgrazing

A common threat to South African wetlands is erosion and overgrazing, especially in those wetlands at close proximity to the Eastern Escarpment. If the vegetation is overgrazed the soil is no longer protected from high levels of water runoff and erosion gullies are formed. This loss of soil through erosion often leads to degradation of the wetland as the gullies allow faster drainage and less water is held in the wetland for prolonged periods. If erosion

gullies become very deep and cut through an entire wetland, that wetland may dry out completely.

7.4.1.3 Urbanization and pollution

Urban wetlands, such as the city of Cape Town, support many aquatic plants many of which may even be regional endemics. Pollution and eutrophication will have a detrimental effect on those wetland species. In cases of eutrophication the plant assemblage is likely to become simplified with only a few dominant species persisting in the nutrient rich environment. In many cases these species will be alien invading species. Indigenous weedy species, such as the duckweeds (*Lemna* spp.), may become dominant and cause shading with a resultant loss of species in the light-deprived lower water column.

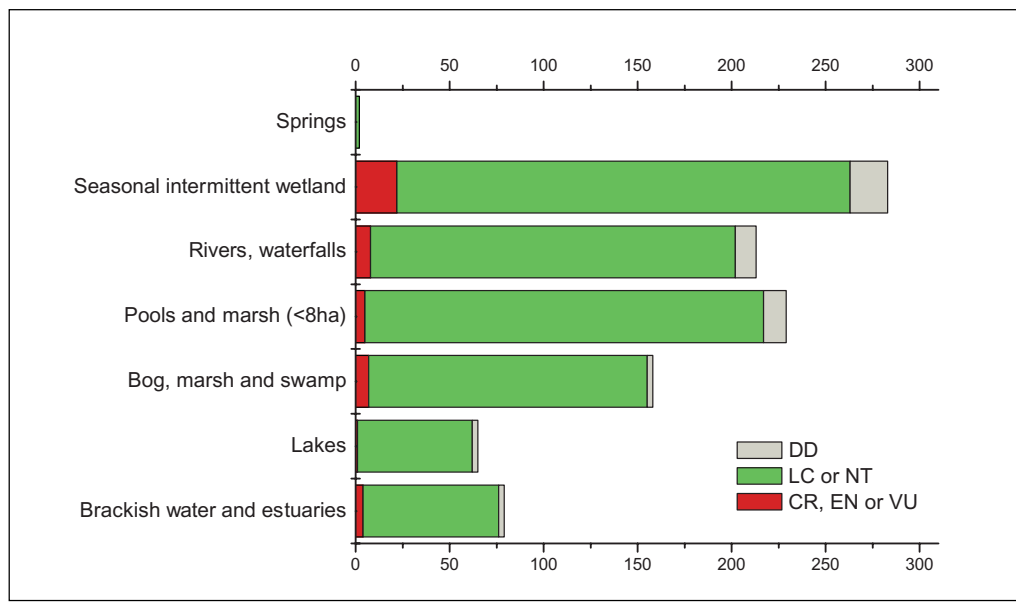


Figure 7.7 Proportion of species that are regionally threatened (CR, EN or VU); Least Concern (LC) or Near Threatened (NT); and Data Deficient (DD) for each habitat type. Species of estuaries and seasonal wetlands are over-represented among those assessed as threatened. Species from springs are under-represented within the list of species assessed and this habitat will probably contain many more threatened species.

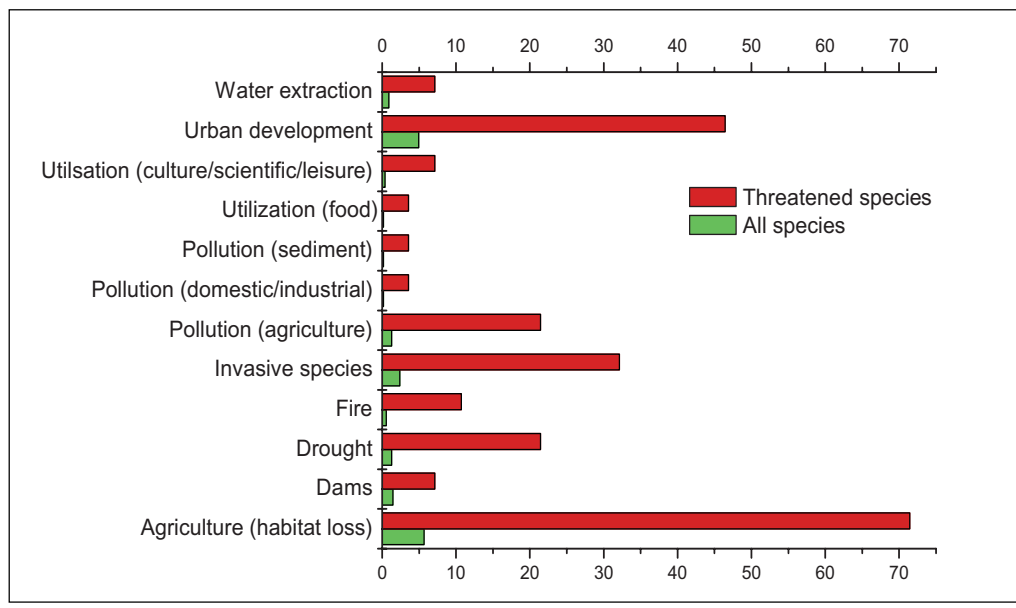


Figure 7.8 Percentages of species affected by each of the major threats identified. Note that many species have more than one major threat listed and others (especially those in the Least Concern Category) have no threats listed.

7.4.1.4 Damming of large rivers

Dams built on large rivers have a major impact on the hydrological and sediment regimes of the rivers and wetlands downstream. In modern dams an ecological flow regime is often established so that instream flow requirements for wetlands and riverine ecosystems below the dam are maintained. This will however not necessarily alleviate alterations to downstream levels of sediment deposition in systems such as the Okavango where sedimentation patterns are crucial to the functioning to the wetland system. Impacts upstream from dams are also significant in that riverine habitats are converted to lacustrine environments which favour a different assemblage of aquatic plants.

7.4.1.5 Alien plants

Alien invasive plants pose a major threat to wetland species. Firstly, there are aquatic invaders such as *Eichhornia crassipes* (Mart.) Solms and *Salvinia molesta* Mitchell which can cover the entire water surface and shade the water column below impacting upon the entire aquatic ecosystem. These species may also impede boat travel and choke waterways. Secondly, alien tree species within a catchment may decrease runoff into the wetland because of their high levels of water uptake thus reducing the size of seasonal and permanent wetlands. Alien tree species that cause such problems include *Pinus* spp., or *Eucalyptus* spp., often growing in large plantations, or trees like *Acacia mearnsii* De Wiild. or *Populus canescens* Moench which line river margins.

7.4.1.6 Water extraction

Abstraction of water is already a serious threat to wetlands in southern Africa and this threat is likely to increase in the future as more water resources are needed to support the increasing population. Ecological flow requirements can be determined for river ecosystems so that rivers can be managed in such a way that they maintain flows sufficient for maintaining basic ecological functioning. At present, however, the flow requirements for wetlands cannot be easily calculated and data are rarely sufficient in systems being managed for human use of water. Water extraction will have an impact, particularly in floodplains, as the permanent and seasonal vegetation zones will be reduced in size.

7.4.2 Threats to specific ecoregions

7.4.2.1 Okavango Floodplains

The Okavango Delta is threatened by a proposal by the Namibian Government to build a dam at Popa Falls in the Caprivi Strip. This will have a significant impact on the Delta as the reduced sediment carrying capacity of the water will likely result in erosion of the islands within the delta and an increasing salinization of the system

(Rogers 1997; Ellery and Ellery 1997). In the long run this may have a negative impact on the entire Okavango River system. This region is also projected to suffer from climate change related effects including severe warming, drying and changes in seasonality of precipitation (Midgley *et al.* 2005) which will have a marked effect on wetland plants.

7.4.2.2 Cape Fold

Wetlands in the Western Cape suffer from a variety of threats including alien invasive species and urbanization. The Cape Flats contain many rare and endemic species threatened by habitat loss and degradation associated with ongoing urbanization. Wetlands in the mountainous areas are less at risk although severe water shortage in the immediate surroundings of Cape Town may lead to the pumping of groundwater from the Table Mountain Sandstone aquifer with unknown consequences for the mountain fynbos vegetation.

7.4.2.3 Maloti-Drakensberg Mountain System

The major threat to the Maloti-Drakensberg wetlands is erosion and overgrazing. Wetlands on the edge of the escarpment or in the foothills of the mountains are naturally vulnerable to erosion as stream flow is quite high and natural erosion is quite common. Reduction of vegetation through overgrazing will however accelerate this process and deep gullies 'dongas' are already a common sight in many areas around the Drakensberg Mountains. The peatlands on the top of the Drakensberg suffer similar problems from communal grazing in Lesotho (Backeus and Grab 1995).

7.4.2.4 Coastal KwaZulu-Natal/Maputaland

This is a densely populated area supporting a number of rare or endemic wetland plant species. The southern stretch of coastline, from Port Edward to Richards Bay, is mostly threatened by coastal development and urbanization, whereas the northern part is threatened by the large population of subsistence farmers who seek out the most fertile areas, mostly on peat soil. Locally, especially around Pondoland and Richard's Bay, there is also the threat of titanium mining in coastal dunes.

7.5 Conservation recommendations

Conservation measures are often habitat-specific but unfortunately the plant assemblages associated with each habitat type are in many cases still not well known. There are many lessons to be learned from current research into indicator species for habitat condition but most of this knowledge focuses on common wetland species, not rare and endemic ones. Given this lack of basic information, most of the conservation recommendations given here are quite general in nature with limited focus on specific habitat types or species. In the future it is hoped that the

scope for use of indicator species will broaden and lead to more specific recommendations.

7.5.1 Specific conservation measures

7.5.1.1 Alien tree/plant removal

Invasive alien trees should be removed from river courses where possible. Much work in this area is already being implemented through the South African Working for Water Programme. Invasive grasses and aquatic species can only be removed through targeted application of herbicides which may pose a high risk to non-target species – the benefits of such actions must therefore be weighed up carefully.

7.5.1.2 Protection against over-extraction of water

Most farmers value wetlands as water supplies but they will often modify these wetlands through building small dams to store the water in a more easily accessible location. Problems then arise on two fronts. The dams are often created on the edge of existing wetland areas leading to a degree of habitat degradation, and excessive pumping of groundwater to fill the dams, or to directly irrigate crops, will often lead to a lowering of the water table and subsequent drying out of wetland habitat. It is therefore recommended that water abstraction be regulated to ensure sufficient water remains to maintain wetland function.

7.5.1.3 Restoration of soil and vegetation in eroded wetlands

Many wetlands have erosion gullies through which water run-off is channelled. This often results in significant soil loss and in some cases the drying out of entire wetlands. The Working for Wetlands Programme was launched to tackle this issue in South Africa and many effective methodologies, such as blocking water channels to retain sediments, have been developed to deal with these problems (Breen *et al.* 2007). It is recommended that the lessons learned through this initiative be adopted more widely throughout the southern Africa region.

7.5.2 Research actions

7.5.2.1 Regional scale monitoring and survey

A network of long-term monitoring sites should be established to keep a close track on the status of wetland species throughout the region. No such programme dedicated to monitoring of wetland sites exists at present. Sites should be selected in those ecoregions that already have a good or moderately good database for long-term monitoring, such as the Cape Fold Mountains, the Drakensberg Mountains, the Okavango Delta and the Namib Coastal ecoregion. New sites should also be established in the poorly known countries following a period of intensive field survey as proposed below.

Angola: The vegetation and the wetlands in Angola have been poorly studied and Cook (2004) reports on only a few of the species occurring close to the Namibian border and expected to be present in the Kavango and Kunene River systems. The species of the coastal regions (Kwanza) and the montane areas are virtually unknown. Field survey is recommended for these areas.

Mozambique: Mozambique has been poorly surveyed when it comes to wetland plants even though a substantial number of wetlands are present in the area, especially the coastal lagoons in Maputaland, Gaza and Inhambane, and the Zambezi River Delta at Marromeu. The north of Mozambique has been virtually unsurveyed. Field survey is recommended for these areas.

Western Zambia: The Upper Zambezi is poorly surveyed but is known to be very rich in wetlands as the Zambezi forms large floodplains in this area. New surveys are recommended to determine the extent to which the wetland flora in this area matches that of the better-known Okavango Delta.

Eastern Zambia/Luangwa Valley: The eastern parts of Zambia contain many wetlands in the floodplains on the Lower Zambezi and the Luangwa Valley. Information on the flora of these wetlands is currently very limited. More field surveys are recommended.

Zimbabwe: Zimbabwe does not contain any extensive wetland areas, except on the Lower Zambezi, but the central plateau is expected to have a rich wetland flora, as in South Africa. The montane regions in the eastern parts of the country contain many endemics and among these there may be several wetland or riverine species. For this reason, Zimbabwe should also be a priority area for future surveys.

7.5.2.2 Species-based actions

Most species assessed as Data Deficient need directed research to clarify their taxonomic status and/or distribution ranges. Those families with large numbers of species listed as Data Deficient, the sedge family (Cyperaceae) in particular, are shown above in Figure 7.2. Sedges are inconspicuous plants often overlooked in surveys, in particular the rarer species. This is also the case for the quillworts (Isoetaceae). This current lack of spatial knowledge for many species poses a significant difficulty for conservation planning at the site scale. In many cases distributions are not well known, particularly in Angola, Zambia and Mozambique, and species typical of specialized habitats, such as sudd or peatlands, may be more scarce than generally assumed. Widespread species currently listed as Least Concern may yet prove to be complexes of species with more restricted ranges making them more vulnerable than previously thought. Research



A newly discovered subpopulation of *Oxalis natans* in a simple farm dam near Elim, Cape Agulhas. The species occurs together with *Crassula natans*, and *Tetraria* spp. The discovery of this new subpopulation may lead to a change in the species current status of Critically Endangered. Photo: © Erwin Sieben.

efforts should focus on completing the necessary taxonomic and field survey to enable more informed site level conservation planning for these species.

Finally, there are a small number of recommendations for additional work to update the Red List assessments for the following species:

***Aponogeton ranunculiflorus* Jacot Guill. and Marais**

This species is currently assessed as Endangered as it has a restricted range and a part of the population is reported to be threatened by ongoing habitat degradation. However, this species is only known to occur in rock pools and these habitats are thought to be safely conserved within a National Park. It needs to be confirmed as to whether this protection is effective and that there are indeed subpopulations outside the National Park which are still subject to ongoing habitat degradation.

***Cotula paludosa* Hilliard**

This species is currently listed as Least Concern. Field survey is required to confirm if the species is indeed widespread within its range as proposed, or if, as suspected, it is restricted to a small number of subpopulations in which case it may be more threatened than currently proposed.

***Lobelia limosa* (Adamson) E.Wimm.**

This species is currently listed as Data Deficient but may be Extinct. Further taxonomic study is required to confirm if it is synonymous with *L. angolensis* Engl. and Diels as suggested by Cook (2004) as this is in doubt. If it is found to be a true species it may be reassessed as Critically Endangered (Possibly Extinct).

***Pseudalthenia aschersoniana* (Graebn.) Hartog**

This species is currently listed as Endangered but it may be extinct. There are no records for the species since the 1960s. Targeted field survey of its known previous range should be a priority to help to confirm its status.

Oxalis natans

This species is currently assessed as Critically Endangered. However, a third subpopulation has recently been discovered near Elim such that the species may qualify to be downgraded to Endangered. The status of the new subpopulation needs to be established.

7.6 References

Alonso, L.E. and Nordin, L. (eds.) 2003. A Rapid Biological Assessment of the Aquatic Ecosystems of the Okavango Delta, Botswana: High Water Survey.

- Rapid Assessment Programs 27. Conservation International, Washington.
- Backeus, I. and Grab, S. 1995. Mires in Lesotho. *Gunneria* 20:243–250.
- Breen, C.M. and Begg, G.W. 1989. Conservation status of Southern African wetlands. In: Huntley, B.J. (ed.) *Biotic diversity in Southern Africa, concepts and conservation*. Oxford University Press, Cape Town.
- Breen, C.M., Dini, J. Mitchell, S. and Uys, M. 2007 (eds.). Wetland Management series. Wetland Research Programme: Wetland Rehabilitation (WRC Project No. K5/1408).
- Cook, C.D.K. 2004. *Aquatic and wetland plants of Southern Africa*. Backhuys, Leiden.
- Cowan, C.I. 1995. Wetlands of South Africa. Department of Environmental Affairs and Tourism, Government Report, Pretoria.
- Cronk, J.K. and Fennessy, M.S. 2001. *Wetland plants. Biology and Ecology*. Lewis publishers, London.
- Driver, A., Maze, K., Lombard, A.T., Nel, J., Rouget, M., Turpie, J.K., Cowling, R.M., Desmet, P., Goodman, P., Harris, J., Jonas, Z., Reyers, B., Sink, K. and Strauss, T. 2004. *South African National Spatial Biodiversity Assessment 2004: Summary Report*. Pretoria: South African National Biodiversity Institute, Pretoria.
- Driver, A., Maze, K., Rouget, M., Lombard, A.T., Nel, J., Turpie, J.K., Cowling, R.M., Desmet, P., Goodman, P., Harris, J., Jonas, Z., Reyers, B., Sink, K. and Strauss, T. 2005. National Spatial Biodiversity Assessment 2004: Priorities for Biodiversity Conservation in South Africa. *Strelitzia* 17. South African National Biodiversity Institute, Pretoria.
- Da Silva, M.C., Izidine, S. and Amude A.B. 2004. A preliminary checklist of the vascular plants of Mozambique. Southern African Botanical Diversity Network Report No. 30. SABONET, Pretoria.
- Ellenbroek, G.A. 1987. Ecology and productivity of an African wetland system: The Kafue Flats, Zambia. PhD Thesis, University of Utrecht.
- Ellery, K. and Ellery, W.N. 1997. *Plants of the Okavango Delta. A field guide*. Tsaro Publishers, Durban.
- Mapaura, A. and Timberlake, J. 2004. A checklist of Zimbabwean vascular plants. Southern African Botanical Diversity Network Report No. 33. SABONET, Pretoria.
- Midgley, G.F., Hughes, G.O., Thuiller, W., Drew, G. and Foden, W. 2005. Assessment of potential climate change impacts on Namibia's floristic diversity, ecosystem structure and function. Report prepared for the Namibian National Biodiversity Program Climate Change Research Group, SANBI, Cape Town.
- Mucina, L., Rutherford, M.C. and Powrie, L. 2006. Inland azonal vegetation. In: Mucina, L. and Rutherford, M.C. (eds.) *The vegetation of South Africa, Lesotho and Swaziland. Strelitzia* 19:616–657, Pretoria.
- Phiri, P.S.M. 2005. A checklist of Zambian vascular plants. Southern African Botanical Diversity Network Report No. 32. SABONET, Pretoria.
- Rogers, K.H. 1997. Freshwater wetlands. In: *Cowling, R.M., Richardson, D.M. and Pierce, S.M. (eds.) Vegetation of Southern Africa*, pp. 322–346. Cambridge University Press, Cambridge, UK.
- Thieme, M.L., Abell, R., Stiassny, M.L.J., Skelton, P., Lehner, B., Teugels, G.G., Dinerstein, E., Toham, A.K., Burgess, N.D. and Olson, D.M. 2005. *Freshwater ecoregions of Africa and Madagascar: a conservation assessment*. Island Press, Washington DC, USA.

Chapter 8. Regional synthesis for all taxa

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The combined data sets for freshwater fishes, molluscs, plants (selected taxa), crabs and odonates are analysed here to present a synthesis of the status and distribution of some key components of freshwater biodiversity throughout southern Africa. For some analyses we have included additional information on freshwater dependent mammals (as defined on the IUCN Red List), freshwater turtles, amphibians, and waterbirds for which regional data sets also exist. The objective is to provide outputs of use in conservation planning for wetlands ecosystems and wetland species at the regional, national, and site scales. The combined data sets also provide a regional-scale knowledge base to enable the integration of freshwater biodiversity considerations within environmental and development planning throughout the region.

8.1 Patterns of species richness

The southern Africa region supports a significant proportion of the world's species dependent upon freshwater wetland habitats (Table 8.1). Given that the region represents approximately 4% of total global land mass (excluding Antarctica), it is apparent that many groups, waterbirds and mammals in particular, are well represented within the region.

Of the 1,279 species assessed at the regional scale, just over 7% are regionally threatened (Table 8.2). When compared with the global level of threat to those

Table 8.1 Estimated numbers of extant inland water-dependent species by major taxonomic group.

Taxon	Number of described species	Number of species in southern Africa	% of global total found in southern Africa
Fish	>15,000	355	2%
Molluscs	>5,000	116	2%
Odonates	5,680	272	5%
Crabs	c.1,300	19	1%
Amphibians	3,908	221	6%
Mammals	c.135	13	10%
Waterbirds	868	221	25%
Turtles	250	15	6%

Data sources: Balian *et al.* (2008); with assistance from Wetlands International, and the IUCN Red List Unit; see also <http://www.globalamphibians.org>

taxonomic groups which have been comprehensively assessed (e.g. birds, 12% threatened; amphibians 32% threatened; mammals, 23% threatened) (Baillie *et al.* 2004), this figure appears relatively low. This relatively low level of threat is most likely a reflection of the current low level of development throughout the region. The exception is South Africa where development has been more extensive and this is reflected in the higher numbers of threatened species in the country (see Figure 8.2). With extensive plans for the development of southern Africa's water resources over the next few decades, however, the

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situation could change dramatically unless impacts to freshwater species are considered during the development planning phases for these projects.

A comparison was made with the eastern Africa region, which is an area very rich in freshwater dependent species (Darwall *et al.* 2005) with very high levels of endemism. The level of threat in eastern Africa is significantly higher than that observed in southern Africa for most of the main taxonomic groups. This was largely attributed to alien invasive species impacting on the many range restricted endemic fish species of the large lakes, and higher levels of wetland degradation than are currently seen in southern Africa (Darwall *et al.* 2005). This situation could be repeated across southern Africa unless the current spread of introduced alien invasive species is controlled and water resources are developed with the benefit and appropriate application of information on the distribution of freshwater species and their ecological requirements.

Many of the southern Africa species are also endemic to the region so their regional Red List assessments are equivalent to global assessments and so also represent

the risk of global extinction for the species. Of the 531 regionally endemic species assessed here 87 species (16% of those assessed) are globally threatened (Table 8.3). This higher level of threat reflects both the higher risk of extinction for restricted range species and the higher concentration of restricted range species in South Africa where development threats are higher.

With the inclusion of Red List assessments for a number of additional taxonomic groups assessed through other initiatives, the number of species assessed for their global risk of extinction is 992 of which 121 species (12% of those assessed) are assessed as globally threatened (Table 8.3).

The Red List status of all species assessed here is listed in Appendix 1 on the accompanying CD-ROM for both the global and regional scales.

8.1.1 Centres of species richness

Species distribution maps for fishes, molluscs, odonates and the selected aquatic plants were overlaid to identify

Table 8.2 Summary of Red List Category classifications at the regional scale by taxonomic groupings.

Taxon	Total*	EX	RE	EW	CR	EN	VU	NT	LC	DD	NA
Fishes	355	0	0	0	12	19	9	9	235	71	0
Odonates	272	0	0	0	1	4	10	3	206	48	21
Molluscs	116	0	0	0	3	7	0	4	63	39	6
Crabs	19	0	0	0	0	0	1	0	15	3	0
Aquatic plants	517	0	0	0	8	4	15	5	450	40	29
Total	1,279	0	0	0	24	34	36	21	969	195	56

IUCN Red List Categories: EX - Extinct, RE - Regionally Extinct, EW - Extinct in the Wild, CR - Critically Endangered, EN - Endangered, VU - Vulnerable, NT - Near Threatened, LC - Least Concern, DD - Data Deficient, NA - Not applicable (e.g. vagrant species not normally resident in the region). * Excludes those species classified as Not Applicable (NA).

Table 8.3 Summary of Red List Category classifications at the global scale by taxonomic groupings.

Taxon	Total	EX	EW	CR	EN	VU	NT	LC	DD
Fishes	239	0	0	12	19	9	8	134	57
Odonates	64	0	0	1	4	10	2	29	18
Molluscs	56	0	0	3	3	0	2	15	33
Crabs	16	0	0	0	0	1	0	12	3
Aquatic Plants	156	0	0	7	4	14	3	105	23
Amphibians	221	0	0	5	13	11	4	160	28
Water Birds	221	0	0	0	0	2	6	213	0
Turtles	6	0	0	0	0	1	1	3	1
Mammals	13	0	0	0	0	2	0	11	0
Total	992	0	0	28	43	50	26	682	163

IUCN Red List Categories: EX - Extinct, EW - Extinct in the Wild, CR - Critically Endangered, EN - Endangered, VU - Vulnerable, NT - Near Threatened, LC - Least Concern, DD - Data Deficient, NA - Not applicable (e.g. vagrant species not normally resident in the region).

Additional data sources: Waterbirds - Wetlands International, Amphibians - IUCN. Global Amphibian Assessment (see: <http://www.globalamphibians.org>), Turtles - Peter Paul Van Dijk, Mammals - IUCN Global Mammal Assessment.

those river basins holding the highest richness of species across all four species groups combined. Crabs were not included in the analysis due to the relatively low number of species (19) found in the southern Africa region. Centres of overall species richness were identified as those sub-basins holding at least 20% of the total numbers of mapped species within each of the four taxonomic groups (Figure 8.1). Three river basins were identified as meeting this threshold for all four species groups. A small number of Data Deficient species were not able to be mapped and so could not be included in this analysis.

Area 1: The area of the Upper Zambezi at the confluence of the Upper Zambezi, Cuando and Chobe rivers above the Victoria Falls at the eastern end of the Caprivi Strip supports an estimated 81 species of fish (23% of the regional total), 89 species of odonate (32% of the regional total), 124 of the selected aquatic plants (24% of the regional total), and 23 mollusc species (20% of the regional total). This area is also important for a number of freshwater dependent mammals, and waterbirds.

The diverse fauna closely reflects the geological history of the region, as summarised by Moore *et al.* (2007).

Linked to the disruption of Gondwana, doming of the continent over major mantle plumes created elevated ground providing headwaters for a new post-Gondwana drainage system, in which the Okavango, Cuando and Upper Zambezi were major south-east-flowing tributaries of the Palaeo-Limpopo River system in the early Cretaceous. The Kafue at that stage was also an Upper Zambezi tributary, which itself had links with the Palaeo-Chambeshi, today part of the upper Congo system (Moore *et al.* 2007). These tributaries, including the Zambezi, then became an endorheic drainage system supplying sediment to an inland Kalahari Basin. The timing of capture of the Upper Zambezi by continued headward erosion of the Middle/Lower Zambezi is tentatively placed in the lower Pleistocene, when there was a complex drainage reorganization in the “Four Corners” area where Namibia, Botswana, Zimbabwe and Zambia meet. The Makgadikgadi Pans in northern Botswana are relics of a major lake, Lake Palaeo-Makgadikgadi (Thomas and Shaw 1991; Joyce *et al.* 2005). There is evidence of other lakes in the region, such as Lake Caprivi (Shaw and Thomas 1988; Moore *et al.* 2007), thus there was a complex history with evidence of the Upper Zambezi having been diverted at least twice (Moore *et al.* 2007). Uplift along the Linyanti fault diverted the Cuando River to the north-east towards the Upper

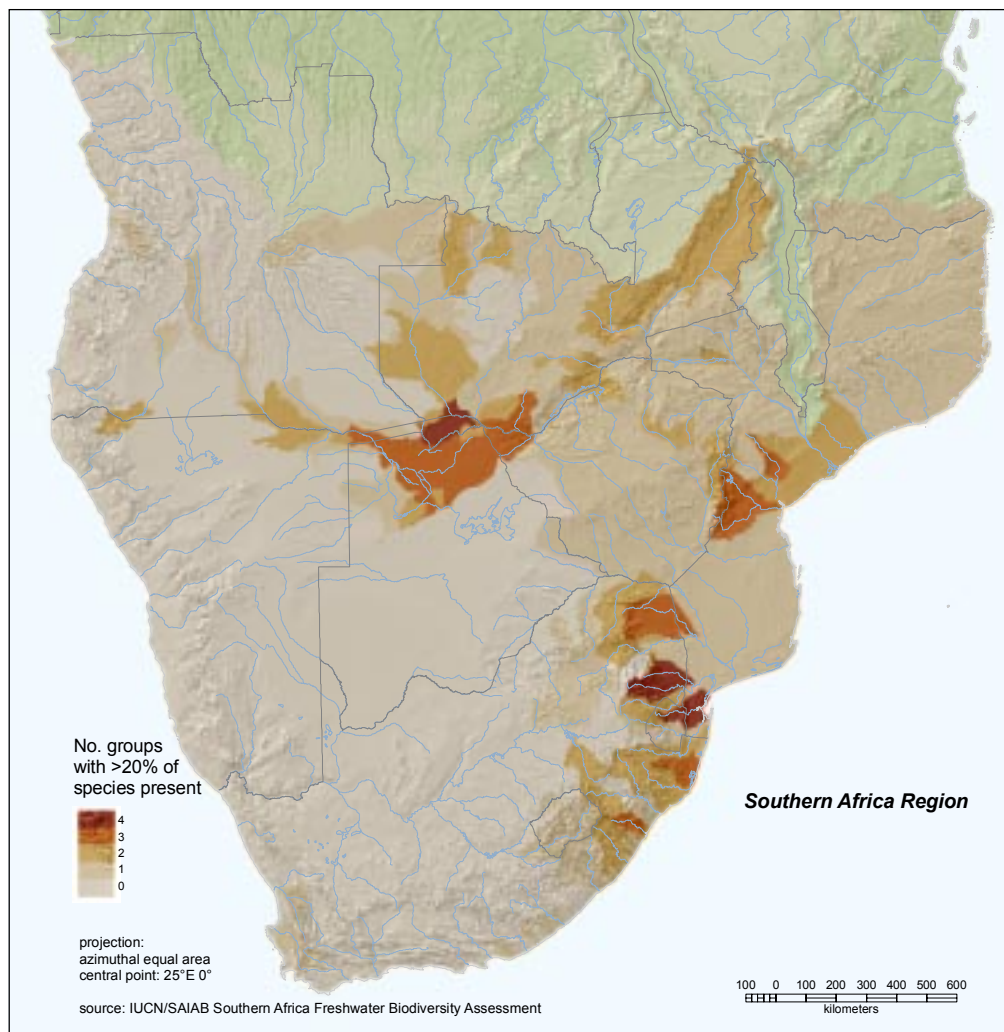


Figure 8.1 Distribution of river basins containing exceptionally high numbers of species from all taxonomic groups. The map represents those Hydro1K level 3 sub-basins holding at least 20% of the total species complement for each of the fishes, molluscs, odonates and plants.

Zambezi, and uplift of the Chobe fault led to the development of the Chobe floodplain. The Cuando River, draining off the Angolan highlands, enters Namibia as the Kwando and in wet years links up with the Chobe River in Botswana, which then joins the Zambezi. The terrain in this area is so flat that, depending on the relative height of the water in the Kwando and the Zambezi, the flow of the Chobe may reverse and, when the Zambezi is high, water is pushed back into the Chobe Marsh and into the ephemeral Lake Liambezi.

This area is therefore centred round the point where a number of major southward draining rivers joined in the past. The fauna reflects links between these rivers up to and including southern Congo tributaries. Wetlands were much more extensive in the past, and are likely to become smaller or more confined in the future, especially given the predictions of 15–20% lower rainfall in the region over the next 50 years owing to global climate change.

At present there are few major threats to the fauna in this area. The rivers upstream are in rural areas with little current disturbance. The Cuando River in Angola is lightly populated following the long civil war, while in Botswana rainfall is erratic and not conducive to intensive development. The Upper Zambezi itself is little impacted by human activities with the exception of locally intensive fishing in areas such as the Barotse Floodplain. In the Chobe area in general, wildlife-based tourism is the major industry and this has little impact on wetland biodiversity and health.

Area 2: Two adjacent sub-basins, the Komati and Crocodile, in the upper part of the Incomati River Basin in Mpumalanga, support an estimated 56 species of fish (16% of the regional total), 75 species of odonate (28% of the regional total), 202 of the selected aquatic plants (39% of the regional total), and 24 molluscs (21% of the regional total).

The Incomati River basin incorporates the Mpumalanga Province in South Africa, part of northern Swaziland, and a small part of southern Mozambique. The main river descends from the highland plateau in South Africa and Swaziland and flows through the coastal plains of Mozambique to the Indian Ocean. Dams with more than 2,060 Mm³ storage capacity have been built in the Incomati basin in South Africa and Swaziland, used primarily for irrigation. Two major dams, Driekoppies Dam in South Africa and the Maguga Dam in Swaziland, fall under the control of the Komati Basin Authority (KOBWA), which has responsibility for the Komati River Basin Development Plan.

As pointed out by Vaz and van der Zaag (2003) “Water use is intense, with 50% of the water generated in the basin being withdrawn. Water scarcity has been evident since the mid-1980s, and has become more severe in the last decade. Competition over water is real, and water abstractions are fast approaching the limits of sustainability. The effects of droughts, but also floods, become ever more pronounced.”

The Chobe River at the Namibia/Botswana border post at Ngoma, flowing strongly inland to the Chobe Floodplain as a result of the higher relative water level in the Zambezi River in full flood, April 2003. Photo: © SAIAB/Denis Tweddle.



The intensive use of the water of the Incomati system for irrigation has impacted on the health of the river system and the use of the river for intensive cultivation of water-hungry crops such as sugar-cane has resulted in criticism (e.g. Pottinger 2007). The recently-constructed Maguga Dam has no provision for fishways and is a total barrier to upstream movement of fish. The health of the river system as a whole is also threatened by extensive coal mining across the headwaters with resultant risk of pollution by acid mine waters.

Area 3: The adjacent Mbuluzi basin, also draining into Maputo Bay, supports an estimated 58 species of fish (16% of the regional total), 62 species of odonate (23% of the regional total), 91 species of the selected aquatic plants (18% of the regional total), and 27 species of mollusc (23% of the regional total). The Mbuluzi River basin is the major source of water for agricultural activities, particularly for sugar estates supplied through Mnjoli dam, and for domestic rural and urban water supplies, including Swaziland's capital, Mbabane. Erosion and consequent siltation as a result of intensive agriculture is a problem throughout Swaziland, as highlighted by Bills *et al.* (2004).

8.1.2 Distribution of threatened species

The Olifants and Berg River systems, both in the Western Cape area, support the highest numbers of regionally threatened species (Figure 8.2).

The Olifants River system: The Olifants River basin located in the Western Cape on the west coast, north of the coastal city of Cape Town, supports 18 threatened species including seven fishes; nine plants and two odonates. The river is approximately 285 km long with a catchment area of 46,220 km². Agriculture comprised approximately 5% of the catchment land-cover of the Olifants system (South Africa Department of Environmental Affairs and Tourism, 2001).

The main threat to fishes is the introduction of invasive alien fishes. The introduction of Smallmouth Bass (*Micropterus dolomieu*) in the 1930s for angling purposes is regarded as a major threat, with predatory impacts also from Bluegill Sunfishes (*Lepomis macrochirus*) and Rainbow Trout (*Oncorhynchus mykiss*). *Tilapia sparrmanii* has also been introduced and is reported to

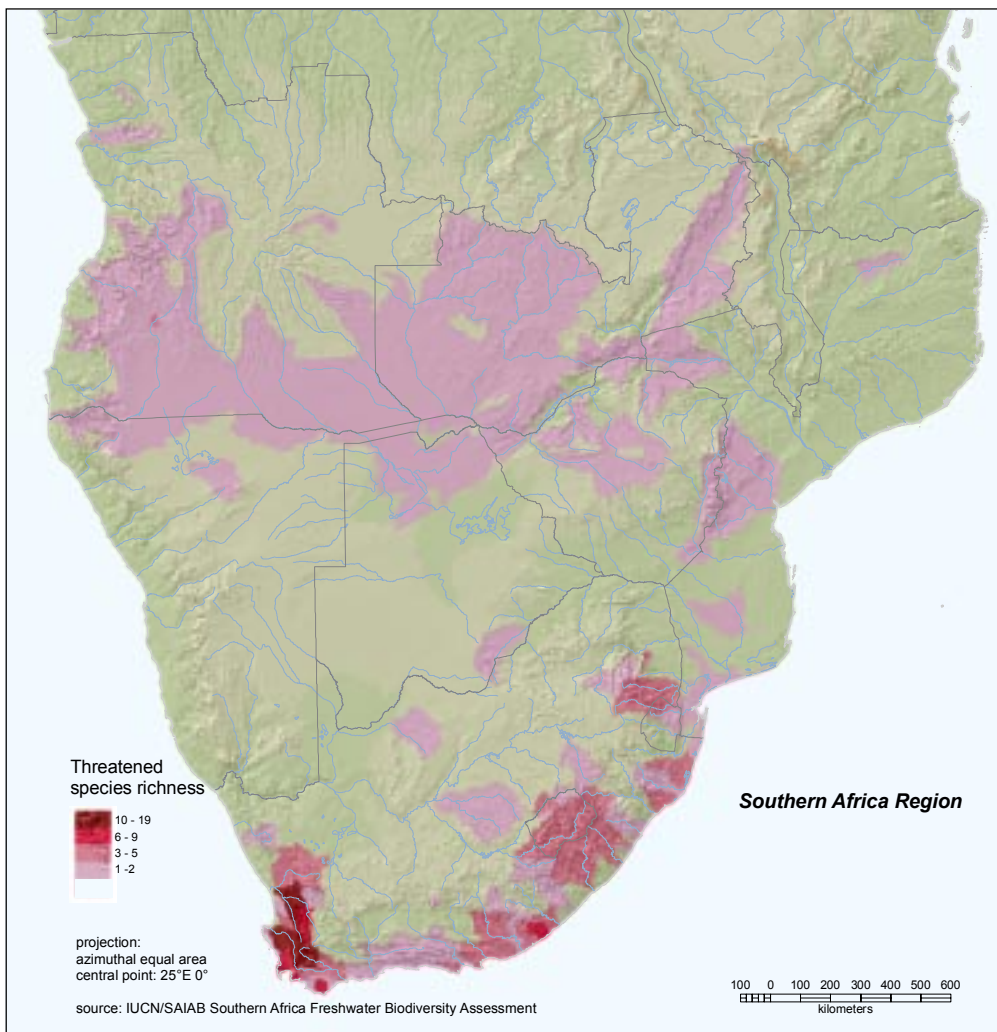


Figure 8.2 The distribution of regionally threatened species of fishes, molluscs, odonates, plants and crabs based on known and inferred species' distributions mapped to river catchments.

compete with native species for food. In another case, *Sandelia capensis*, a species widespread throughout the Western Cape, was introduced to the Olifants River System, where it is not native, via a local farmer in a misguided attempt to use an “indigenous” fish for mosquito control (Hamman *et al.* 1984). It is now common and widespread in the Suurvlei River where it competes with *Barbus erubescens*, a native species, for food and it possibly also predated on juveniles (Marriot 1998). In another case where a native species has been introduced to an area outside its normal range, *Labeobarbus capensis* has been introduced above three waterfall barriers into the upper and middle Twee River by the Cape Department of Nature Conservation in an attempt to create a sanctuary for an indigenous fish. It is thought that this has had a negative impact on populations of *B. erubescens* above the falls. As a final example, *Pseudobarbus phlegethon* has gone extinct in the Jan Dissels River, a major tributary of the Olifants River, and is no longer found in mainstream areas where it probably occurred before the introduction of alien fishes.

Habitat degradation is another substantial threat to fishes as the Olifants catchment and some tributaries are the focus for intensive citrus, deciduous fruit and vineyard development. The major problem is over-abstraction of water during the dry summer months and the planting of orchards within the 1:1 yr floodline of the river. The absence of a natural riparian zone, and hence buffer area between the river and intensive agriculture, allows fertilizers and copper-based pesticides easy access to the aquatic environment. Two large instream dams (Clanwilliam and Bulshoek) act as barriers to fish migration, and rivers are over-abstracted to fill hundreds of smaller farm dams. Instream dams prevent adults of migrating *Labeo seeberi* from reaching spawning grounds. The lower reaches of many tributaries have been bulldozed and canalized for flood protection purposes. The excess use of fertilizers and pesticides (many copper based) also poses a substantial threat to indigenous fishes (Bills 1999).

The main threats to plants include the drying up of wetland areas, such as small ponds, marshlands and temporary pools, in association with urbanization. For example, four of the 12 recorded locations of *Aponogeton angustifrons* have been lost due to urbanization of Cape Town and Stellenbosch over the past 120 years. These wetland areas are also suffering from increased ploughing for conversion to agriculture, in particular for wheat. This is a major past and future threat to *Romulea aquatica* which lives in vernal pools completely surrounded by wheat fields. The farmers are largely unaware of the biodiversity within the pools that are being degraded by conversion, by infilling, and through trampling by large numbers of stock (J. Manning pers. comm.). In the case of *Moraea stagnalis* the main threat is from land

conversion for production of Rooibos tea. *Oxalis uliginosa* is a restricted range plant species threatened by loss of habitat through dam construction where the habitat is completely lost when areas are inundated. As in the case of fish, there is a significant threat to many restricted range species from invasive alien species.

Dragonflies are also suffering due to over-extraction of water leading to loss of habitat. The streams in the Ceres area (where *Metacnemis angustata* was recorded in 1920) have been radically transformed and some no longer flow at all due to over-extraction of water for the fruit industry. Other threats come from shading of the habitat by alien invasive trees, such as *Acacia* spp., and loss of habitat through damming of streams. Alien fishes, especially rainbow trout, may also be a threat due to their predation of dragonfly larvae.

The Berg River system: The Berg River system is on the west coast of the Western Cape, north of Cape Town. The river is approximately 294 km long with a catchment area of 7,715 km². The Berg River basin has the next highest number of threatened species with a total of 11 species recorded including two fish, two odonates, and seven plants. Approximately 65% of the Berg catchment is under agriculture, mostly temporary commercial dryland agriculture, permanent commercial irrigated agriculture, and commercial forestry (South Africa Department of Environmental Affairs and Tourism 2001).

The main threats to the two threatened fish species, *Barbus andrewi* and *Pseudobarbus burgi* are once again invasive alien fishes and habitat degradation, with experts agreeing that the predatory impacts of smallmouth bass (*Micropterus dolomieu*) are the most significant factor driving *B. andrewi* to local extirpation from the Berg. Bass (*Micropterus* spp.) dominate preferred *Barbus andrewi* habitat and have effectively halted their recruitment. Over-abstraction of water and pollution have largely reduced the river catchment to a haven for other alien fish species such as *Cyprinus carpio* and *Oreochromis mossambicus* both of which are competitors to *Barbus andrewi*. The main threat to *Pseudobarbus burgi*, endemic to the Berg River system, is *Micropterus dolomieu* which has reduced the species to isolated populations in upper reaches of tributary streams. The Rainbow trout (*Oncorhynchus mykiss*) has a further impact higher up in some of the tributary streams where they are able to survive due to colder temperatures. The relatively recent introductions of another alien species, *Clarias gariepinus*, will need to be monitored for their potential impact.

As in the Olifants, the main threats to the two threatened odonates, *Ecchlorolestes peringueyi* and *Ceratogomphus triceraticus* include alien invasive trees (pines and *Acacia longifolia*) which shade the habitat and alien invasive

rainbow trout which are thought to predate on the larvae. The former threat of habitat removal (mostly for plantation forestry) has largely subsided although *C. triceraticus* is still threatened by loss of habitat to the wine industry and, to a lesser extent, cattle farming and plantation forestry. Over-extraction of water from streams and possibly pollution from the wine industry are increasing threats.

As in the Olifants system the main threats to plants include the drying up of wetland areas, such as small ponds, marshlands and temporary pools, in association with urbanization and increased ploughing for conversion to agriculture, in particular for wheat. This is again a major past and future threat to *Romulea aquatica* which lives in vernal pools completely surrounded by wheat fields. Livestock grazing and trampling, especially by cattle and horses, has likely led to the loss of *Cadiscus aquaticus* from many of its historic localities. Infilling of wetlands, mechanical damage by heavy machinery, and invasion by alien grasses caused by dumping of cattle feed in dry pools during summer are also significant threats. Eutrophication resulting from run-off of fertilizers used on surrounding ploughed lands is also a problem. One population of *Cotula vulgaris* is known to be under threat due to groundwater pumping.

Loss and degradation of habitat is the leading threat followed by water pollution and alien invasive species (Figure 8.3).

8.1.3 Distribution of restricted range species

Species with restricted ranges were defined as those regionally endemic species restricted to any level 3 river basin as defined in the Hydro1 K data layer. The average area of a level 3 basin is approximately 36,000 km².

Most restricted range species were found in South Africa within the eastern seaboard and Western Cape (Figure 8.4).

8.2 Important sites of freshwater biodiversity

8.2.1 Key Biodiversity Areas (KBAs)

Key Biodiversity Areas are sites of global significance for biodiversity conservation. They are identified using globally standard criteria and thresholds, based on the needs of biodiversity requiring safeguards at the site scale. These criteria are largely based on the framework of **vulnerability** and **irreplaceability** widely used in systematic conservation planning (Langhammer *et al.* 2007).

In the freshwater context we propose a KBA be defined as a river or lake basin which could practically be managed as a single site. The size of these basins may be highly varied and include small lakes, such as the tiny lake in Aigamas Cave where the Critically Endangered *Clarias cavernicola* is found, to large river catchments, such as the Rovuma River catchment, which holds a number of globally threatened and restricted range species.

The criteria and thresholds appropriate for freshwater systems are still being developed and evaluated. For the purposes of this study, a site meets the vulnerability criterion for KBA status if it holds one or more globally threatened species in either of the threat categories of Critically Endangered or Endangered, and individuals of three or more species in the Vulnerable Category, according to the IUCN Red List™. These species are

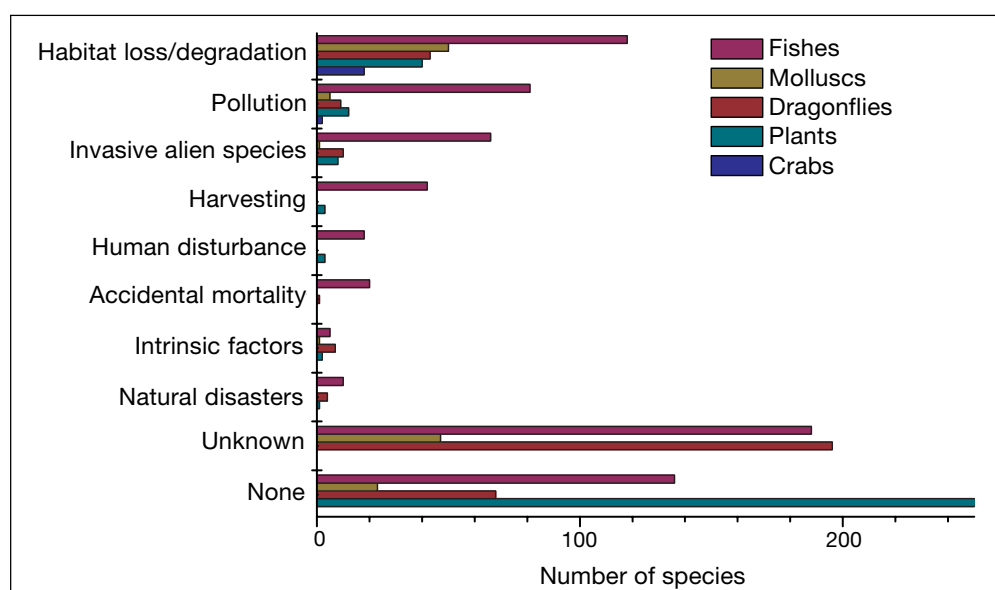


Figure 8.3 Major threats to freshwater species in southern Africa.

considered as facing an extremely high, very high, or high risk of extinction in the wild, respectively. A site meets the irreplaceability criterion for KBA status if it maintains a globally significant proportion of a species' total distribution range at some point in that species' lifecycle. This includes many species that have restricted ranges, highly clumped distributions within large ranges, congregate in large numbers, source populations on which significant proportions of the global population depend, or are restricted to particular biomes or bioregions. As data on species congregations are currently limited, in this study the irreplaceability criterion is largely based on species of restricted range. In this case, a species qualifies as having a restricted range if it is entirely confined within a single river/lake basin as defined under the level 3 delineation in Hydro1 K.

A KBA can be identified under the vulnerability and the irreplaceability criteria simultaneously; indeed many individual species trigger both the vulnerability and the irreplaceability criteria. A KBA network defined according to the presence of species meeting the criteria would be expected to include all sites that play a crucial role in maintaining the global population of these species.

This analysis is only based on those species endemic to the southern Africa region for which a global Red List assessment has been completed and for which the total distribution is mapped. It is possible some of the more widespread species, with distribution ranges extending beyond the southern Africa region, may later be assessed as globally threatened and could thus trigger additional basins to qualify as KBAs. However, given the wide ranging distributions of these species, it is thought unlikely they will be assessed as globally threatened.

Figure 8.5 shows all level 6 basins that hold any Critically Endangered or Endangered species, three or more Vulnerable species, or any restricted range (as defined above) species. A total of 246 "trigger" species met these criteria qualifying 540 level 6 sub-basins as candidate KBAs. These sub-basins may qualify as KBAs in their own right or as a combination of connected sub-basins, depending on local management options. For example, a single level 6 sub-basin, such as that associated with the Aigamas Cave in Namibia, might be defined as the appropriate local management unit for *Clarias cavernicola* and would therefore qualify as a KBA in its own right. More often, the most practical management unit will

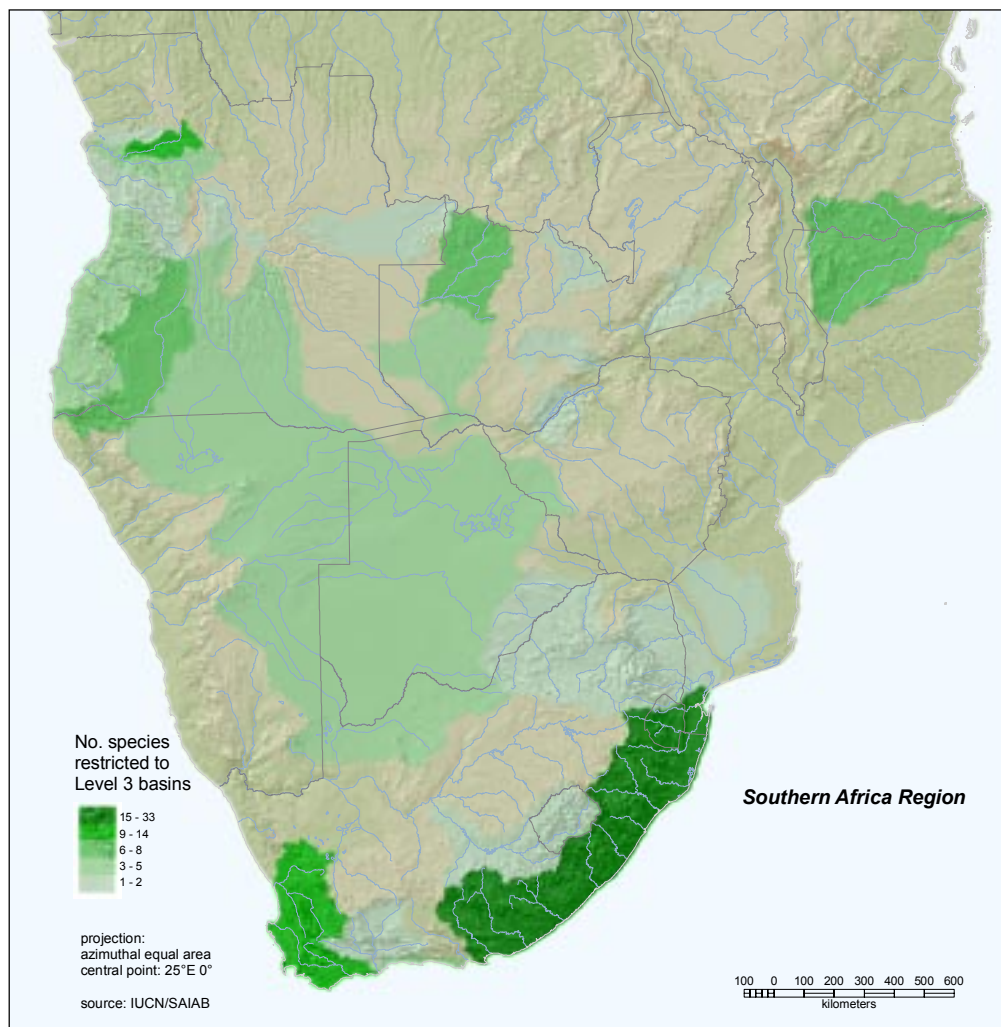


Figure 8.4 Richness of species restricted to single Hydro1K level 3 sub-basins. The map shows the numbers of species restricted to each of the level 3 river basins.

consist of an amalgamation of connected level 6 sub-basins, such as those making up the Rovuma River catchment. The spatial structure of each KBA will therefore be determined according to the combination of connected level 6 sub-basins which provides the most practical management unit and which each support trigger species.

Many of the KBA trigger species met the irreplaceability criterion of restricted range (Table 8.4). Of these, 61 are currently listed as Data Deficient and might yet be found, through additional field survey, to be more widespread. However, until we know otherwise, we should assume these species have restricted ranges and are of conservation concern. Fishes and plants had the greatest numbers of

species meeting the vulnerability criterion of Critically Endangered (CR) or Endangered (EN) status (Table 8.4). Fourteen sub-basins also contained three or more Vulnerable species but, in this case, all these sub-basins had already qualified as candidate KBAs through also containing CR, EN and/or restricted range species.

8.2.2 Alliance for Zero Extinctions – AZE sites

The Alliance for Zero Extinctions (AZE) is an initiative led by a group of biodiversity conservation organizations to identify and protect the last remaining habitats for the world’s most threatened species (see <http://www.zeroextinction.org>). AZE Sites are designated

Taxon	Number of KBA trigger species	Number of restricted range species	Number of Critically Endangered and Endangered species	Number of Vulnerable species (>3 spp. in a single basin)
Fishes	156	118 (47 under DD)	23 (CR); 39 (EN)	3
Odonates	16	11 (4 under DD)	1 (CR); 8 (EN)	6
Molluscs	18	12 (6 under DD)	4 (CR); 7 (EN)	0
Crabs	8	8 (3 under DD)	0	0
Plants	48	35 (1 under DD)	14 (CR); 8 (EN)	6

Table 8.4 Summary of the number of species qualifying as trigger species for KBA delineation under the different options of vulnerability (threatened species) and irreplaceability (restricted range species).

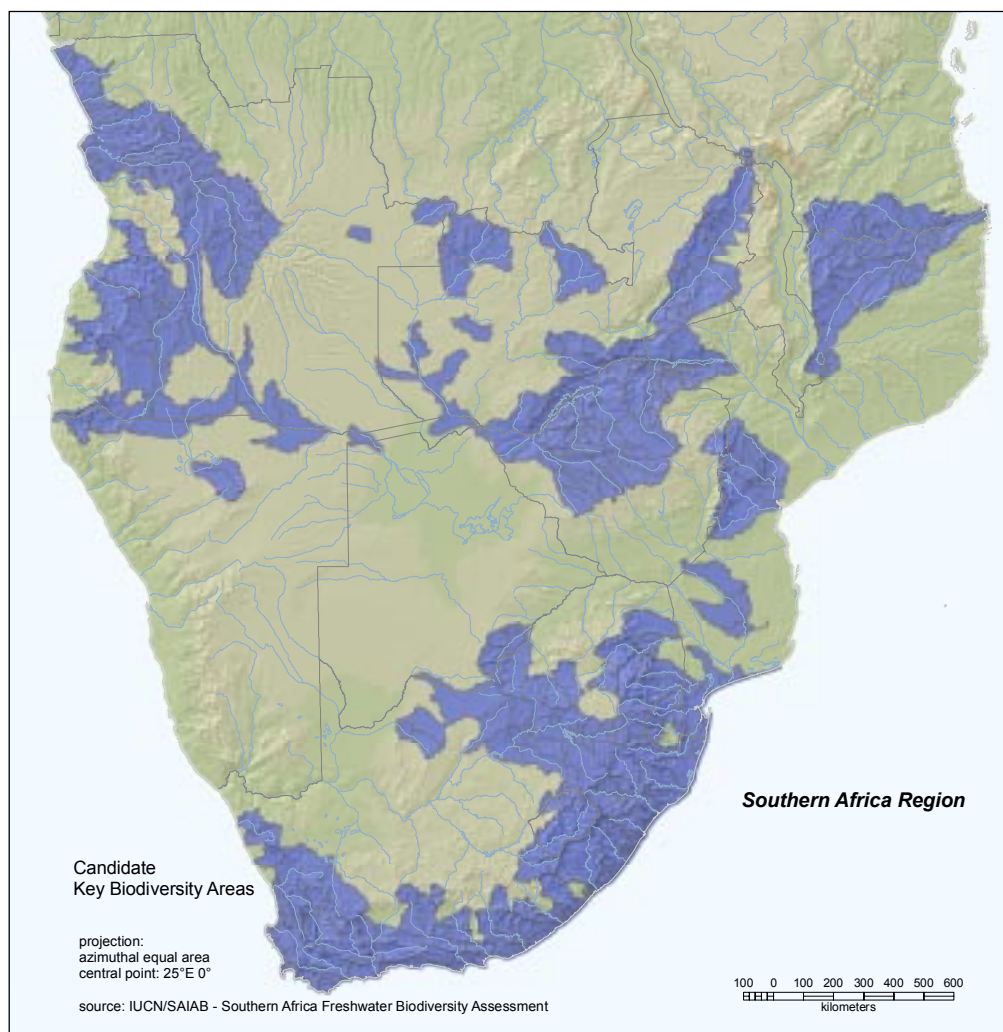


Figure 8.5 Candidate Key Biodiversity Areas (KBAs) defined as those Hydro1K level 6 sub-basins supporting individuals of Critically Endangered, Endangered and/or Vulnerable (three or more species) species, and/or species with total ranges restricted to a single Hydro1K level 3 sub-basin.

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 globally 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 where definable boundaries are relatively easy to identify. To date, sites have been identified for those taxonomic groups that have been globally assessed for threat level: mammals, birds, some reptiles (crocodilians, iguanas, turtles, and tortoises), amphibians, and conifers. 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 these cases we have taken the river or lake basin or sub-basin as the appropriate management unit and as the site. In a preliminary effort to address freshwater taxa 10 candidate AZE sites are

identified (Figure 8.6, Tables 8.5–8.8). An additional 10 fish taxa still being described will, if given full species status, also likely qualify for recommendation as candidate AZE sites - all are currently assessed as CR or EN and have very limited distributions.

These candidate AZE Sites will be put forward for consideration by the AZE Criteria Committee.

8.3 Protected areas for freshwater ecosystems

8.3.1 Design of protected areas for freshwater ecosystems

A recent study has shown that only 50% of the rivers in South Africa within protected areas are intact (Nel *et al.* 2007). Although this means that 50% of “protected rivers” are in a bad state it is also true that the state of those rivers outside protected areas is even worse with only 28% remaining intact. Their study also highlighted the importance of protection of tributaries for achieving river conservation, and the need for managing the main rivers as conduits across the landscape to support ecological

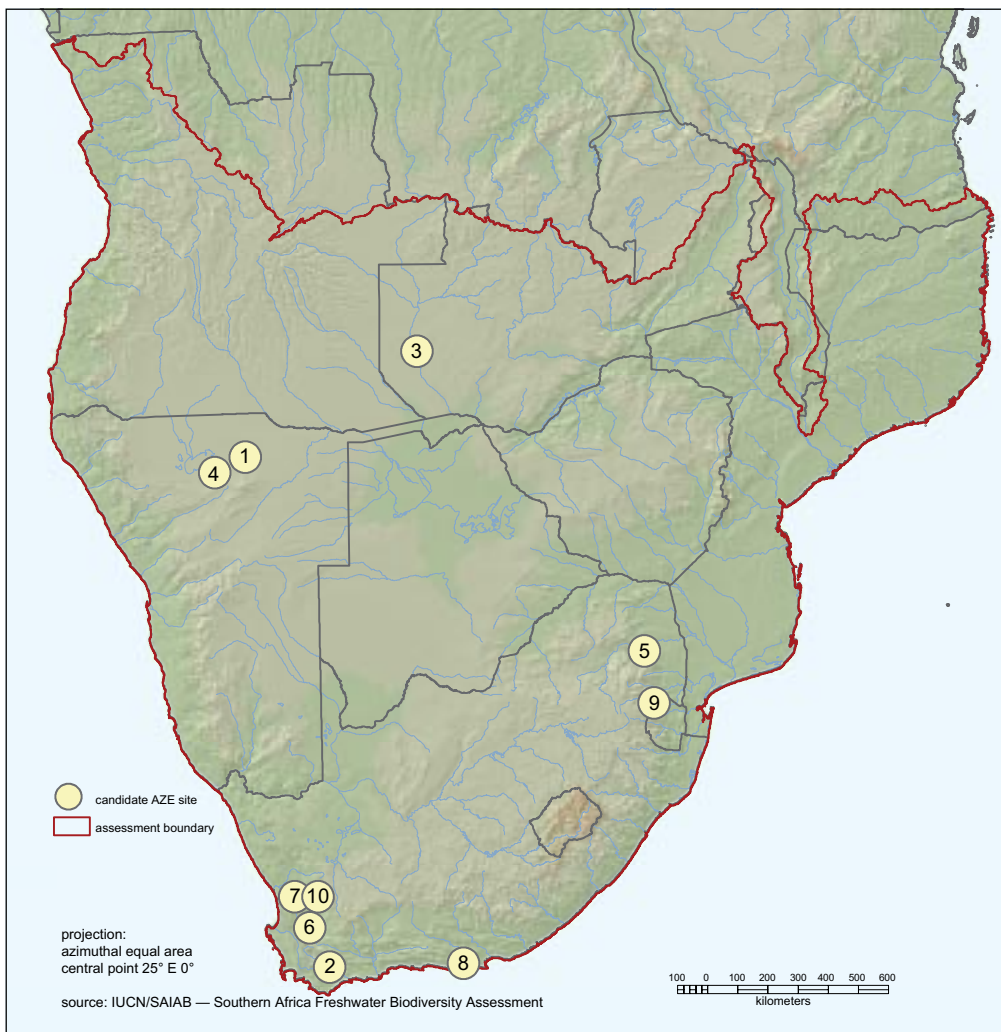


Figure 8.6 Candidate AZE sites. See Tables 8.5–8.8 for information on the species at each site.

Table 8.5 Candidate AZE sites for fish species endemic to the southern Africa region.

Site No.	Species	IUCN Global Red List Category	Location and threats
1	<i>Tilapia guinasana</i> Trewavas, 1936	Critically Endangered	Naturally occurs in a single location (Lake Guinas). Benign introductions have been made into Lake Otjikoto and other farm dams but these have no formal protection. Two major threats are ground water extraction and the introduction of alien fishes (primarily tilapiine cichlids).
2	<i>Pseudobarbus burcbelli</i> (Smith, 1841)	Critically Endangered	Restricted to the Tradou catchment of the Breede River system (Moeras River in Barrydale that continues into the Tradou River in Tradou's Pass). The main threat is from alien fish species which occur throughout most of the species' range
3	<i>Neolebias lozii</i> Winemiller and Kelso-Winemiller, 1993	Critically Endangered	Apparently restricted to the Kataba River and its tributary, the Sianda stream, a small tributary system of the Upper Zambezi, which it joins on the eastern side of the Barotse Floodplain. The main threats are river canalization, habitat degradation and water abstraction.
4	<i>Clarias cavernicola</i> Trewavas, 1936	Critically Endangered	Known only from the type locality: Aigamas Cave, Otavi, Namibia. The pool is 18 m by 2.5 m in area, and 30–52 m deep. The main threat is depletion of ground water; the cave lake has been used as a water supply in an otherwise very dry area.
5	<i>Barbus treurenensis</i> Groenewald, 1958	Endangered	The only remaining natural population is above a waterfall in the upper Blyde River. It has been reintroduced to the Treur River (part of its natural distribution). Alien fish predators are the major threat to this species, particularly small mouth bass (<i>Micropterus dolomieu</i>).
6	<i>Barbus erubescens</i> Skelton, 1974	Critically Endangered	Endemic to the Twee River and its tributaries, part of the Olifants River System in the Western Cape Province of South Africa. The greatest threat is from invasive alien fishes. Other significant threats include habitat degradation caused primarily by intensive farming of deciduous fruit and citrus and over-abstraction of water.
7	<i>Austroglanis barnardi</i> (Skelton, 1981)	Endangered	This species is endemic to three tributary streams in the Olifants system. The subpopulation in the Noordhoeks tributary has been established as the most important for conservation, since it has the best habitat and has the largest population. The main threats are alien invasive fishes and over-abstraction of water.

Table 8.6 Candidate AZE sites for mollusc species endemic to the southern Africa region.

Site No.	Species	IUCN Global Red List Category	Location and threats
8	<i>Tomichia tristis</i> (Morelet, 1889)	Critically Endangered	It is likely that the species only occurs at Aston Bay (Geoffreys Bay), on the southern Cape coastal strip west of Port Elizabeth, South Africa. There is a current and future threat to the species from residential and recreational development of the bay and estuary. However, more survey work is required as the species may occur in surrounding areas.

Table 8.7 Candidate AZE sites for odonate species endemic to the southern Africa region.

Site No.	Species	IUCN Global Red List Category	Location and threats
9	<i>Pseudagrion inopinatum</i> Balinsky, 1971	Endangered	The species is known from only a few specimens from two localities in eastern South Africa. Only one female of the species has been rediscovered since 1968, collected from near its type locality (Badplaas, Mpumalanga) in 2002. It is possible that livestock farming, damming of streams, invasive alien trees, and trout together may impact on this species, potentially aggravating its susceptibility to drought and flood.

Table 8.8 Candidate AZE sites for aquatic plant species endemic to the southern Africa region.

Site No.	Species	IUCN Global Red List Category	Location and threats
10	<i>Oxalis uliginosa</i> Schlechter, F.R.R.	Critically Endangered	The species only exists at one remaining extant locality (of at least four originally), Brandewyn River in South Africa, where it is experiencing a decline in habitat caused by heavy grazing and alien plants. The other localities were lost to dams and agricultural development.

processes that depend on the connectivity provided by rivers. This has obvious implications for the future sighting and design of protected areas.

The majority of protected areas (Figure 8.7), with the notable exception of Ramsar sites, are not designed for the protection of freshwater habitats and species – any such protection is often incidental. This is visually demonstrated with maps showing how well river catchment boundaries correspond with the boundaries of protected areas. In few cases do protected area boundaries follow catchment boundaries, more often the rivers themselves are used as protected area boundaries such that little if any protection is given to the river itself. For example, the Niassa Game Reserve (bordered by the Rovuma river in the north, Lugenda river in southeast, Luatize River in the southwest and Lussanhando River in the west) has been designed with no apparent focus on protection of the upper catchment and rivers are used as boundary markers for the reserve (Figure 8.8). In such cases any impact of activities on the river bank and catchment adjacent to the protected area, upstream activities, or impacts from downstream (for example from invasive alien species) are free to spread, rapidly in most cases, throughout the river systems and to any connected

lakes or swamps supposedly protected within the reserve. A protected area boundary will not stop the spread of threats such as pollution, invasive species, sedimentation, and altered flow regimes. Protected areas need to be designed specifically to protect upper catchments and to include entire river systems within their boundaries if they are to provide effective protection to the freshwater species within these systems.

8.3.2 Gap analysis – inclusion of freshwater species within the current protected areas network

The ranges of all Critically Endangered, Endangered and restricted range (as defined for this study) species were mapped against the existing protected areas network to evaluate their level of inclusion (Table 8.9). It should of course be remembered there will be a number a river basin management plans in place which are not officially recorded as National or International protected areas and are therefore not included in this analysis.

Species fully enclosed within protected areas: Only one fish species, *Paramormyrops jacksoni*, is fully enclosed with the boundaries of an existing protected area, in this case the Kameia National Park in Angola.

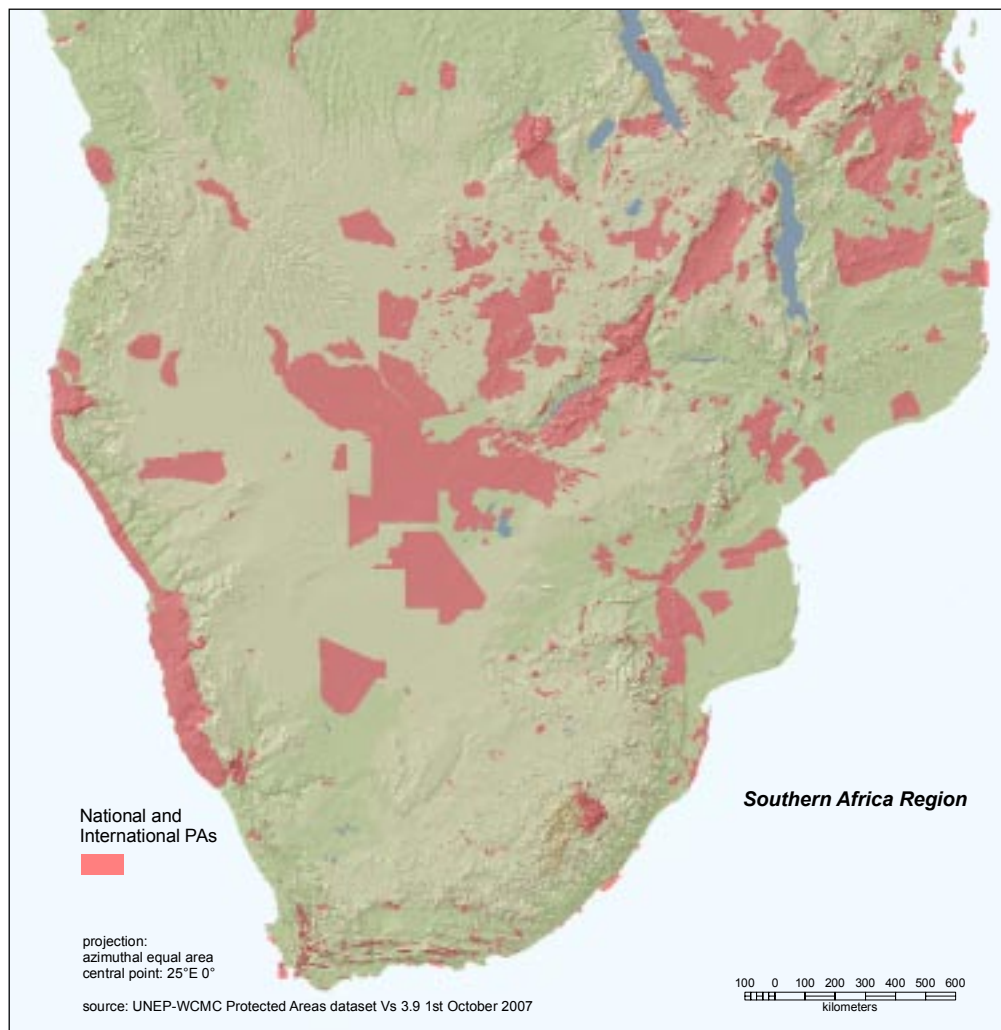


Figure 8.7 Location of all National and International protected areas as given in the UNEP-WCMC Protected Areas dataset Vs 3.9, 1 October 2007. Note: the larger Marine Protected Areas are not shown.

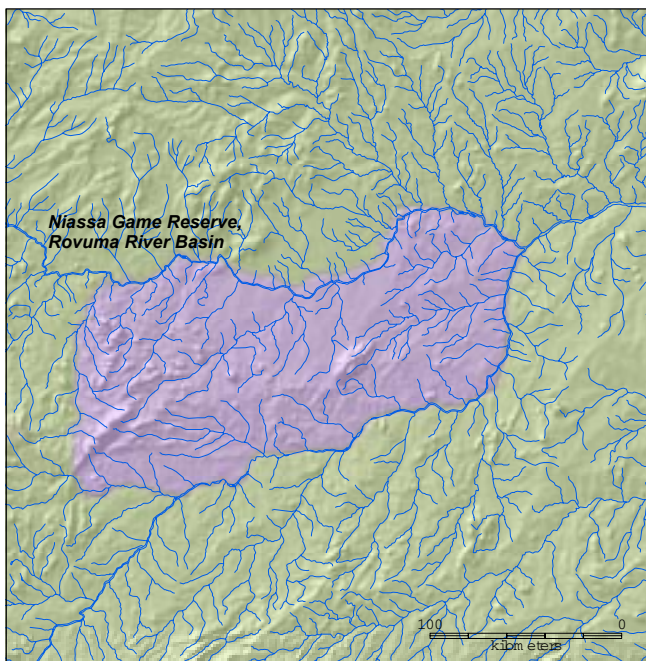


Figure 8.8 Niassa Game Reserve in the Rovuma river catchment, Mozambique, demonstrating the use of river channels as boundary markers for the protected area with no upper catchment protection.

Table 8.9 Levels of inclusion of all Critically Endangered, Endangered and restricted range species within the existing protected areas network in southern Africa. This analysis is based on assessments of fish, molluscs, odonates, crabs, and selected aquatic plants.

Species status	Number of species fully enclosed within a PA	Number of species not enclosed within a PA	Number of species with partial inclusion in a PA
CR	Nil	Nil	42
EN	Nil	Nil	61
Restricted range	1 (Data Deficient fish species)	34 (mainly Data Deficient fish species)	61 108
Total	1	34	211

PA = Protected Area, CR = Critically Endangered, EN = Endangered

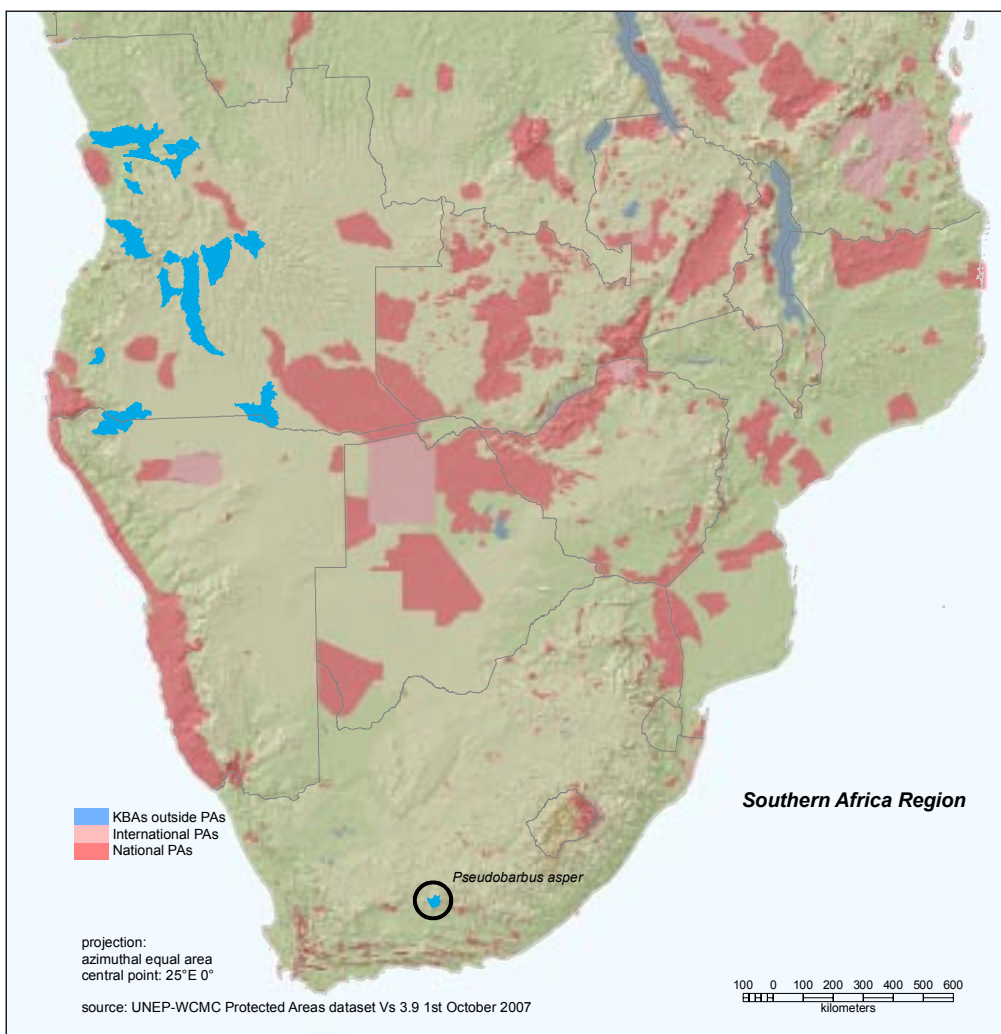


Figure 8.9 River basins that qualify as candidate Key Biodiversity Areas (shown in blue) that are not included within any of the international or national protected areas. The protected areas are mapped as extracted from the UNEP-WCMC Protected Areas dataset Vs 3.9, 1 October 2007. Notes: 1) the larger Marine Protected Areas are not shown; 2) in order to improve clarity the restricted location of *P. asper* is highlighted with a circle.

However, this species is Data Deficient and is only known from its type specimen with no survey conducted for several decades due to political instability in the area.

Species falling outside all protected areas: The known distributions of all those restricted range and threatened species which triggered selection of candidate Key Biodiversity Areas that do not currently fall within the boundaries of any protected area were identified (Figure 8.9). Thirty-four such species were identified, of which 31 are fish species, two are crabs and one is a mollusc. With the exception of one fish species, *Pseudobarbus asper*, which is restricted to the Gamtoos and Gourits River systems in South Africa (Figure 8.10), all species are in, or on the border with, Angola. Twenty-six of these species are Data Deficient and thought to have restricted ranges. A further seven species are assessed as Least Concern and also qualified as restricted range species. Given that survey intensity in Angola is particularly low it is possible that many of these species may have wider ranges than currently mapped. Until the true ranges can be confirmed, based on the available evidence, it is assumed that none of these species have any protection within the existing protected areas network. *Pseudobarbus asper* is the only threatened species, currently assessed as Endangered on account of the invasive alien fish species *Clarias gariepinus*, which has no part of its range within a protected area.

8.4 Congruence of species-richness patterns

Lack of time and funds to conduct biodiversity surveys raises the question of how well the species distributions of one taxonomic group can effectively represent the distribution of another group, or of overall biodiversity. In such cases it might then be possible to limit efforts to mapping a single taxonomic group and to base general freshwater biodiversity conservation plans on the distribution of species in that group alone, on the

understanding that other taxonomic groups with a high level of distribution congruence will also be conserved.

Preliminary analysis of the degree of congruence between patterns of species richness for different taxonomic groups within the 1,512 level 6 sub-basins in southern Africa (Table 8.10) found the strongest positive pairwise correlation between species richness patterns of amphibians and odonates ($r = 0.882$; $p < 0.001$), fishes and odonates ($r = 0.725$; $p < 0.01$) and amphibians and fishes ($r = 0.680$; $p < 0.001$). Not surprisingly, given the current limitation on available data for aquatic plants to South Africa, Namibia and Botswana, the correlation between aquatic plants and the other taxa was not strong.

The best indicator of overall biodiversity for the seven species groups analysed (*BD*) in the region was the fish ($r = 0.683$; $p < 0.001$). The second best indicator of *BD* was the amphibians ($r = 0.667$; $p < 0.001$), followed by the odonates ($r = 0.622$; $p < 0.001$). Again the crabs and plants were poor indicators of overall biodiversity. In the case of the plants this could be largely due to the incomplete and spatially skewed dataset for the region.

In conclusion, this preliminary analysis suggests that, for the seven species groups analysed, fish are the best indicator of overall biodiversity in terms of species richness patterns. This suggests that, in cases where it is not feasible to survey all taxonomic groups the survey of fishes might provide the best indication of overall biodiversity patterns throughout the region. A more detailed analysis of species distribution patterns across the whole of Africa will be completed shortly.

8.5 Conservation priorities for the region

8.5.1 South Africa

In the southern African region, the freshwaters of South Africa are most impacted by human activities and thus

Table 8.10 Results of pairwise correlations (Pearson correlation coefficient) of the species richness of the seven groups of taxa across southern Africa in 1,512 river sub-basins.

	Amphibians	Crabs	Fish	Odonates	Molluscs	Plants	Turtles	<i>BD</i> ^a
Amphibians	1	0.017	0.680	0.882	0.642	-0.111	0.615	0.667
Crabs		1	0.113	0.101	-0.030	0.435	-0.019	0.267
Fishes			1	0.725	0.575	0.090	0.559	0.683
Odonates				1	0.597	-0.022	0.663	0.622
Molluscs					1	0.028	0.409	0.582
Plants						1	-0.136	0.001
Turtles							1	0.518

^a *BD* = Overall biodiversity calculated as the total number of species (for all seven groups combined) found in a sub-basin minus the number of species belonging to the group being compared.

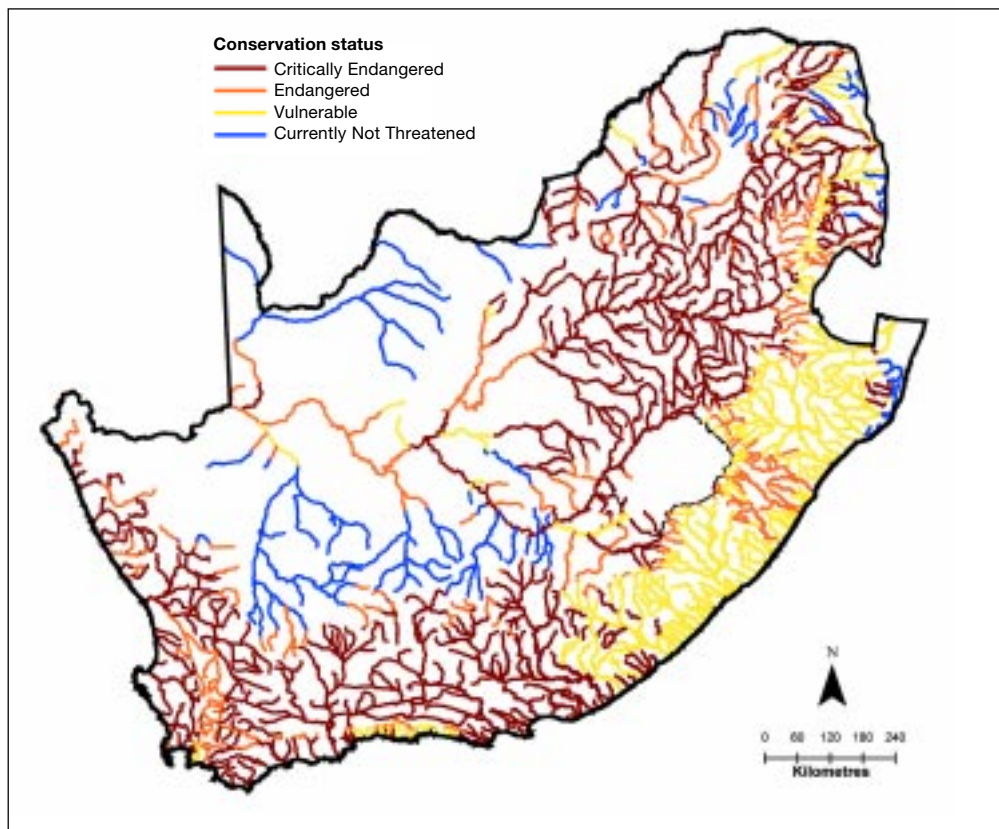


Figure 8.10 Conservation status of mainstem rivers in South Africa, reproduced with permission from Nel *et al.* (2004).

have flora and fauna most in need of conservation action. The species approach used in this biodiversity assessment may be compared with the river integrity approach followed by Nel *et al.* (2004, 2007) (Figure 8.10). Both approaches highlight the Critically Endangered status of the rivers of the Cederberg in the Cape Floristic Region (CFR), and also the rivers of Gauteng and Mpumulanga where human impacts are particularly concentrated. These studies confirm the need for conservation action in these areas, while Figure 8.10 also indicates many other areas where river health is in vulnerable and endangered categories.

Conservation of fishes in the CFR has been identified as of high priority and the responsible government conservation authority, Cape Nature, has initiated a pilot project, currently (August 2008) in the Environmental Impact Assessment phase, to eradicate alien invasive fishes from streams where fish species are threatened. If conducted in collaboration with the Working for Water alien tree removal programme to remove invasive riparian trees, it is envisaged that the project will also be of long-term benefit to the invertebrates, amphibians and aquatic plants in the affected streams.

Arising from the South African National Spatial Biodiversity Assessment report (Nel *et al.* 2004), South African conservation authorities have initiated a programme to identify National Freshwater Ecosystem Priority Areas (NFEPAs Project). The NFEPAs project draws extensively

on the red data assessments and mapping of this IUCN Red Data assessment project.

Throughout South Africa, wetlands are routinely drained for agriculture and streams and seeps are dammed for irrigation and livestock. The previous apartheid government provided grants to farmers for developments such as dams and thus excessive numbers dot the South African landscape to the detriment of river continuity and wetland integrity.

8.5.2 Other southern African countries

Conservation of freshwater fauna and flora has been and often still is of low priority in the other countries in the region. With the exception of fisheries management, which is itself limited by capacity constraints, particularly a shortage of trained and adequately funded personnel, little or no attention has been paid to conservation. As stated in Section 8.3 above, conservation areas were established primarily for terrestrial ecosystems and rivers routinely form the boundaries of such reserves instead of being integrated within the protected areas. Conservation efforts will need to place a much greater focus on design of protected areas and basin management plans that provide effective protection for freshwater species.

Although the overall picture for the region is that most freshwater species assessed are, with the exception of

those in South Africa, not greatly threatened at present, a number of sites have been proposed as AZE sites (see Section 8.2.2) where the species are at a very high risk of extinction – these sites should be prioritized for immediate conservation action if species loss is to be prevented. More generally, the major threat identified for the whole region is the impact of future development activities. In particular, the development of water resources for supply of drinking water, sanitation, hydropower, and water abstraction for agriculture will have a major impact on freshwater species unless due consideration is given to the needs of those species. The information compiled through this assessment provides the baseline which should be consulted to ensure these developments proceed in a manner which minimizes and mitigates for any adverse impacts.

8.6 References

- Baillie, J.E.M., Hilton-Taylor, C. and Stuart, S.N. (eds.) 2004. *2004 IUCN Red List of Threatened Species. A Global Species Assessment*. IUCN Gland, Switzerland and Cambridge, UK. xxiv + 191 pp.
- Balian, E.V., Segers, H., Lévêque, C. and Martens, K. 2008. The freshwater animal diversity assessment. *Hydrobiologia* **595**:1–637.
- Darwall, W., Smith, K. and Vié, J.-C. 2005. *The Status and Distribution of Freshwater Biodiversity in Eastern Africa*. IUCN, Gland, Switzerland and Cambridge, UK.
- Hamman, R.C.D., Thome, S.C. and Skelton, P.H. 1984. The discovery of the Cape kurper, *Sandelia capensis* (Cuvier in C and V, 1831) in the Olifants River system (Western Cape Province). *The Naturalist* **28(1)**:24–26.
- Joyce, D.A., Lunt, D.H., Bills, R., Turner, G.F., Katongo, C., Duftner, N., Sturmbauer, C. and Seehausen, O. 2005. An extant cichlid fish radiation emerged in an extinct Pleistocene lake. *Nature* **435**:93–95.
- Langhammer, P.F., Bakarr, M.I., Bennun, L.A., Brooks, T.M., Clay, R.P., Darwall, W., De Silva, N., Edgar, G., Eken, G., Fishpool, L., Fonseca, G.A.B. da, Foster, M., Knox, D.H., Matiku, P., Radford, E.A., Rodrigues, A.S.L., Salaman, P., Sechrest, W. and Tordoff, A. 2007. *Identification and Gap Analysis of Key Biodiversity Areas as Targets for Comprehensive Protected Area Systems*. IUCN, Gland, Switzerland.
- Moore, A.E., Cotterill, F.P.D., Main, M.P.L. and Williams, H.B. 2007. Chapter 15: The Zambezi River. In: A. Gupta (ed.), *Large Rivers*, pp.311–332. John Wiley and Sons, Ltd.
- Nel, J., Maree, G., Roux, D., Moolman, J., Kleynhans, N., Sieberbauer, M. and Driver, M. 2004. National Spatial Biodiversity Assessment, Technical Report, Volume 2: River Component. CSIR Report Number ENV-S-I-2004-063.
- Nel, J.L., Roux, D.J., Maree, G., Kleynhans, C.J., Moolman, J., Reyers, B., Rouget, M. and Cowling, R.M. 2007. Rivers in peril inside and outside protected areas: a systematic approach to conservation assessment of river ecosystems. *Diversity and Distributions* **13(3)**:341–352.
- Pottinger, L. 2007. Lowering the bar on big dams: making a case for WCD compliance on African Dams. International Rivers Network, July 2007.
- Shaw, P.A. and Thomas, D.S.G. 1988. Lake Caprivi: a late Quaternary link between the Zambezi and middle Kalahari drainage systems. *Zeitschr. Geomorphol.* **32**:329–337.
- South Africa Department of Environmental Affairs and Tourism, 2001. Downloaded from <http://www.environment.gov.za/> on 30 July 2008, last updated March 2001.
- Thomas, D.S.G. and Shaw, P.A. 1991. *The Kalahari Environment*. Cambridge University Press, Cambridge, UK.

Chapter 9. Conclusions and recommendations

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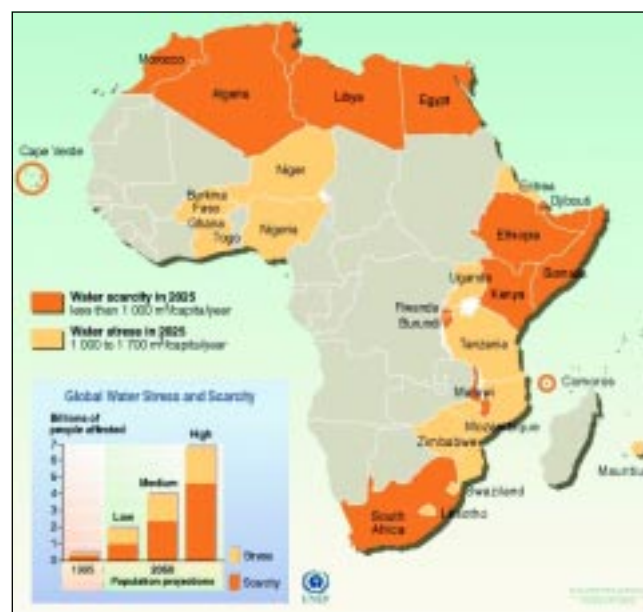
Southern Africa has been shown here to support a high diversity of freshwater species of which a significant proportion is threatened. The level of threat to the associated habitats is further demonstrated through an assessment of South Africa's rivers which found 82% threatened with 44% assessed as critically endangered (Driver *et al.* 2005). Without management intervention it is therefore expected that the overall status of southern Africa's freshwater biodiversity will worsen as development pressures on natural resources increase. Indications from other more developed parts of the world are that the impact on freshwater ecosystems and their associated biodiversity will increase as development proceeds. In the Mediterranean basin, for example, the level of threat to freshwater species is extremely high (e.g. 59% of endemic freshwater fishes are assessed as globally threatened or extinct (Smith and Darwall 2006)), mainly due to pressures induced by activities such as high levels of water extraction, pollution and alien species – all of which are associated with more developed countries.

As the southern Africa region moves forward and develops its water resources to improve access to potable drinking water and sanitation, and to provide greater production of food and power (hydropower), careful planning on the basis of reliable biodiversity information sets such as those provided here is essential if the impacts on freshwater biodiversity are to be minimized. Adequate account must be taken of the ecological requirements of freshwater species if we are to prevent their loss and the loss or degradation of the many benefits provided by wetland ecosystems. A major tool available for the protection of freshwater biodiversity is the Protected Area. However, it is clear that the current network of Protected Areas in southern Africa is in the large part not designed to target freshwater species such that any protection provided is largely incidental. The design of Protected Areas must

move forward to take account of the high degree of connectivity within freshwater ecosystems. In particular, upper catchment areas should be protected to minimize downstream impacts of activities such as deforestation or excessive water withdrawal. The flow of water in wetland systems must be maintained at sufficient levels and cycles to maintain ecosystem functions in wetlands. Levels of water stress are already high in many parts of the region as shown by the map of Freshwater stress and scarcity in Africa by 2025 (Figure 9.1).

Figure 9.1 Freshwater stress and scarcity in Africa by 2025. Downloadable from http://maps.grida.no/go/graphic/freshwater_stress_and_scarcity_in_africa_by_2025 (last visited 20 June 2008).

Source: United Nations Economic Commission for Africa (UNECA), Addis Ababa, Global Environment Outlook 2000 (GEO), UNEP, Earthscan, London, 1999, Population Action International.



¹ IUCN Species Programme, 219c Huntingdon Road, Cambridge CB3 0DL, UK.

A number of approaches for protective management of freshwater resources are now discussed.

9.1 Integrated River Basin Management (IRBM)

It is generally accepted that the appropriate management unit for freshwater ecosystems is the river or lake catchment. Within catchments, or basins, the principles of IRBM should be adopted. The basic principles of IRBM are explained, along with a number of example case studies, at: <http://www.gwptoolbox.org/>

In brief, IRBM is the process of integrating the work of conservation with other management actions focused on the development of water, land and related resources within a given river basin. It therefore requires communication, coordination and integration of actions across all related sectors. The aim is to maximize social benefits from the management, development and conservation of natural resources within the basin in a balanced way that also ensures the preservation and, where necessary, restoration of freshwater ecosystems. The setting up of River Basin Authorities, such as the Komati Basin Water Authority (KOBWA), a bi-national company formed in 1993 between the Kingdom of Swaziland and the Republic of South Africa, go a long way towards tackling these issues and are particularly important for bringing together the relevant management bodies from neighbouring countries in the cases of transboundary catchments. One of the key methodologies employed to ensure the use of water is managed in a way which provides for the continued functioning wetland ecosystems is through the provision of “Environmental Flows”. Environmental flow setting is conducted as part of the IRBM process.

9.2 Environmental flows

An environmental flow is “the water regime provided within a river, wetland or coastal zone to maintain ecosystems and their benefits where there are competing water uses and where flows are regulated. Environmental flows provide critical contributions to river health, economic development and poverty alleviation. They ensure the continued availability of the many benefits that healthy river and groundwater systems bring to society.” (Dyson *et al.* 2003).

In order to calculate an appropriate environmental flow, information is required on the water requirements of all potential stakeholders in the system and this includes the environment. For the ecosystem to remain functional it is necessary to understand the water flow requirements of

those freshwater species within the system. These species not only require a specific quantity and quality of water to flow but the timing of the flow cycle is also critical, for example, as a trigger for migration or spawning in some fish species. The biodiversity assessment conducted here aims to supply much of the species information required to initiate such a study of species flow requirements. The assessment provides baseline data sets of the species found within each catchment, and provides information on their basic ecological requirements and life histories. More detailed studies can then be focused on those species for which specific flow requirements are thought to be most critical.

9.3 Priority areas for conservation

Limitations on the available time and resources deny us the luxury of developing and implementing conservation actions for all water catchments throughout the southern Africa region. It is therefore useful to identify those areas where management intervention will provide the greatest rewards in terms of species conservation. The candidate Key Biodiversity Areas identified in Chapter 8 (Section 8.2) provide an excellent starting point for such conservation focus as they identify those catchments containing species most at risk from global extinction on account of their vulnerability (e.g. threatened species) and/or irreplaceability (restricted range species found nowhere else). We would recommend as a priority that those candidate Key Biodiversity Areas and AZE sites identified through this assessment serve as an initial focus for conservation actions at the catchment scale across the region.

9.4 Packaging outputs for decision-makers

One of the most challenging parts of the process is presentation of the biodiversity assessment outputs in a format which is suitable and accessible to the widest range of stakeholders. In particular, the outputs need to be accessible to natural resource managers, developers and policy makers. This requires production of a range of products including, brief summaries of the issues and recommendations (policy briefs), more detailed technical reports, and comprehensive data sets. This report will serve as the detailed technical report of the assessment findings, and the full database including all species distribution shape files is provided in the attached CD. Policy briefs will be forthcoming. All species global assessments and distribution maps (jpegs) will be directly accessible online through the IUCN website www.iucnredlist.org. Regional assessments will also be available online shortly. Ultimately, all species distribution shape files will be accessible online.

Identification of the primary end-users of this information is also a challenge given the multitude of different organization with overlapping and sometime contradictory jurisdiction for the management of wetland ecosystems. Preliminary efforts have been taken to identify these stakeholders through an online survey of end-user data needs but more work needs to be done in this area. The preliminary results can be found on: http://www.unep-wcmc.org/freshwater_biodiversity/Africa/survey/

9.5 Integration of biodiversity information within water resource development planning processes

Having identified the stakeholders and packaged the outputs as required a process has to be established for ensuring that the information provided is now given the appropriate level of consideration within the decision making processes for development and conservation actions. Four case study demonstration sites have been set up as part of this project to determine the best process for integrating biodiversity information within these planning processes. The results of these case studies will be made available in the form of documents on “Good

Practice” and “Lessons learned”. Descriptions of each case study are available from the project website (http://www.iucn.org/themes/ssc/our_work/freshwater/panafrican_sites.htm) and the results will be downloadable from December 2009.

9.6 Filling the information gaps

Many areas in the southern Africa region are still not well surveyed such that the available information on freshwater species is insufficient for environmental and development planning. The areas where information is lacking can be identified most easily through mapping the locations of all species assessed for the IUCN Red List as Data Deficient (DD) (Figure 9.2). From the information available on species ranges it is clear that the focus for future field survey should include the Upper Zambezi, Rovuma and much of Angola. The additional areas highlighted in South Africa primarily reflect a number of species complexes that need to be resolved taxonomically. It is proposed that new funding be sourced to take the project to the next stage of implementing a programme of new field surveys and taxonomic work to complete the baseline information set assembled through this project.

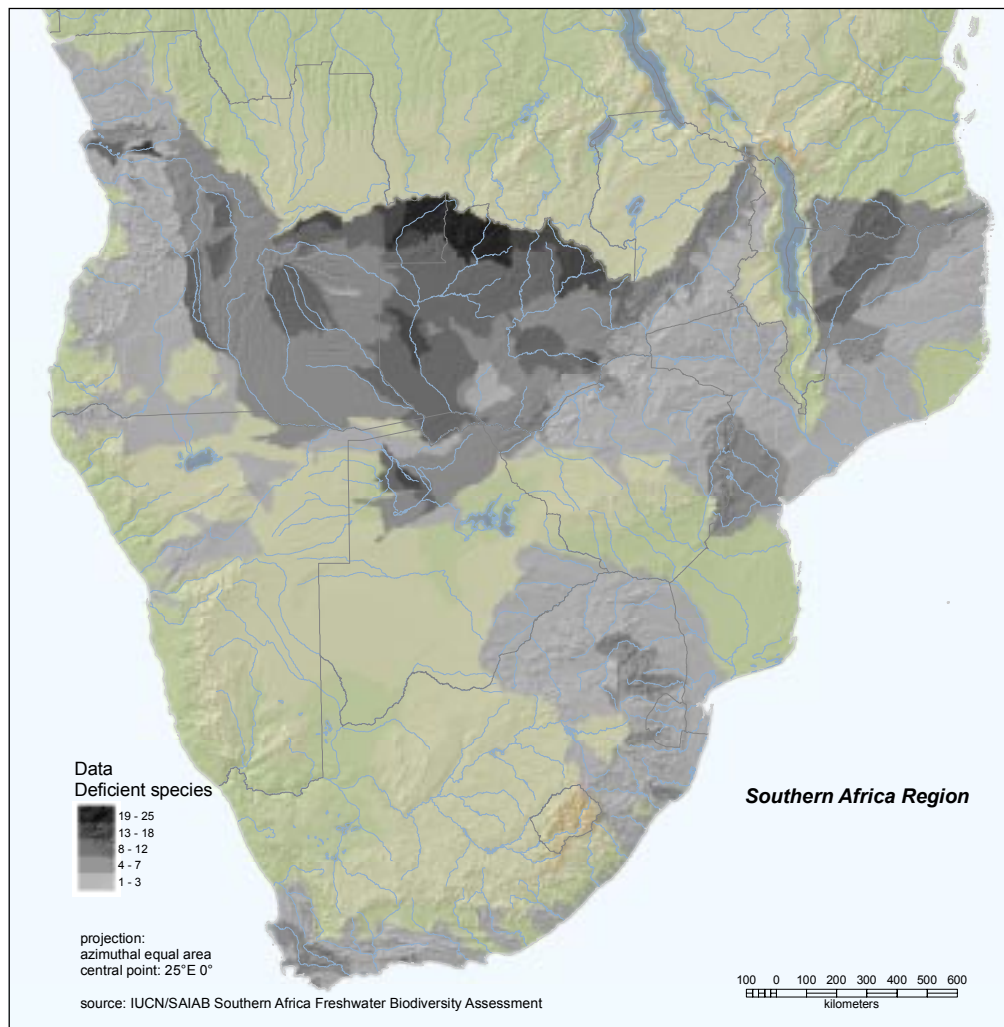


Figure 9.2 Distribution of all species classified as Data Deficient. The map of course fails to show those many species which could not be mapped due to lack of information on their distribution ranges.

In conclusion, we hope that the information provided through this assessment will be taken up by the key stakeholders in freshwater ecosystems throughout southern Africa and will be integrated in the decision making processes for environmental and development planning in wetland ecosystems. In this way we hope that the future impacts of development actions affecting wetland ecosystems can be minimized and mitigated to the benefit of freshwater species and those people who rely on freshwater species for their livelihoods and pleasure.

9.7 References

- Dyson, M., Bergkamp, G. and Scanlon, J. (eds). 2003. *Flow. The Essentials of Environmental Flows*. IUCN, Gland, Switzerland and Cambridge, UK. xiv+118pp.
- Driver, A., Maze, K., Rouget, M., Lombard, A.T., Nel, J., Turpie, J.K., Cowling, R.M., Desmet, P., Goodman, P., Harris, J., Jonas, Z., Reyers, B., Sink, K. and Strauss, T. 2005. National Spatial Biodiversity Assessment 2004: priorities for biodiversity conservation in South Africa. *Strelitzia* 17. South African National Biodiversity Institute, Pretoria.
- Smith, K.G. and Darwall, W.R.T. (Compilers) 2006. *The Status and Distribution of Freshwater Fish Endemic to the Mediterranean Basin*. IUCN, Gland, Switzerland and Cambridge, UK. v+34pp.

IUCN Red List of Threatened Species™ – Regional Assessments

The Status and Distribution of Freshwater Biodiversity in Eastern Africa. Compiled by William R.T. Darwall, Kevin G. Smith, Thomas Lowe, Jean-Christophe Vié, 2005

The Status and Distribution of Freshwater Fish Endemic to the Mediterranean Basin. Compiled by Kevin G. Smith and William R.T. Darwall, 2006

The Status and Distribution of Reptiles and Amphibians of the Mediterranean Basin. Compiled by Neil Cox, Janice Chanson and Simon Stuart, 2006

The Status and Distribution of European Mammals. Compiled by Helen J. Temple and Andrew Terry, 2007

Overview of the Cartilaginous Fishes (Chondrichthyans) in the Mediterranean Sea. Compiled by Rachel D. Cavanagh and Claudine Gibson, 2007

IUCN – The Species Survival Commission

The Species Survival Commission (SSC) is the largest of IUCN's six volunteer commissions with a global membership of 8,000 experts. SSC advises IUCN and its members on the wide range of technical and scientific aspects of species conservation and is dedicated to securing a future for biodiversity. SSC has significant input into the international agreements dealing with biodiversity conservation. Web: www.iucn.org/themes/ssc

IUCN – Species Programme

The IUCN Species Programme supports the activities of the IUCN Species Survival Commission and individual Specialist Groups, as well as implementing global species conservation initiatives. It is an integral part of the IUCN Secretariat and is managed from IUCN's international headquarters in Gland, Switzerland. The Species Programme includes a number of technical units covering Species Trade and Use, The IUCN Red List, Freshwater Biodiversity Assessment Initiative (all located in Cambridge, UK), and the Global Biodiversity Assessment Initiative (located in Washington DC, USA).



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