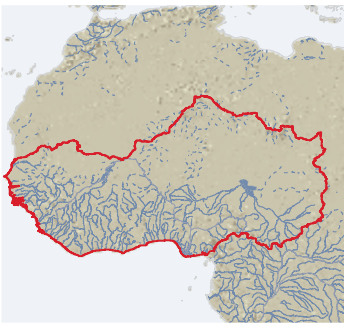
THE STATUS AND DISTRIBUTION OF FRESHWATER BIODIVERSITY IN WESTERN AFRICA

Smith, K.G., Diop, M.D., Niane, M. and Darwall, W.R.T.

WESTERN AFRICA



The IUCN Red List of Threatened Species™ – Regional Assessment

SSC Species Survival Commission

WETLANDS INTERNATIONAL

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Smith, K.G., Diop, M.D., Niane, M. and Darwall, W.R.T.

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Laying fishing nets in a river in Cameroon. Photo: © Kevin Smith

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Executive Summary

Biodiversity within inland water ecosystems in western Africa is both highly diverse and of great regional importance to livelihoods and economies. However, western Africa is currently undergoing huge levels of development, with a population which is projected to double by 2050 to over 600 million people. 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 Wetlands International, conducted a regional assessment of the status and distribution of 1,395 taxa of freshwater fishes, molluscs, odonates, crabs, and selected families of aquatic plants from across western Africa. In the process of the study, which is based on the collation and analysis of existing information, regional experts from eight 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).

Five areas have been identified as key centres of species diversity: i) the southern coastal area of Guinea; ii) the lower river Jong in Sierra Leone; iii) Ebrié Lagoon in Côte d'Ivoire; iv) lower Ogun and Oueme rivers and their coastal lagoons in Benin, and; v) western Nigeria and the Niger Delta to the lower Cross river in southern Nigeria. The combined diversity of fishes, molluscs and odonates is exceptionally high in these areas. Levels of regional endemism are high, with over a third of the species assessed only found in western Africa. The majority of these endemic species are found within the coastal drainages of the Upper Guinea region from southern Guinea to Liberia and in the basins of western Ghana and eastern Côte d'Ivoire.

Around 14% of all species assessed are regionally threatened according to IUCN Red List Categories and Criteria. This level of threat is predicted to increase dramatically along with the growing levels of development and population, 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 current threats are identified as habitat loss and water pollution, in particular from sedimentation due to deforestation, agriculture, human settlements, mining, and oil. The majority of threatened species are found in the Niger Delta and south-east Nigeria, largely reflecting the greater levels of development and population density. The data set provided here provides a great opportunity for helping development to proceed while minimising or mitigating for impacts to freshwater biodiversity.

The key priorities identified include the need for immediate conservation actions in those areas containing high levels of threatened species. It is critically important that any conservation measures taken, including the designation of protected areas, need to take into consideration the high levels of connectivity within freshwater systems. Water resource management approaches that integrate economic, environmental, and social dimensions at a catchment scale, such as integrated water resource management and environmental flows, need to be adopted, particularly due to the high number of transboundary rivers within the region. Environment impact assessments, when correctly undertaken, are a valuable tool to inform the development planning process but they must be based on the best available information as provided through this study. In the many cases where information is lacking we recommend new research be prioritised.

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 western 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 region's people.

■ More than 14% of species across the region are currently threatened and future levels of threat are expected to rise significantly due to a growing population and the corresponding demand of natural resources.

■ Data on the distributions, conservation status, and ecology of all 1,395 known species of fishes, molluscs, odonates, crabs and selected 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 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 species within the region, with between 10% (fishes) and 22% (crabs) assessed as Data Deficient. Information on the status and distribution of aquatic plants needs to be greatly improved throughout the region.

Children washing clothes in a stream in Cameroon. Photo: © Kevin Smith.

Chapter 1. Background

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The goods and services derived from inland waters have an estimated global value of up to USD 15 trillion and include essential products such as food and drinking water in addition to providing less measurable services such as water filtration and flood control (Millennium Ecosystem Assessment 2005). The best estimate of current tropical river and inland fisheries production is 5.46 million tonnes valued at USD 5.58 billion (gross market value), which is equivalent to 19% of the current value of annual fish exports from developing countries (USD 29 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 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 potable water and about 313 million people lacking access to adequate sanitation (UN 2006). 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 (UN 2006). 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 *et al.* 2000). The developments needed 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 within the water development planning process. Without this baseline information it will be difficult to minimize 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 western Africa, a region with significant dependence on freshwater biodiversity products, and widely dispersed, largely inaccessible, information on freshwater biological diversity. This report represents the results of work completed to assess the distribution and status of freshwater biodiversity throughout western 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), the second for southern Africa in 2008 (Darwall *et al.* 2008) and reports will be published for central, 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. The definition of freshwater plants or hydrophytes

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

is generally accepted to be "all plants that tolerate or require flooding for a minimum duration of saturation/inundation" (Gopal and Junk 2000). 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% (~15,000 species) of known species of fish inhabit fresh water, 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 fresh water. 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). 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, Lévêque *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 2004, 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. 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, over-harvesting 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

Young girls selling fishes on a market in Komadugu Yobe river basin, North East Nigeria. Photo: © IUCN/Danièle Perrot-Maître.

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 minimise 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, 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 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. An Intergovernmental Panel on Climate Change (IPCC) report on climate change and water (Bates *et al.* 2008) showed that western Africa has experienced a major decline in annual rainfall since the end of the 1960s (20% to 40% below levels recorded since 1930). The report states that this had severe impacts upon food security in the region leading to droughts, particularly in the Sahel region. 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 – any changes in precipitation and temperature will 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-

Deforestation near the village of Simpa in Western Ghana in the region of the Upper Guinean Rainforest Photo: © IUCN/Johannes Förster

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 2008) (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 (Smith and Darwall 2006), 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 2008 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, while 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 western Africa

There is a paucity of published data on wetland losses in Africa (Moser *et al.* 1996), therefore the production of wetland inventories and studies on the rate and extent of wetland loss are urgently required (Spiers 2001). Information exists for some areas, for example, Coleman *et al.* (2008) showed that between 1987 and 2002 in an area of 1,110 km^2 of the lower Niger delta some 88 km^2 (at 6 km^2/year) of wetlands had been converted to open water or converted to agricultural usage.

Western Africa is made up of different habitat types from the dry Sahel in the north, moving south through grassland and savannah into tropical moist forests near the coast. Covering the northern part of the region in Niger, Mali, Mauritania and Chad is the Sahel, a dry region, characterised by scattered oases, semi-permanent pools and temporary rivers, which receives on average just 30-50mm of rain per year (Thieme *et al*. 2005). Permanent rivers are found south of the Sahel rising in the savannah belt, the largest being the Niger, Senegal, Volta and the Lake Chad catchment. Most of the savannah rivers have strong seasonal flows and go through a cycle of flood and drought inundating large areas of floodplains that, due to their high productivity, provide vital resources for local human populations and biodiversity. The Niger River, the longest in

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 2008 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: Balian *et al*. 2008, IUCN Red List 2008. Waterbird figures are for 2009 (BirdLife International 2009)).

Taxon	Estimated total number of inland water-dependent species	Estimated percentage assessed for the 2008 IUCN Red List	Number of species assessed as threatened for the 2008 IUCN Red List
Plants	~2,614	<1.5% (37 species)	31 (DD: 1)
Insects	>75,000	<1% (662)	195 (DD: 91)
Molluscs	~5,000	<16.5% (812)	406 (DD: 143)
Crustaceans	>11,900	<14.5% (1722)	597 (DD: 659)
Fishes	~15,000	<17.5% (2593)	1061 (DD: 335)
Reptiles	510	<45% (228)	114 (DD: 11)
Amphibians	4,231	100% (4231)	1106 (DD: 974)
Waterbirds	1989	100% (1989)	199 (DD: 9)
Mammals	145	100% (145)	54 (DD: 19)

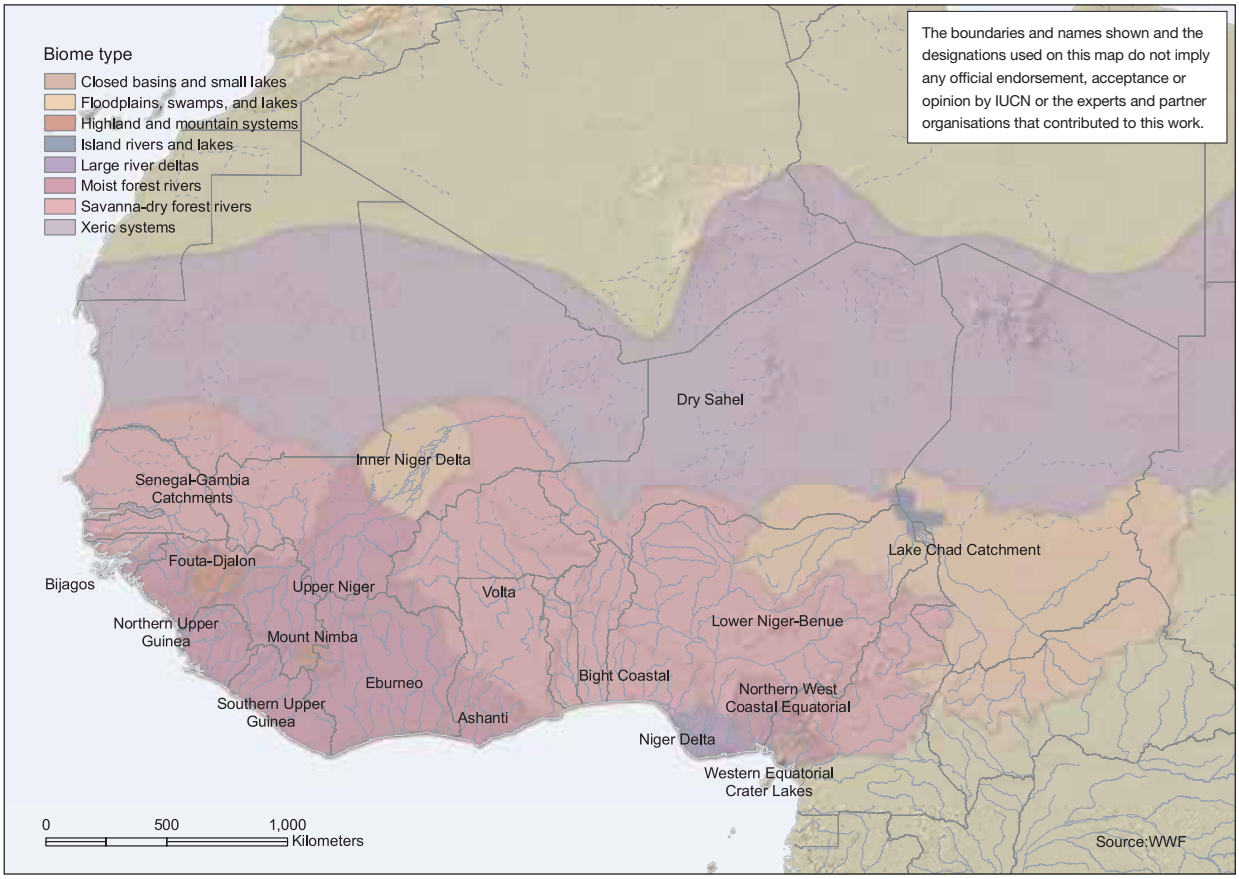
Akosombo dam, Volta river, Ghana. Photo: © Kevin Smith

western Africa at 4,100km (third longest in Africa) has its headwaters in the Fouta Djalon mountains and central Guinean plateau where rainfall is relatively high. The river flows north-eastwards into Mali and through semi-arid grasslands bordering the dry Sahel region. Here the river broadens and forms the inland Niger delta, where it "loses" nearly two-thirds of its potential flow due to seepage and evaporation (FAO 1997). From Mali the river turns south-eastwards and flows through Niger, receiving tributaries from Burkina Faso and Benin, and into the savannah of Nigeria where it has its confluence with its largest tributary, the Benue River which rises in Chad and flows south-westwards through Cameroon into Nigeria. From the Niger-Benue confluence, the river flows 450km south into the rainforest zone and forms the Niger Delta on the Atlantic coast of Nigeria. The Volta (1,600 km long) starts as intermittent streams in the savannah grasslands of Burkina Faso, flowing south through savannah woodland forming floodplains and finally into tropical forest near the coast in Ghana (Thieme *et al*. 2005). The Senegal river, also around 1,600 km long, rises in the wet savannah in Guinea and south-west Mali, flowing north-west into Senegal and Mauritania and into dryer semi arid grasslands. The Lake Chad system is just south of the Sahara desert, with the majority of its water coming from the highlands of Central African Republic and Cameroon via the Logone and Chari rivers that flow through savannah and swamps to the south-east. The coastal rivers of Guinea, Sierra Leone and Liberia descend steeply from the Fouta Djalon and Nimba mountain ranges. Those of Côte d'Ivoire are of a more gentle gradient descending from a plateau that slopes southwards towards the Atlantic. The Upper Guinea region is a tropical area, receiving high levels of rainfall (although it is drier in northern Côte d'Ivoire), and is dominated by moist forest, particularly in the lower reaches of the rivers.

The presence of so many transboundary river basins in western Africa raises the need for shared management and use of water resources between countries. A number of basin wide authorities and projects have been set up to try and develop the sustainable use and management of these transboundary rivers, including the Niger River Basin Authority (www.abn.ne), Senegal River Basin Authority and the World Bank Senegal River Basin Water and Environmental Management Project (http://go.worldbank.org/ZYWU0HFL20) and the Lake Chad Basin Commission (http://lakechad.iwlearn.org/).

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 western Africa are shown in Figure 1.1 and are summarised in Table 1.2.

Figure 1.1. Western African Ecoregion Map (Thieme *et al.* 2005).



1.2.1 Regional threats

The threats to western Africa's rivers and wetlands, and their associated biodiversity and ecosystem services, are linked to a growing population, industrial and agricultural development and a changing climate. Some 43% of the population of sub-Saharan Africa resides in western Africa, which currently stands at around 300 million people (OECD 2008). The high pressure upon freshwater resources is set for further rapid increases as the human population is projected to double to over 600 million by 2050, twice the rate of global population growth (UN 2006). According to Thieme *et al.* (2005) 12 of the 17 freshwater ecoregions in western Africa, are either listed as Critical or Endangered (see Table 1.2) and the region contains over a third of all the ecoregions in Africa listed as Critical.

Climate change, desertification and water abstraction

The Sahel region has undergone multi-decadal changes in rainfall since the last glaciation. For example, there were wetter periods in the 1950s and 1960s and drier conditions from the 1970s to 1990s that led to devastating droughts and the loss of grassland, acacia and associated biodiversity, and shifting sand dunes (Bates *et al.* 2008). It is not known whether the current dry spell that threatens the region's wetlands is part of this natural climate cycle or is the result of environmental degradation and/or global warming (Collier *et al.* 2008). Desertification poses another significant threat to the area's wetlands region as the Sahara is predicted to move south in Mali and Burkina Faso (de Wit and Stankiewicz 2006). Current levels of water extraction have also impacted wetlands as exemplified by Lake Chad, which has shrunk from a surface area of 25,000 km^2 in the early 1960s to around 1,350 km^2 in 2001. Some 50% of this decrease is attributed to increased levels of water abstraction and the remaining 50% due to a change in climate patterns (Pietersen and Beekman 2006). Despite the picture painted above, it is, however, predicted by some that water stress is likely to reduce in some areas of western Africa over the coming decades, but the combined impacts of socio-economic pressures, land use and climate change could lead to a decline in forest ecosystems, their associated biodiversity, water quality and other key ecosystem goods and services that they provide (Bates *et al.* 2008). Inland wetland ecosystems would clearly also be impacted through these changes.

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

Table 1.2. The western Africa ecoregions defined in Thieme *et al.* (2005). *Major habitat types*: Xeric systems –XS; Savannah dry forest – SDF; Highland and mountain systems – HMS; Island rivers – IR; Moist forest rivers – MFR; Floodplains, swamps and lakes – FSL; Large river deltas – LRD. *Biological distinctiveness:* Globally outstanding – GO; Continentally outstanding – CO; Bioregionally outstanding – BO; Nationally important – NI. *Conservation Status*: Critical – C; Endangered – E; Vulnerable – V; Relatively stable – RS; Relatively intact – RI.

Ecoregion	Major Habitat Type	Biological Distinctiveness	Conservation Status	Ecoregion delimitation
Dry Sahel	XS	NI	RI	Atlantic coast to the Nile, with the Sahara desert to the north and Chad to the south. Contains remnants of Sudanian fauna with drought resistant lifestages.
Senegal-Gambia catchments	SDF	NI	V	Includes coastal basins from the Senegal river to the Gébe. Nilo-Sudanian fauna, the fish species probably colonised from the Niger.
Volta	SDF	BO	C	Delimited by the Volta basin and includes similar fish species to the Niger.
Bight Coastal	SDF	CO	C	Coastal basins that lie in the Dahomey Gap (an area of savannah breaking the coastal forest strip) and flows into the Gulf of Guinea, from the Mono to the Ogun-Oshun. Nilo-Sudanian fauna, the fish species probably colonised from the Niger.
Lower Niger-Benue	SDF	CO	C	Niger basin from the end of the Inner Niger Delta at Tombouctou to the start of the coastal Niger Delta, including the whole Benue catchment. Typical Nilo-Sudanian fauna assemblage.
Fouta-Djalon	HMS	BO	V	Rivers of the Fouta-Djalon plateau and includes headwaters of the Senegal and Niger rivers. Upper Guinean fish fauna with endemic species adapted to headwater streams.
Mount Nimba	HMS	BO	E	Streams of Mount Nimba in the southern area of the Guinean highlands. High levels of species richness among invertebrates.
Bijagos	IR	BO	V	The Bijagos Archipelago contains depauperate freshwater fauna but is important for wading birds.
Northern Upper Guinea	MFR	CO	E	Coastal forest drainages from the Coliba and Kogon to the Moa. High levels of endemism amongst fish species.
Southern Upper Guinea	MFR	BO	E	Coastal forest drainages from the Mano to the Cavally. High levels of endemism amongst fish species.
Upper Niger	MFR	NI	V	Upper Niger basin above the Inner Niger Delta. Nilo-Sudanian fauna, similar to the Senegal River.
Northern West Coastal Equatorial	MFR	GO	E	Coastal rivers from the Cross River to the Bay of Cameroon and the Island of Bioko. This area acted as refuge during last ice age and has many endemic species. Fish fauna is in common with Nilo-Sudan and the Congo.
Ashanti	MFR	BO	E	Coastal rivers in western Ghana from the Bia to the Pra. Primarily Nilo-Sudanian fish fauna.
Eburneo	MFR	NI	E	Coastal rivers predominantly in Côte d'Ivoire. Possesses highly productive coastal lagoons.
Inner Niger Delta	FSL	CO	E	Defined by the floodplains of the Inner Niger Delta. A species-rich area with some endemic fishes and an important area for wetland birds.
Lake Chad Catchment	FSL	NI	E	The Lake Chad basin including the Logone and Chari rivers. Has typical Nilo-Sudanian fish fauna but is important for wetland birds.
Niger Delta	LRD	GO	C	The affluents, swamps and mangrove forest of the Niger Delta from the Imo to the Benin river. The delta possesses high levels of aquatic species richness and has an endemic family of fish species (Denticipidae).

Drought-impacted forest in Mauritania. Photo © IUCN/Ibrahim Thiaw

A house destroyed by floods caused by the diversion of river channel caused by siltation and growth of invasive typha grass in Komadugu Yobe river basin, North East Nigeria. Photo: © IUCN/Danièle Perrot-Maître.

and recreational opportunities provided by new reservoir … 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." The majority of African countries rely upon hydro-power to supply their electricity and they also use dams to provide irrigation and water supplies. This demand had led to the construction of 1,272 large dams across Africa by 1998 (ICOLD 1998). More recent estimates report the amount of hydropower under construction in Africa jumped 53% from 2004 to 2007, according to the Hydropower & Dams World Atlas and Industry Guide, an industry reference journal. In western Africa in 1964 the Volta river was dammed at Akosombo in Ghana, forming Lake Volta, the largest man-made lake in the world, with a surface area of nearly 8,500 km^2 covering 3% of Ghana's land surface (LakeNet 2003-2004). The dam has impacted downstream fisheries and, due to the decreased levels of sediment load, has led to erosion of the coastlines of Togo and Benin at a rate of 10 to 15 metres per year (World Commission on Dams 2000). The Senegal river used to flood an area of about 5,000 km^2, providing fertile land and fisheries to local communities until the construction of two major dams significantly reduced the floodplain area (Thieme *et al*. 2005). Fisheries in the Inland Niger Delta have also been affected by dams and drought, which have altered flow regimes, blocked fish migrations, and led to the loss of floodplains (Thieme *et al*. 2005, World Commission on Dams 2000). With growing demands for hydropower, the number of dams is likely to increase throughout the region.

Sedimentation and pollution

A rapidly growing population is accompanied by a growing demand for resources. The result has been that forests in western Africa are disappearing at a faster rate than anywhere else in tropical Africa (FAO 1997), and this has led to increased levels of runoff and greater sediment loads in rivers and lake systems, with subsequent impacts on freshwater species and habitats. Mining in many parts of the region and oil production in the Niger Delta is also degrading and destroying wetland habitats and polluting rivers and lakes.

Table 1.3. Numbers of inland water-dependent species in western Africa assessed for the 2008 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 2008). * Waterbird figures are for 2009 (BirdLife International 2009).

Taxon	Number of species assessed	Percentage threatened or extinct
Plants	3	100% (3 spp) DD = 0
Insects	169	<1% (1 sp) DD = 0
Molluscs	6	50% (3 spp) DD = 3
Crustaceans	25	40% (10spp) DD = 5
Fishes	6	0% (0 sp) DD = 1
Reptiles	6	17% (1 sp) DD = 1
Amphibians	150	18% (27 spp) DD = 17
Waterbirds*	380	<3% (10 spp) DD = 1
Mammals	16	31% (5 spp) DD = 0

In summary, there are a great number of existing and potential threats to western Africa's wetland species, yet, prior to this project, there had been no comprehensive assessment of the threatened status, and conservation needs of freshwater species throughout the region (Table 1.3). A more comprehensive regional assessment was therefore required to determine the true regional levels of threat to these species.

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 realised, in dollar values, it will remain extremely difficult to convince development planners and politicians of their value and the need to account for biodiversity conservation within the development planning process. It is difficult to quantify, in economic terms, the value of, or the reliance on, wetland goods and services by local communities; many products are consumed within rural households and never enter formal markets. Furthermore, as many of the dependent local communities are among the poorest in the world, dollar values for goods and services, when placed in an international economic system, would appear low and would mask the social and even survival benefits they may provide (Emerton 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).

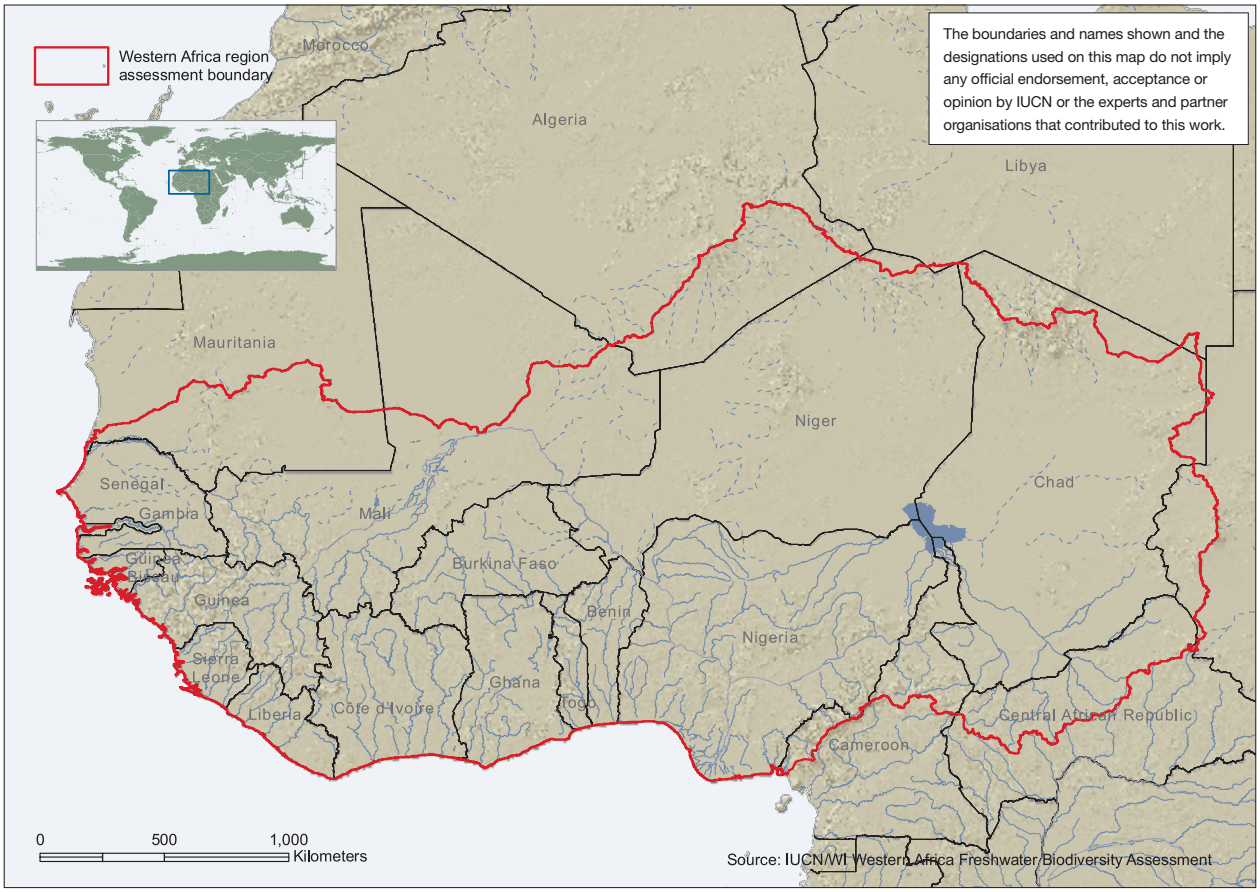
The market water pump in Komadugu Yobe river basin, North East Nigeria. Clean, portable water is vital for the health of local communities.
Photo: © IUCN/Danièle Perrot-Maître.

For example, the value of fisheries production for the major river systems in western Africa is estimated as just over USD 200 million per year (The WorldFish Center 2008). In another example, a study of the Hadejia-Nguru wetlands, northern Nigeria, in 1997 estimated the value of the wetland agricultural, fishing and fuel wood benefits to be around USD 34-51 per hectare, based on 1989/90 prices (Barbier *et al.* 1997). Any wetland valuation methodology, such as employed in these two examples, would benefit greatly from a more comprehensive source of biodiversity information as provided through the assessment reported here.

1.3 The precautionary approach to species conservation

Even when the economic value of a wetland and its associated biodiversity has been determined as high, in many cases it still remains a difficult task to justify the need to conserve all species. This is particularly true where the diversity is already exceptionally high, such as in the freshwater fish communities of many of the African lakes. In such cases fishery managers may argue that it would be easier to manage a fishery of just a few fast-growing and commercially valuable species than to manage the multi-species fisheries typical of these lakes. This argument may seem logical, but a vivid example for

Figure 1.1. Western Africa region defined for this assessment.



Fishes (some introduced species) caught in Komadugu Yobe river basin, North East Nigeria. Photo: © IUCN/Danièle Perrot-Maître

demonstrating the potential value in conserving all species comes from Lake Victoria, where the impact of species loss on local livelihoods has been reported. Here, introduction of the Nile perch (*Lates niloticus*) and Nile tilapia (*Oreochromis niloticus*) has contributed to the possible extinction or decline of an estimated 200 species of fish that formerly provided the main source of income and protein to many lakeside communities (Witte *et al.* 1992). Clearly the loss of so many species is a disaster but, in studying the patterns of recovery for some species, it has also become more apparent as to why we should take a precautionary approach to species conservation. Research is starting to show that in some cases formerly rare species, once poorly represented in fishery catches, are the species best adapted to the degraded environmental conditions now prevailing in the lake (e.g., Witte *et al.* 2008). A few of these species are 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 degraded conditions now prevalent throughout the lake and future fisheries might be lost. The message given here is to adopt the precautionary approach where it is assumed that all species are important and may one day be key components of the fisheries or their supporting foodwebs.

1.4 Objectives of this study

IUCN, in partnership with Wetlands International (WI) initiated a programme in 2006 to build capacity to conserve and sustainably manage inland water biodiversity resources throughout western Africa (Figure 1.4). A 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 western 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 region and global presence of IUCN and partners.

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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 that provide obvious benefits to humans through direct consumption, or the more charismatic groups, such as 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). Clearly, it is not practical to assess all species. Therefore, 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 supply, benefits provided by the other taxa may be indirect and poorly appreciated but nonetheless equally important. Given the wide range of trophic levels and ecological roles encompassed within these five taxonomic groups, it is proposed that 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

Arguably fishes form the most important wetland product on a global scale. They provide 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 water capture (FAO 2006), providing essential nutrition for the poorest of communities and employment and income for many more (165,000 people earn a living as fishermen on the major rivers of western Africa (WorldFish Center 2008)). 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 around 15,000 freshwater fish species in the world, and by 2008 only 17.5% of them had had their risk of extinction assessed using the IUCN Red List Categories and Criteria.

2.1.2 Molluscs

Freshwater molluscs in some regions of the world are one of the most threatened groups of freshwater taxa (Kay 1995). They remain fairly unobtrusive, and are not normally considered as being charismatic creatures, so rarely attract the attention of the popular media. This is unfortunate as they are essential to the maintenance of wetland ecosystems, primarily due to 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 5,000 freshwater molluscs for which valid descriptions exist, in addition to a possible additional 10,000 undescribed species. Of these species, only a small number have had their conservation status assessed (around 16.5% of freshwater molluscs had been assessed for the IUCN Red List in 2008) and their value to wetland ecosystems is poorly appreciated. The impact of developments such as dams has not been adequately researched and there is little awareness of the complex life histories of some groups such as unionid mussels that rely on

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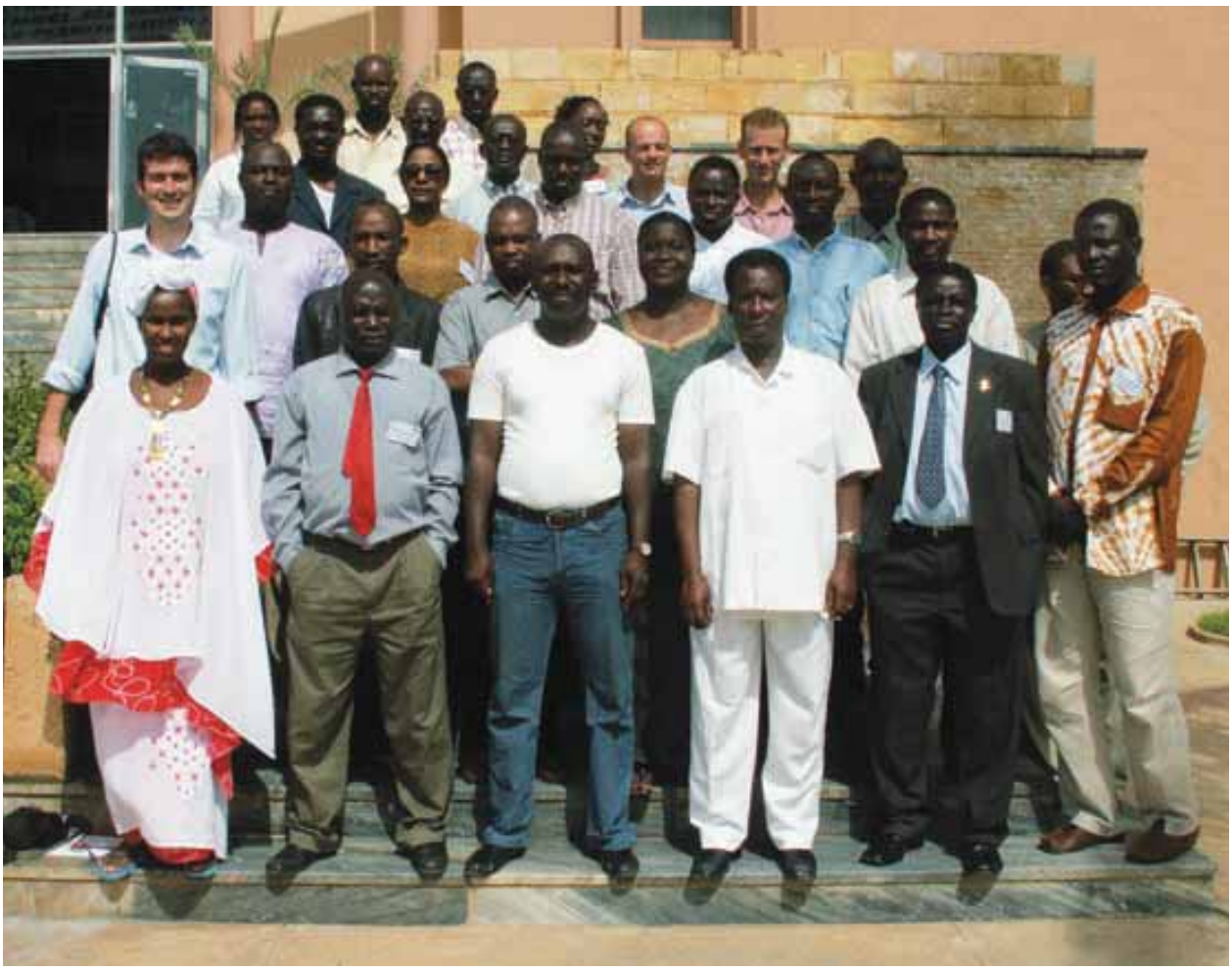
Participants of the training workshop, Dakar, Senegal. Photo: © Caroline Pollock.



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 channelisation, pollution, sedimentation and siltation also impact heavily on unionid mussels.

2.1.3 Odonates

Larvae of almost all of the 5,680 species of the insect order Odonata (dragonflies and damselflies) are dependent on freshwater habitats. The habitat selection of adult dragonflies strongly depends on the terrestrial vegetation type and their larvae develop in water where they play a critical role with regards to water quality, nutrient cycling, and aquatic habitat structure. A full array of ecological types are represented within the group which, as such, has been widely used as an indicator for wetland quality in Europe, Japan, the USA and Australia. Of these 5,680 species, less than 11% had had their risk of extinction assessed using the IUCN Red List Categories and Criteria by 2008. A baseline dataset is needed for Africa to facilitate the development of similar long term monitoring schemes.

2.1.4 Crabs

There are an estimated 1,446 species of freshwater crab of which 141 species are recognised from Africa. Density estimates are highly variable, but they consistently show that crabs make up a 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. All of the 141 species native to Africa have had their risk of extinction assessed using the IUCN Red List Categories and Criteria by 2008, these are global assessments (a number of which are a product of the work reported here) and risk of extinction within western Africa is assessed for this project.

Freshwater fishes working group, evaluation workshop, Accra, Ghana. Photo: © Kevin Smith.

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, such as water filtration and nutrient recycling. An aquatic plant is defined here as a plant that is physiologically bound to water (a hydrophyte) or essentially a terrestrial plants whose photosynthetically active parts tolerate long periods submerged or floating (a helophyte) (Cook 1996). According to Balian *et al.* (2008) there are around 2,614 aquatic plants (hydrophytes only) and only 37 species of aquatic plants have been assessed for the 2008 IUCN Red List.

For this project, the conservation status of all the aquatic plant species from 69 selected plant families was assessed. The selection of families was based on the criteria that: i) the family contains a relatively large proportion of aquatic species, ii) there is a reasonable level of available information on the relevant species, iii) the taxonomy is relatively stable, iv) the selected families would, when combined, cover a wide range of ecological niches and contain a substantial number of species, and v) the families are widely represented at the global scale. The families assessed are shown in Table 2.1.

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). Regional and international experts for these taxa were first identified by WI, 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), in the application of the IUCN Red List Categories and Criteria (IUCN 2001), to assess a species risk of extinction in the wild, and in mapping freshwater species distributions.

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 the 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 was both complete and correct; and ii) the Red List criteria had been applied correctly.

Table 2.1 Plant families from which aquatic species have been assessed for the western Africa assessment. Those highlighted in blue are fully aquatic families.

Phylum	Class	Order	Family
Charophyta	Charophyceae	Charales	Characeae
Lycopodiophyta	Isoetopsida	Isoetales	Isoetaceae
	Sellaginellopsida	Selaginellales	Selaginellaceae
Polypodiophyta	Polypodiopsida	Blechnales	Lomariopsidaceae
			Thelypteridaceae
		Marsileales	Marsileaceae
		Pteridales	Parkeriaceae
		Salviniales	Azollaceae
			Salviniaceae
Tracheophyta	Liliopsida	Alismatales	Alismataceae
			Limnocharitaceae
		Arales	Araceae
			Lemnaceae
		Arecales	Palmae
		Commelinales	Commelinaceae
			Xyridaceae
		Cyperales	Cyperaceae
			Gramineae
		Eriocaulales	Eriocaulaceae
		Hydrocharitales	Hydrocharitaceae
		Liliales	Amaryllidaceae
			Pontederiaceae
		Najadales	Aponogetonaceae
			Potamogetonaceae
		Typhales	Typhaceae
		Zingerberales	Marantaceae
	Magnoliopsida	Apiales	Umbelliferae
		Asterales	Compositae
		Campanulales	Campanulaceae
		Capparales	Capparaceae
			Cruciferae
		Caryophyllales	Amaranthaceae
			Caryophyllaceae
			Molluginaceae
			Portulacaceae
		Euphorbiales	Euphorbiaceae
		Fabales	Leguminosae
		Geraniales	Balsaminaceae
		Haloragales	Haloragaceae
		Lamiales	Boraginaceae
			Verbenaceae
		Malvales	Malvaceae
			Sterculiaceae

Table 2.1 cont. Plant families from which aquatic species have been assessed for the western Africa assessment. Those highlighted in blue are fully aquatic families.

Phylum	Class	Order	Family
(Tracheophyta cont.)	(Magnoliopsida cont.)	Myrtales	Lythraceae
			Melastomataceae
			Myrtaceae
			Onagraceae
			Trapaceae
		Nepenthales	Droseraceae
		Nymphaeales	Ceratophyllaceae
			Nymphaeaceae
		Podostemales	Podostemaceae
		Polygonales	Polygonaceae
		Ranunculales	Ranunculaceae
		Rhamnales	Rhamnaceae
		Rhizophorales	Rhizophoraceae
		Rubiales	Rubiaceae
		Salicales	Salicaceae
		Scrophulariales	Acanthaceae
			Lentibulariaceae
			Scrophulariaceae
		Solanales	Convolvulaceae
			Hydrophyllaceae
			Menyanthaceae
			Solanaceae
		Theales	Elatinaceae
			Ochnaceae
		Urticales	Moraceae
		Violales	Cucurbitaceae

2.3 Species mapping

All species distributions (apart from plants) were mapped to river sub-basins as delineated by the HYDRO1k Elevation Derivative Database (USGS EROS) (Figure 2.1) using ArcView/Map GIS software. The majority of plant species were mapped to countries due to the lack of detailed distribution information. 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. All the point localities for the fishes came from the publication *The fresh and brackish water fishes of west Africa* (Paugy *et al.* 2003). The crab and odonate point localities were based on museum records from 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, course scale distribution records and unpublished information. 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.

Figure 2.1 Level 6 river basins as delineated by Hydro1K and as used to map and analyse species distributions.

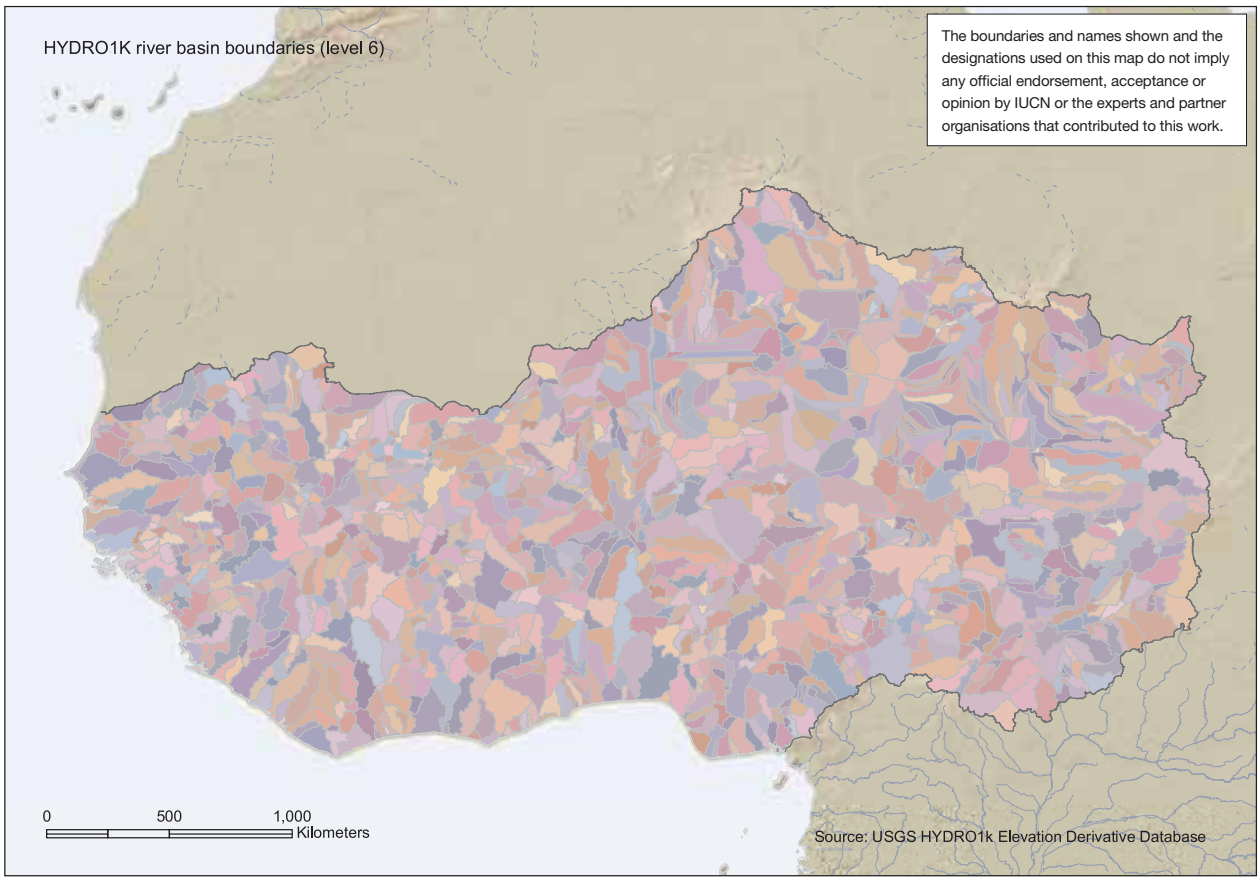
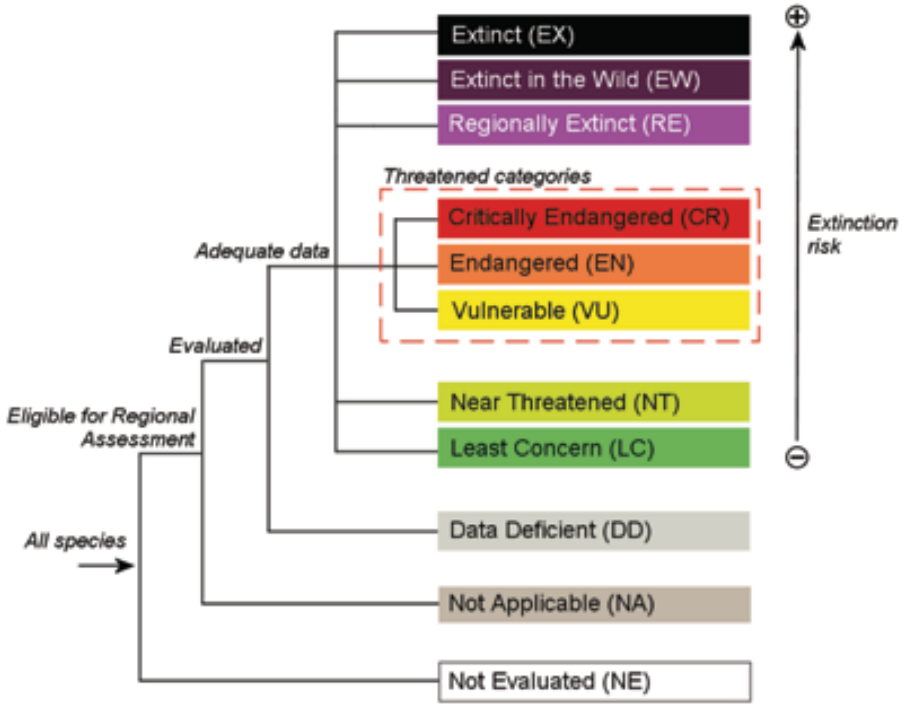


Figure 2.2 IUCN Red List Categories at a Regional Level.



Species distributions were also described within the context of the Freshwater Ecoregions for western Africa, as defined and delineated by WWF-US (Thieme *et al.* 2005) (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 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 western Africa should not be assessed, the main assessment being completed for the neighbouring region.
2) Species present in western Africa prior to 1500 were treated as being "naturalised" and subject to a Red List assessment. Those species arriving in western Africa post 1500 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	Near Threatened, NT
Extinct in the Wild, EW	Least Concern, LC
Regionally Extinct, RE	Data Deficient, DD
Critically Endangered, CR	Not Applicable, NA
Endangered, EN	Not Evaluated, NE
Vulnerable, VU	

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 on the accompanying CD. An example output is given in Appendix 1.

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Chapter 3. Freshwater fishes of western Africa

Laleye, P.[1] and Entsua-Mensah, M.[2]

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3.1 Overview of West African fishes

During the last 30 years many research programs have contributed to the status of knowledge of freshwater fishes in western Africa. At the beginning of the century (1909-1916) Boulenger catalogued the African fish collections of the British Natural History Museum. Later, Pellegrin (1923) published the West Africa fishes fauna (from Senegal to Niger) in which he retained 293 species belonging to 35 families. After World War II, several regional syntheses have been compiled on the Western Africa ichthyofauna. The most widely known are: Ghana (Irvine *et al.* 1947, Dankwa *et al*. 1999); Mount Nimba (Daget 1952, 1963); Upper Niger (Daget 1954); Gambia (Johnels 1954); Benin (Gras 1961); Niokolo Koba (Daget 1961); Lower Guinea (Daget 1962); Chad (Blache *et al.* 1964); Côte d'Ivoire (Daget & Iltis 1965); Ogun (Sydenham 1977).

Later, an important catalogue of Africa freshwater fishes (CLOFFA) (Daget *et al.* 1984-1991) was published and followed by several research programs. For western Africa, the results have been gathered in an important book, published by ORSTOM and MRAC (Lévêque *et al.* 1990, 1992) that identified 558 fish species belonging to 180 genera and 61 families in the western Africa region. This assessment was updated by Paugy *et al*. (2003), increasing the number of species to 584, from 192 genera and 64 families. During the last five years, two new species of *Synodontis* (Musschot & Lalèyè 2008) have been described, bringing the total number of described freshwater fish species for western Africa to 586 (about 10% of Africa's described freshwater fish species). The figures from this analysis differ from Paugy *et al.* (2003) as their analysis included a number of predominantly marine species also found in brackish waters; these are not included here. This current work reports on the conservation status of all freshwater fish species included in Paugy *et al.* (2003), with a few new additions, such that 553 freshwater species with 44 sub-species, from 170 genera and 57 families are now recorded from western Africa. Of these, 10 species and one sub-species are introduced and one species is

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Protopterus annectens annectens (LC) from Pendjari Park (Volta River) in Benin. Photo: © T Moritz

Traditional fishing in Pendjari Park (Volta River) in Benin. Photo: © T Moritz

a misidentification, leaving 542 native freshwater fish species and 43 sub-species. Of these, 300 species and 24 sub-species are endemic to the region.

The western African region, as defined here, contains 17 of the freshwater ecoregions defined by Thieme *et al.* (2005). The biological distinctiveness and current conservation status of each ecoregion, summarised from Appendix D of Thieme *et al.* (2005), is listed in Table 1.2 in Chapter One of this report. Levels of fish species richness and endemism are discussed below for each ecoregion.

3.1.1 Xeric systems

3.1.1.1 Dry Sahel

A few of the region's fish species are specially adapted to live in the temporary water systems that exist in the Dry Sahel. These species are able to air-breathe and aestivate in the mud during the dry period, or are able to lay drought resistant eggs which hatch once the habitat is flooded again in the rainy season (Skelton 1993). Species adapted to these conditions in western Africa are found in temporary rivers, pools and swamps in Sahel Savannah areas and include *Protopterus annectens annectens* (LC), an air breathing lungfish and *Pronothobranchius kiyawensis* (NT), a killifish with drought resistant eggs.

3.1.2 Savannah dry forest rivers

3.1.2.1 Senegal-Gambia catchments

Some 144 fish species are recorded from this ecoregion, with an additional 20 species also thought to occur here. In those cases where a species is thought to be present, its inferred presence is based on expert opinion or on locality records yet to be digitised, such that point locality data could not be used in GIS analysis (see 3.3). Of the freshwater fish species found here 54 are endemic to the western Africa region, but only one species *Malapterurus occidentalis* (NT) is endemic to the ecoregion, and is recorded from the middle Gambia River (in Gambia) and the Géba River (Guinea-Bissau). There are, however, three other species that are almost entirely restricted to this ecoregion, but as the upper Baffing river (Senegal catchment) is within the Fouta-Djalon ecoregion, they are not strict ecoregion endemics. These Senegal-Gambia catchment endemics are *Barbus niokoloensis* (VU), *Barbus ditinensis* (VU) and *Synodontis tourei* (NT). This relatively low level of endemism is thought to be due to the past desiccation of the basins and relatively recent re-colonization by a Nilo-Sudanian fauna (Thieme *et al.* 2005).

3.1.2.2 Volta

There are 160 species recorded from the Volta ecoregion, with an additional 25 species also thought to occur there. Of these, 59 are endemic to western Africa and eight are endemic to the Volta system. The endemic species are *Barbus guildi* (DD), *Barbus parablabes* (LC), *Brycinus luteus* (VU), *Irvineia voltae* (EN), *Micropanchax bracheti* (VU), *Steatocranus irvinei* (NT), *Synodontis arnoulti* (VU), and *Synodontis macrophthalmus* (VU).

3.1.2.3 Lower Niger-Benue

The Lower Niger-Benue contains a rich fish fauna with many species adapted to seasonal flooding (Thieme *et al.* 2005). Part of this ecoregion, the upper Sanaga in Cameroon, is not included in the western Africa region, as defined here, so species found

Chrisichthys nigrodigitatus being sold at Kpong Head ponds of the Volta system. Photo: © Mamaa Entsua-Mensah

there are not included in this assessment. Some 180 species are recorded from this ecoregion, with an additional 15 species also thought to occur there. Of these, 72 are endemic to the western Africa region and seven are endemic to the Lower Niger-Benue ecoregion. These endemics are *Alestes bouboni* (EN), *Chiloglanis benuensis* (VU), *Chiloglanis niger* (VU), *Garra allostoma* (VU), *Garra trewavasae* (CR), *Synodontis guttatus* (EN) and *Synodontis xiphias* (DD).

3.1.2.4 Bight coastal

The interconnected network of rivers and coastal lagoons of the Bight Coastal ecoregion host a rich fish fauna but with low levels of endemism (Thieme *et al.* 2005). Some 153 species and one sub-species have been recorded, with an additional 27 species also thought to be present. Fifty-two of these species are endemic to western Africa but only three, possibly four, species are endemic to the ecoregion – these are *Aplocheilichthys keilhacki* (VU), *Synodontis ouemeensis* (DD) and *Marcusenius brucii* (VU), with *Barbus lagoensis* (DD) a possible endemic, which may also be recorded from Ghana and Cameroon. The coastal lagoons contain very high numbers of fish species as they include an estuarine component that is the basis of the lagoon fauna community, a marine component that appears in the lagoon during the dry season when the salinity remains high, and a freshwater component that enters the lagoon from the river during the flood period. Lake Nokoue in Benin, a lagoon 20km long and 11km wide, contains an estimated 51 fish species, belonging to 47 genera and 34 families (Laleye *et al.* 2003).

3.1.3 Highland and mountain systems

3.1.3.1 Fouta Djalon

This ecoregion includes the upper stretches of the Bafing (Senegal basin), Tinkisso (Niger basin), Gambia, Corubal, Konkoure and Little Scarcies rivers and is dominated by species of Cyprinidae (minnows), Mormyridae (snoutfishes), and Alestiidae (African tetras) (Thieme *et al.* 2005). Eighty species have been recorded from the ecoregion, with 10 species being strict endemics. These endemic species are *Barbus anniae* (VU); *Barbus cadenati* (VU), *Barbus ditinensis* (VU), *Barbus foutensis* (VU), Barbus guineensis (DD), *Barbus salessei* (VU), *Rhexipanchax lamberti* (VU), *Rhexipanchax kabae* (VU), *Scriptaphyosemion cauveti* (CR), and *Synodontis tourei* (NT).

3.1.3.2 Mount Nimba

The Mount Nimba Ecoregion is very small – only 11,000km² – and covers the upmost stretches of the Cavally, Saint Paul, St John and Sassandra rivers. While there are many narrow range endemic species within the Mount Nimba 'region', there are only two strict endemics to this ecoregion: *Chiloglanis lamottei* (DD), which is known only from the holotype collected in the Upper Cavally basin, and *Epiplatys hildegardae* (VU), a species known only from a restricted area around N'Zérékore in southeastern Guinea in the upper drainage systems of the Saint John/Mani and Saint Paul/Oulé rivers.

3.1.4 Moist forest rivers

3.1.4.1 Northern Upper Guinea

The forested coastal streams and rivers of Upper Guinea support a diverse and endemic aquatic fauna (Lévêque *et al.* 1989). The Konkoure River is one of the richest among the Atlantic basins, with 96 freshwater fish species recorded there. When the uppermost stretches of the Konkoure, Corubal and Little Scarcies rivers are included (strictly within the Fouta-Djalon ecoregion), there are 180 species and six sub-species recorded from this ecoregion, and an additional 15 species with an inferred distribution. The level of endemism is extremely high with 124 species endemic to western Africa and 45 species and two sub-species being ecoregion endemics. The endemic species are mainly from the families Cyprinidae, Nothobranchiidae and Mochokidae, but also include species of Cichlidae, Poeciliidae, Amphiliidae, Claroteidae, Mormyridae, Malapteruridae and Eleotridae. These endemic species are generally small-bodied fishes adapted to the swift currents and clear waters of the ecoregion (Thieme *et al.* 2005).

3.1.4.2 Southern Upper Guinea

As for the Northern Upper Guinea ecoregion, the southern part also contains many aquatic species and high levels of endemism (Thieme *et al.* 2005, Hugueney and Lévêque 1994). It contains 151 recorded fish species, with an additional 23 species also thought to be present. Some 105 species in the ecoregion are endemic to western Africa, of which 34 species and an additional three sub-species are endemic to the Southern Upper Guinea ecoregion. The endemic species are mostly within the families Cyprinidae, Nothobranchiidae and Cichlidae.

3.1.4.3 Eburneo

The Ebureno ecoregion incorporates predominantly slow flowing rivers with extensive coastal lagoon complexes supporting relatively high number of species, but low levels of endemism (Thieme *et al.* 2005). The ecoregion largely follows basin boundaries but excludes the uppermost reaches of the Sassandra and Comoé rivers. Using the strict ecoregion

Inner Niger Delta. In 1960, the fishermen used nets with a mesh width of 50mm, compared to 33-41mm in 1985. Fishermen started using nets of only 10mm. Photo: © Leo Zwarts

boundary, there are 138 recorded species with an additional 17 species also thought to be present. Of these, 56 species are endemic to western Africa but only one species, *Epiplatys etzeli* (EN), and three sub-species, *Epiplatys olbrechtsi dauresi* (EN), *Epiplatys chaperi spillmanni* (VU) and *Petrocephalus bane comoensis* (VU), are endemic to the ecoregion. If the upper catchments of the Sassandra and Comoé are included, the numbers increase to 141 recorded species, of which five are endemic. The additional endemics are *Micralestes comoensis* (VU), *Synodontis comoensis* (NT), *Synodontis koensis* (NT), *Synodontis punctifer* (LC), all recorded just outside the ecoregion boundary. *Citharinus eburneensis* (NT) is almost restricted to the ecoregion but is also recorded from the Tano river in Ghana.

Brycinus nurse & *Chromidotilapia guntheri* captured at Tagbo Waterfalls below Mount Afadjato, the highest mountain in Ghana. Photo: © Mamaa Entsua-Mensah

3.1.4.4 Ashanti

This ecoregion, with its relatively short and low gradient rivers, is located in the previously forested south-western corner of Ghana and southeast Côte d'Ivoire (Thieme *et al.* 2005). There are 109 recorded species and an additional 25 species with an inferred distribution within the ecoregion. Of these, 55 species are endemic to western Africa, while six species and one subspecies are endemic to the ecoregion. The ecoregion endemics are *Tilapia discolor* (VU), *Tilapia busumana* (VU), *Malapterurus murrayi* (EN), *Limbochromis robertsi* (EN), *Chrysichthys walkeri* (EN), *Barbus subinensis* (EN), and *Epiplatys chaperi schreiberi* (EN).

3.1.4.5 Upper Niger

The Upper Niger ecoregion includes many fast-flowing rivers and streams fed by high levels of rainfall, with many fish species specialised for survival in rapid flowing waters (Thieme *et al.* 2005). There are 150 recorded fish species, with an additional three species with an inferred distribution. Of these, 55

species are endemic to western Africa, and three, possibly four, species are endemic to the ecoregion: *Brycinus carolinae* (VU), *Micropanchax ehrichi* (NT), *Mormyrops oudoti* (DD), and *Barbus kissiensis* (VU), which may also be present in the Niger River in Nigeria.

3.1.5 Floodplains, swamps, and lakes

3.1.5 1 Inner Niger Delta

The fish fauna in the Inner Niger Delta have life cycles that take advantage of the large areas of seasonally inundated habitats that are used for spawning and feeding when the river floods (Thieme *et al.* 2005). There are 116 recorded fish species, plus one additional species with an inferred distribution. Of these species, 29 are endemic to western Africa but none are endemic to the ecoregion.

3.5.1.2 Lake Chad catchment

Many fish species are adapted to the seasonal flooding that takes place on the plains of the Logone and Chari Rivers, causing Lake Chad to swell (Thieme *et al.* 2005). There are 127 fish species recorded from the lake and its catchment, with an additional 20 species thought to be present. Of these, 26 are endemic to western Africa, but only two species and one sub-species are endemic to the ecoregion. The ecoregion endemics are *Citharinops distichodoides distichodoides* (LC), *Raiamas shariensis* (DD), and *Nothobranchius rubroreticulatus* (DD).

3.1.6 Large river deltas

3.1.6.1 Niger Delta

The Niger River Delta is one of the largest deltas in the world. Up to 80% of the delta is inundated through seasonal flooding. It supports a wide variety of habitats ranging from freshwater swamps and swamp forest in the upper riverine floodplain to mangrove forest in the lower tidal floodplain (Thieme *et al.* 2005). There are 180 recorded freshwater fish species in the Delta and an additional 19 species with an inferred distribution. Of these species, 54 are endemic to western Africa and six are endemic to the ecoregion. The ecoregion endemics are *Rhabdalestes smykalai* (NT), *Neolebias powelli* (CR), *Fundulopanchax arnoldi* (EN), *Parauchenoglanis buettikoferi* (DD), *Epiplatys biafranus* (EN), and *Neolobias powelli* (CR). *Parauchenoglanis akiri* (EN) is endemic to the delta but not to the ecoregion as it is also recorded just across the boundary from the North West Coastal ER.

3.2 Conservation status (IUCN Red List status: regional scale)

There are 553 species of freshwater fishes recorded from western Africa; however only 537 have been assessed at the species level. This is because some species that occur within the region as two or more sub-species, have only been assessed at the sub-species level. When conducting the analysis (see below) only the species level assessments are used. The risk of extinction for the freshwater fish fauna in western Africa was assessed using the IUCN Red List Categories and Criteria, and Regional Guidelines. All species assessed as regionally threatened, and which are endemic to the region, are also globally threatened.

Table 3.1 The number of freshwater fish species in each regional Red List Category in the western Africa region.

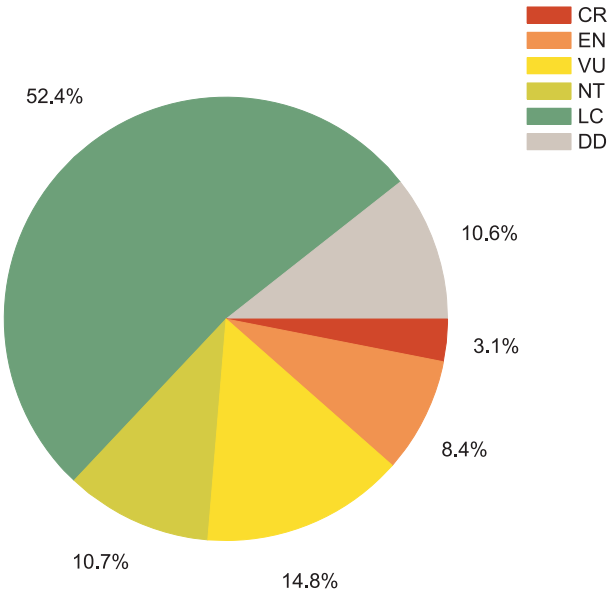
	Regional Red List Category	Number of species	Number of regional endemics
	Extinct	0	0
	Regionally Extinct	0	-
	Extinct in the Wild	0	0
Threatened categories	Critically Endangered	16	15
	Endangered	44	39
	Vulnerable	77	59
	Near Threatened	56	45
	Least Concern	273	109
	Data Deficient	55	33
	Not Applicable	16	-
	Total	521	300

Note: The total figure does not include NA (Not Applicable) species. All species assessed as regionally threatened which are endemic to the region are also globally threatened.

Table 3.1 shows that just over half of all species (52.4%) fall into the Least Concern category. Over a quarter of all species (26.3%) are, however, listed in a threatened category (CR, EN or VU) and are therefore considered to have a high risk of extinction from western Africa. This is a very high level of threat, more than twice that of freshwater fishes in southern Africa (11.2%) (Darwall *et al.* 2009), and only slightly below that in eastern Africa (26.7%) (Darwall *et al.* 2005). The level of Near Threatened species is also high at 10.7% (southern Africa 2.5%, eastern Africa 1.6%) reflecting the number of species in the region that are close to meeting the thresholds for a threatened category. Just over 10% are classified as Data Deficient (DD) as there is not enough information to identify the risk of extinction. Most of these DD species are only known from a few locality records and/or the threats to the species are unknown. Of the Not Applicable (NA) species, 11 are non-native species introduced to the region and five species have less than 5% of their global range within the region.

55.4% of freshwater fishes are endemic to the western Africa region (3050 of the 542 native species), which is lower than southern Africa (67.3% of species are endemic) and lower than eastern Africa which has exceptional levels of endemicity (82% of species are endemic), mainly on account of the hundreds of lake endemic cichlids.

Figure 3.1 The proportion of freshwater fish species in each Regional Red List Category in the western African region. CR: Critically Endangered, EN: Endangered; VU: Vulnerable, NT: Near Threatened, LC: Least Concern, DD: Data Deficient.



3.3 Species richness patterns

All of the freshwater fishes have been mapped to river sub-basins. Information (point locality data) published by Paugy, Lévêque and Teugels (2003) was used to identify species presence within individual sub-basins. Then expert opinion, and the additional information collated through the assessment process, was used to construct inferred distribution ranges in addition to those sub-basins already confirmed by the point locality records to hold the species.

Figure 3.2 shows that the highest species richness is in the Niger Delta region of Nigeria where up to 181 fish species are mapped as present within a single grid cell (289km²). Other species rich areas (77-115 species) include the lower Chari river (Lake Chad basin), the upper Niger from the inland delta, coastal drainages from Guinea to western Liberia, lower coastal drainages of south-eastern Cote d'Ivoire, upper Black Volta in Burkina Faso, Pra river in Ghana, the Ogun in western Nigeria and the upper and lower Cross river in Nigeria and Cameroon.

There are two main centres of endemism (Figure 3.3), the upper Guinea region (coastal drainage of Guinea, Sierra Leone and western Liberia) and the Niger Delta with up to 56 species mapped to a single grid cell. Other river systems containing

Figure 3.2 The distribution of freshwater fish species in western Africa. Species richness = the number of species present in each 289km² hexaganol grid.

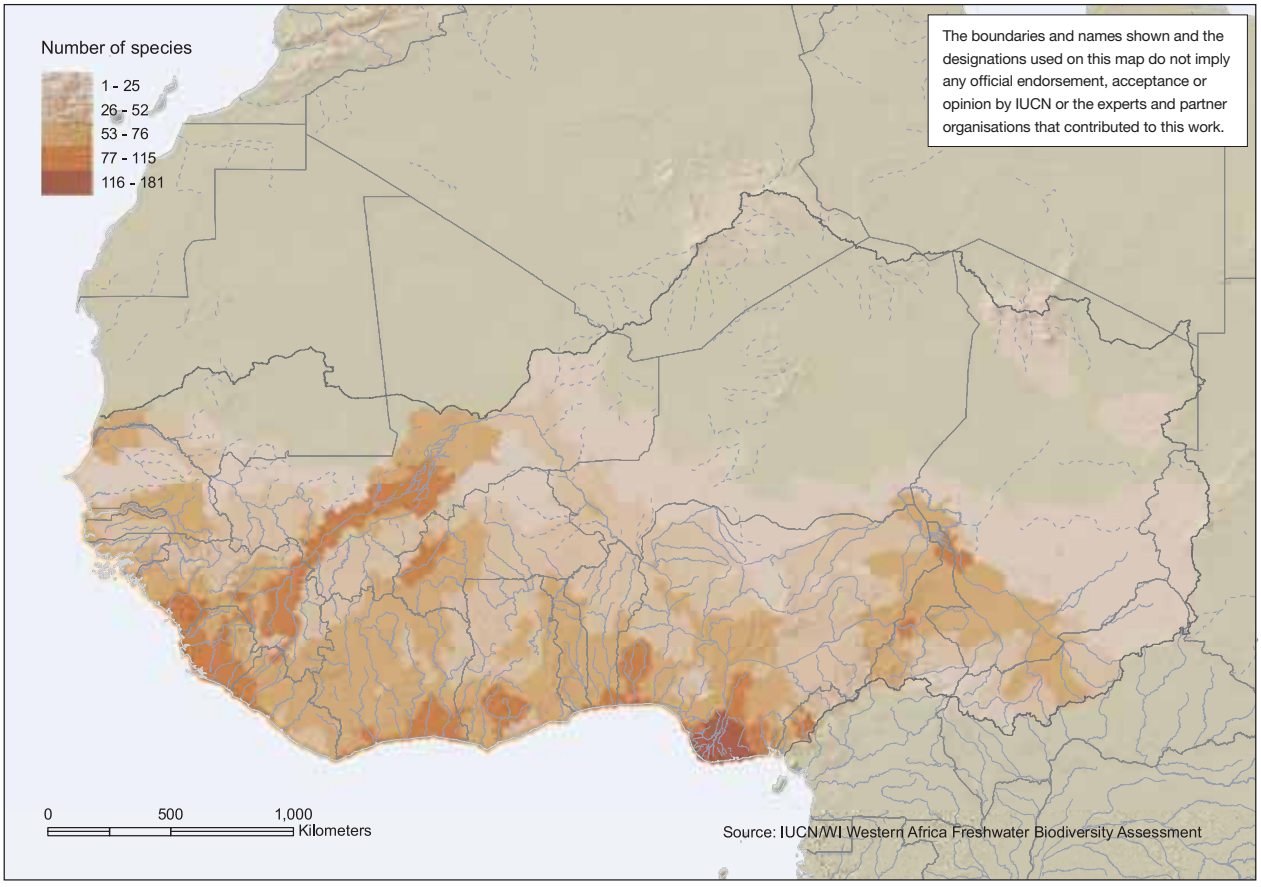


Figure 3.3 The distribution of freshwater fish species endemic to western Africa. Species richness = the number of species present in each 289km² hexaganol grid.

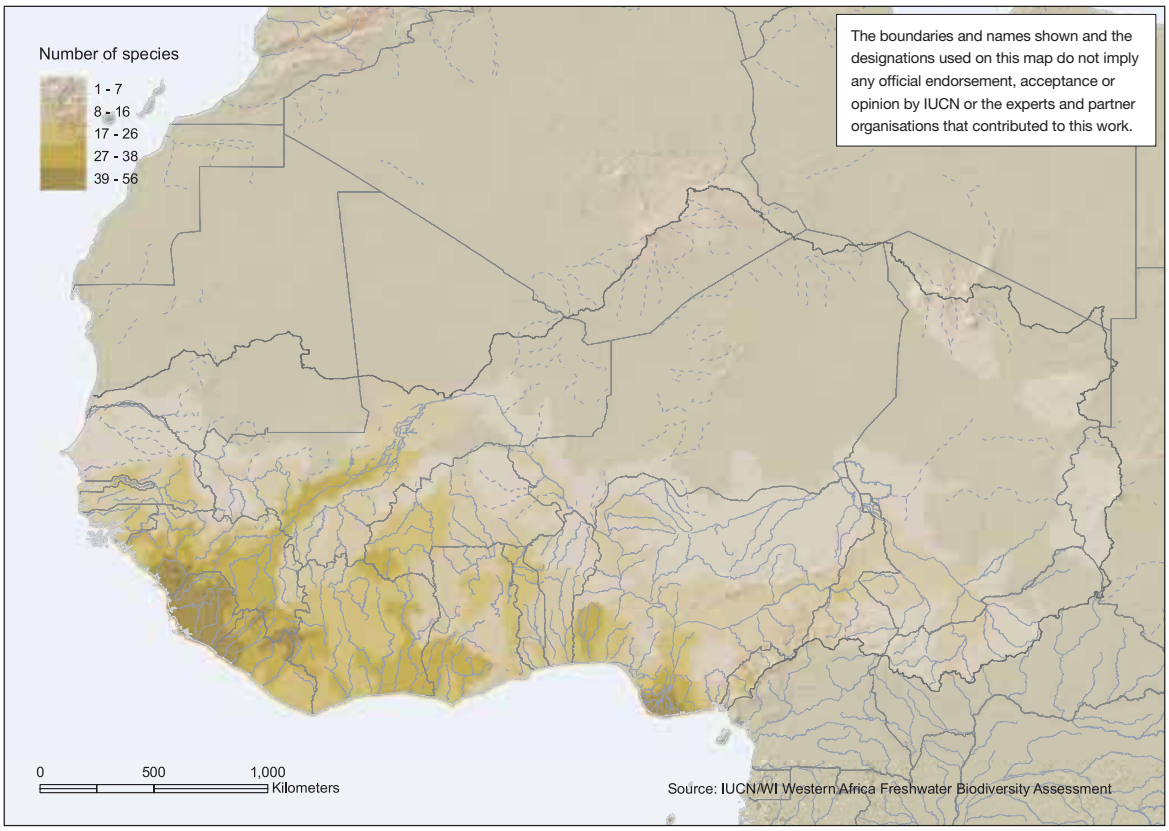


Figure 3.4 The distribution of threatened freshwater fish species in western Africa. Species richness = the number of species present in each 289km² hexaganol grid.

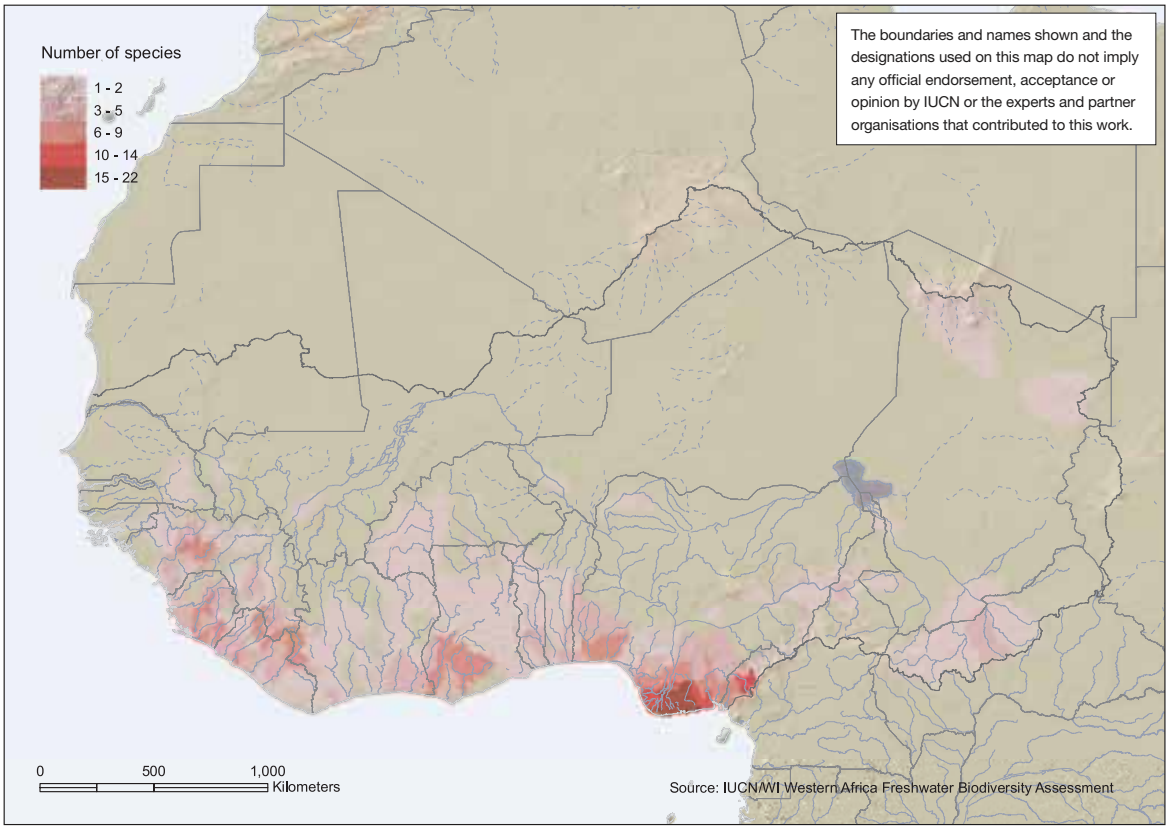
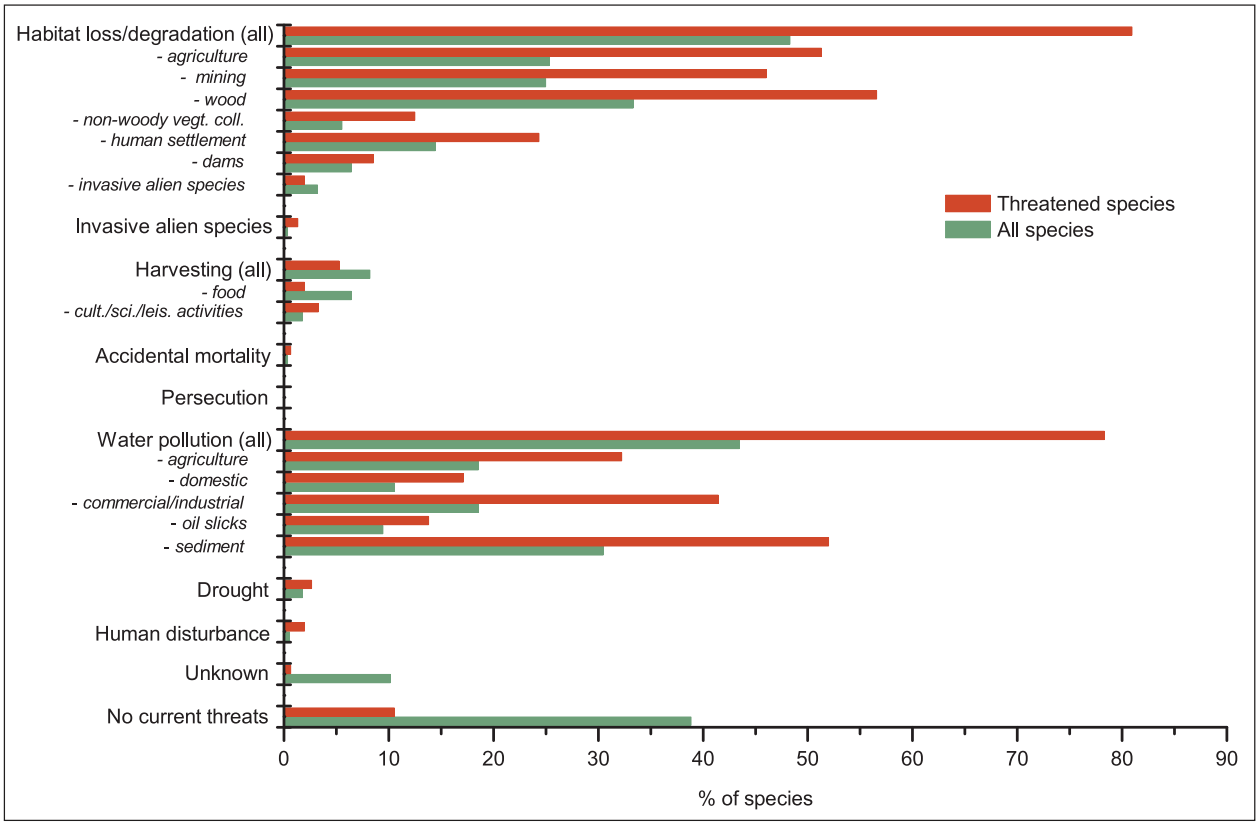


Figure 3.5 Percentages of species currently affected by each threat. Note that many species have more than one threat listed and others (particularly LC species) have no threats listed.



high numbers of endemic species (27-38 species per grid cell) are the upper Niger inland delta, coastal drainages of eastern Cote d'Ivoire and western Ghana and the Ogun in western Nigeria.

The highest concentration of threatened species (15-22 species per grid cell) is in the Niger Delta (Figure 3.4). Other areas with high numbers of threatened species (10-14 species per grid cell) include the upper Cross River in Cameroon. The Pra and Tano rivers in Ghana, the lower Ogun in Nigeria, upper area of coastal rivers in Liberia/southern Guinea/western Cote D'Ivoire, the Moa, Waanje and Siwa rivers in Sierra Leone, and the upper Baffing river in Guinea all contain between six and nine threatened species per grid cell.

3.4 Major threats to freshwater fishes

The assessment has identified the major current threats to freshwater fish species throughout western Africa. Water pollution, habitat loss due to deforestation, mining, and agriculture are the greatest threats to freshwater fishes in the region (Figure 3.5). These threats are closely linked, as, for example, deforestation for agricultural expansion leads to increased sedimentation, which in turn leads to habitat loss as water quality declines. This is evidenced through the similar levels of threat due to water pollution and habitat loss: sedimentation, habitat loss due to agriculture, and deforestation impact 52%, 51% and 57% of threatened species, respectively. Mines and oil drilling also pose a major threat to freshwater fishes, with 46% of threatened species impacted through habitat loss due to mining, 41% impacted through commercial and industrial pollution, and 14% through oil pollution. Other threats include dams, which impact 9% of threatened species and overharvesting, which impacts 5%. Only 39% of all species are thought to be free from any known current widespread threats, and 10% of threatened species have no current threats but are subject to a number of future plausible threats – these species are assessed as VU under the Criterion "D2". Some 10% of all species have their threats listed as "unknown", which matches the percentage of species listed as Data Deficient (10%, see Figure 3.1).

3.4.1 Deforestation and sedimentation

Deforestation is prevalent along the banks of many rivers in western Africa, especially along the Volta, Niger and Senegal Rivers. Agricultural expansion, a major driver of deforestation, has led to increased sediment loads in rivers as soil, once protected by natural vegetation, is left exposed to the elements. In the flood plain wetlands, where the rearing of cattle and small scale dry season agriculture are traditional practices, overgrazing is leading to soil erosion and, as a result of reduced vegetation cover, flooding is more frequent (World Bank,

Irrigated tomato field fed by Tiga dam outside Kanoon, Komadugu Yobe river basin (Lake Chad catchment), North East Nigeria. Photo: © IUCN/Danièle Perrot-Maître

Flooded field as a result of river siltation and typha invasion in Komadugu Yobe river basin, North East Nigeria. Photo: © IUCN/Danièle Perrot-Maître

2005). Abban (1991) reported that while international actions to limit deforestation have been concerned with the depletion of timber and wood products from forests, local demand for fuel wood has been the major cause for the depletion of vegetation cover for fish habitats. Vegetation is also cleared to provide more housing, roads and other infrastructure as the economies and populations in most west African countries grow.

Deforestation and sedimentation alters not only the ecology of the aquatic system but also the species composition of the fish assemblages, and diminishes the availability of certain food items to aquatic species (Payne and Welcomme 2000). The water storage capacity of catchments is reduced, increasing the volume and occurrence of flooding. The quality of silt, which provides fertile land in flood plains after flooding and serves as a valuable food source for many species, may also be affected as not enough time is allowed for formation of the complex organic molecules that are characteristic of normal alluvial deposits.

3.4.2 Water pollution

The major sources of aquatic pollution in western Africa are urban development, industrial waste, and the use of pesticides. Urban pollution is mainly organic and stems from domestic waste, particularly sewage and garbage. It originates from residential buildings, commercial activities, offices and institutions such as schools and hospitals. Industrial waste may include chemicals, mine waste, waste from breweries, food processing plants and tanneries (FAO 1991).

Aquatic pollution is both physical and chemical. Physically, sedimentation in freshwater bodies results in a reduction of habitable aquatic space, creating physical discomfort and reducing the productivity of the system. Chemical pollution creates a situation where fishes are more concerned with avoiding pollution than looking for food. Reproductive capacity is reduced and the food sources for the fish are removed.

Aquatic pollution from pesticides results from their widespread use in agriculture and vector control programs to combat malaria, schistosomiasis, and trypanosomiasis. Few are absolutely specific to their target organisms and other species such as fish may be at risk, as even sub-lethal concentrations may significantly affect their physiology, reproduction, and behaviour.

In Ghana, along the Rivers Ankobra and Birim, small scale alluvial mining and commercial extraction of sand adjacent to the river occurs. The combination of organic and mining discharges into the Ankobra and Birim has resulted in the rivers becoming very turbid. This increased turbidity reduces photosynthetic activity in plants and leads to a decrease in feeding activity in the fish fauna, due to impaired vision. Fish

life is practically nonexistent below the mine discharge site on the Ankobra and pollution is clearly visible (Entsua-Mensah 1996). Fishermen in some areas along the Volta River system use poison to fish, and in doing so kill immature individuals, thus depleting the stocks.

Pollution from oil extraction in Nigeria, Ghana and Cameroon may directly kill fishes or taint their flesh, thereby reducing their economic value. Following spills or leaks, oil spreads across the water surface and may inhibit gas exchange between the water and atmosphere, and may smother feeding and nursery grounds (FAO, 1991).

3.4.3 Dams

Most river systems in western Africa have at least one or two dams, with more than 150 large dams (as defined by International Commission on Large Dams) in the region (Diop and Diedhiou 2009). Some of the major dams in the region are on the Niger River – the Markala (Niger) and Kainji (Nigeria); on the Volta system – Akosombo (Ghana) and Bagre (Burkina Faso); and on the Senegal River – Diama and Lac de Guieres.

Large dams create ecological problems for fish living both upstream and downstream. Fish migrations are physically impacted and the discharge and siltation patterns, which are often used by many species as a cue for different life stage strategies, are altered. Curtailment of the flow regimes can suppress flooding and may stop or reduce the seasonal inundation of flood plains, thus interrupting lateral fish migrations and the availability of feeding, breeding, and nursery grounds.

Above dams large areas will change from riverine to lacustrine conditions with resultant changes in the chemistry and stratification of the water, and oxygen regimes. Spawning and feeding grounds such as rocky areas and gravel beds are lost or degraded through flooding and siltation. In the Volta system, after the river was dammed in 1963, the dominance of insectivorous fishes gave way to predominantly herbivorous and plankton feeding fishes in the lake.

3.4.4 Invasive species

Water hyacinth (*Eichhornia crassipes*) infestation is a critical problem for the health of many systems in western Africa. Experience from other areas, specifically Lake Victoria, suggests that if rapid action is not taken to address the problem there will be serious economic, health, and environmental consequences. Weed infestation impedes transportation, damages equipment used for fishery (boats, nets tackles etc), irrigation and water supply (pumps and other water extraction machinery), and potentially impacts operation of hydroelectric plants with huge associated costs. Weeds also multiply, by several times, the rates of evapo-transpiration and provide habitats for disease vectors. Extensive lake surface cover by plants such as water hyacinth can also reduce light penetration and oxygen levels as the detritus of plant leaves accumulates – this can have a significant impact on associated fish communities.

Sarotherodon melanotheron (LC) in culture at the Aquculture Research & Development Centre, CSIR – Water Research Institute, Ghana © Mamaa Entsua-Mensah

3.4.5 Over fishing

In many freshwater bodies in western Africa, especially in the Volta system, increased harvesting has led to changes in fish community structures and distributions, with an overall reduction in recruitment. Over fishing also causes a decline in average fish size and often lowers trophic levels of fish communities following the disappearance of larger species. This 'fishing down food webs' has been seen in the Ouèmè river in Benin, where large predatory centropomids and catfishes have been replaced by small catfish, cichlids and cyprinids (Helfman 2007). It can also reduce genetic diversity, especially when the stock size is greatly reduced from natural levels. Brainerd (1995) reported that most fishery resources in Africa are either close to their maximum level of exploitation, fully exploited in some cases, or overexploited.

3.5 Conservation recommendations

The political will and action of western African countries is essential if any of the following recommended conservation measures are to succeed.

3.5.1 Deforestation

Reforestation programmes are needed for many wetland systems, in particular in the upper catchments. As these programmes are primarily required in areas of heavy human use, education of local populations and the raising of public awareness of the problems and solutions are equally important.

3.5.2 Pollution

Water quality needs to be improved. This requires training in methods for monitoring water quality, and training for aquatic

pollution assessment and control. A harmonizing of current pesticide registration requirements is required to help limit the illegal use of chemicals.

3.5.3 Dams

The restoration of natural flow regimes (the quantity, quality and timing of water flows) needs to be adopted by the dam management authorities, along with the construction of mechanisms to facilitate fish passage up and down stream of dams.

3.5.4 Invasive species

Control of aquatic weeds through manual, chemical and biological control needs to researched and put into practice. Action also needs to be taken to minimize the introduction and movement of invasive alien species to systems where they are not present.

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Chapter 4. The status and distribution of freshwater molluscs (Mollusca)

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

The western African region covered here contains 17 of the freshwater ecoregions defined by Thieme *et al*. (2005). These 17 ecoregions are categorised under eight major habitat types, which are the basis for this report. The biological distinctiveness and current conservation status of each ecoregion, summarised from Appendix D of Thieme *et al*. (2005), is listed in Table 1.2. Although these ecoregions do not relate specifically to the distribution of the mollusc fauna, they will be used to review the available information on different taxa. In terms of mollusc species richness (number of species), the most important ecoregions are Senegal-Gambia Catchments, Volta, Bight Coastal, Lower Niger-Benue and the Lake Chad Catchment.

The first records of molluscs from the western Africa region came during the early phase of European colonisation. Before this, poor geographic information such as 'Africa' or 'west Africa' was the only locality data given in the largely taxonomic papers. Subsequent records from exploration at the turn of the century added to our knowledge of the region, but many of these areas have not been revisited. These early research expeditions often resulted in records of species that were new to science. In many cases there are still no more than a few records of the species, making it impossible to determine their true distributional ranges or fully understand their ecological needs. This particularly applies to several species occurring in the eastern parts of northern and southern Upper Guinea, Eburneo and Ashanti ecoregions.

The gastropod fauna is reasonably well known for most of the western African region. This is largely because certain species of the genera *Lymnaea* (Lymnaeidae), *Biomphalaria* and *Bulinus* (Planorbidae) act as intermediate hosts for medically

Freshwater snails (Pila spp) being sold for food at a market in Accra, Ghana..
Photo: © Kevin Smith.

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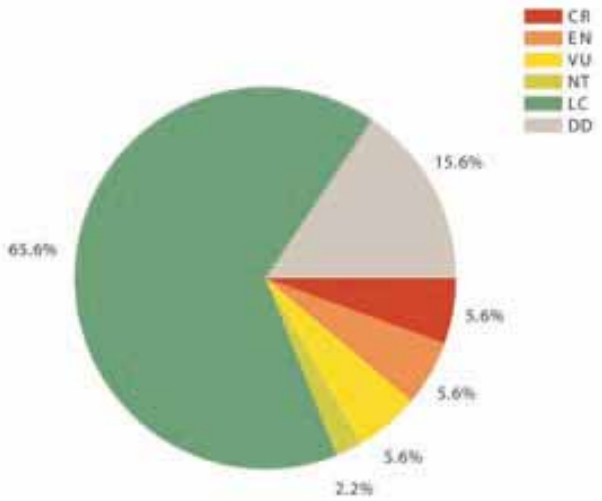
Table 4.1. The number of freshwater mollusc species in each regional Red List Category in the western African region.

	Regional Red List Category	Number of species	Number of regional endemics
	Extinct	0	0
	Regionally Extinct	0	-
	Extinct in the Wild	0	0
Threatened categories	Critically Endangered	5	5
	Endangered	5	3
	Vulnerable	5	5
	Near Threatened	2	2
	Least Concern	59	11
	Data Deficient	14	10
	Not Applicable	4	-
	Total	90	36

Note: The total figure does not include NA (Not Applicable) species. All species assessed as regionally threatened that are endemic to the region are also globally threatened.

Figure. 4.1 The proportion of freshwater mollusc species in each regional Red List Category in the western Africa region. CR = Critically Endangered, EN = Endangered, VU = Vulnerable, NT = Near Threatened, LC = Least Concern, DD = Data Deficient.



important trematodes of humans and domestic animals. National surveys carried out in several countries over the past century were designed to target these genera but they also recorded other species. The results of these surveys and of other collections were collated by Brown (1980, 1994) in his seminal work *Freshwater Snails of Africa and their medical importance*. Brown indicated in this monograph those species that he considered to be poorly known, and those regions where further research would be merited. Since his work, large areas with remote headwaters in Guinea and Côte d'Ivoire, where it is expected that several new species could be located in river rapids and upper tributaries, have been difficult to survey because of political disturbance. Islands, such as the Bijagos off Guinea Bissau, also represent areas that need more survey work, as the knowledge of their mollusc fauna is very poor.

For this project, 94 species from the west African region were assessed. Of these, 73 species are gastropods belonging to 13 families (Brown 1994) and 21 species are bivalves belonging to six families (Daget 1998, Mandahl-Barth 1988, Graf and Cummings 2007).

Only six species of western Africa freshwater molluscs are on the 2008 IUCN Red List, all assessed by Brown in 1996 using the IUCN Red List Categories and Criteria: Version 2.3 (IUCN 1994). Two species are listed as Critically Endangered, one as Vulnerable and three as Data Deficient. This was the last conservation assessment for the region.

4.2 Conservation status (IUCN Red List: Regional Scale)

The results presented below are based on an assessment of each species' conservation status using the IUCN Red List Categories and Criteria: Version 3.1 as applied at a regional scale (IUCN 2001, 2003) to western Africa (Table 4.1). For those species endemic to western Africa, the Red List status at the regional level is also the global Red List status.

During the last 100 years, parts of western Africa have changed radically from the environments of the late 18th/ early 19th century, as human exploitation of the forests, minerals and, more recently, construction of irrigation schemes, large dams and pesticide control have affected the region. The majority of freshwater molluscs species (*c.* 65%) are classed as Least Concern (Figure 4.1). Most of the species that occur in western Africa are widely distributed across most of the range states. Although there is a decline of species' ranges and populations in most habitats, the overall impact does not qualify many species for a threatened status, as most molluscs have a short generation time, requiring a catastrophic collapse of populations to trigger the 30% decline in 10 years. Of the 94 species found within the region four species were assessed as Not Applicable, as more than 95% of their population is based outside the region, predominantly in the central African region, or are introduced species and were excluded from the analysis.

The proportion of species in the Data Deficient category (15.6%), is relatively low when compared to assessments from other regions; in southern Africa the proportion of species classed as DD is 33.6% (Darwall *et al.* 2009) and in eastern Africa it is 38% (Darwall *et al.* 2005). Fifteen species (16.6%) are classed as regionally threatened (Table 4.2), which represents a similar level of threat as is faced by freshwater molluscs in eastern Africa (18.6%) but almost double that in southern Africa (8.6%). Of these 15 regionally threatened species, 13 are endemic to the region, making them globally threatened with extinction.

4.2.1 Gastropods

Within the family Neritidae, one species, *Neritina tiassalensis,* is listed as Critically Endangered. This species has a very limited distribution, being restricted to only the rapids of the Bandama River at Itassalé in Côte d'Ivoire (Brown 1994). This species has been highlighted as *Possibly Extinct*, as the site where it was found is now downstream of two dams, which have in the past totally dried up.

The family Hydrobiidae is well known to hold many range-restricted species that are threatened with extinction (e.g., Seddon 1998, Darwall *et al*. 2009). Of the four species known from the western Africa region, only one species is considered to be threatened. *Hydrobia guyenoti* (EN) has a very limited range; it is found in Toupah Bay of the Lagune d'Ebrié, Côte d'Ivoire, where it is threatened by organic pollution and eutrophication, which is leading to near total oxygen depletion in some of the bays (Ukwe *et al.* 2006). The other two species, *H. accrensis* and *H. lineata* are Near Threatened and Data Deficient respectively.

Table 4.2. Threatened freshwater mollusc species in the western Africa region

Family	Genus species	Red List Category
Viviparidae	*Bellamya liberiana*	CR B1ab(iii) +2ab(iii)
Bithyniidae	*Gabbiella neothaumaeformis*	CR B1ab(iii)
Neritidae	*Neritina tiassalensis*	CR B1ab(ii,iii)
Bithyniidae	*Sierria outambensis*	CR B1ab(iii)
Bithyniidae	*Soapitia dageti*	CR B1ab(i,ii,iii,iv,v)
Assimineidae	*Assiminea hessei*	EN[RG] B1ab(iii) +2ab(iii)
Planorbidae	*Biomphalaria tchadiensis*	EN B1ab(i,ii,iii) +2ab(i,ii,iii)
Planorbidae	*Bulinus natalensis*	EN[RG] B1ab(iii) +2ab(iii)
Hydrobiidae	*Hydrobia guyenoti*	EN B1ab(iii)
Bithyniidae	*Gabbiella tchadiensis*	EN A2c; B2ab(iii)
Planorbidae	*Bulinus obtusus*	VU B2ab(iii)
Mutelidae	*Mutela franci*	VU B2ab(iii)
Thiaridae	*Potadoma vogeli*	VU B1ab(iii); D2
Bithynidae	*Sierraia expansilabrum*	VU B1ab(iii)
Bithynidae	*Sierraia leonensis*	VU D2

[RG] = Regional Red List status

Afropomus balanoidea (NT) (left) and *Saulea vitrea* (DD) (right). Photo: © Henry Madsen.

The larger gastropod species of the family Viviparidae are represented by two species belonging to the genus *Bellamya.* One of these, *B. liberiana* is classified as Critically Endangered and is known only from the type locality, on the rock near Bavia, St.Pauls River, Liberia (Brown 1994). It is considered threatened due to the potential for disruption of the water course and declining water quality from water pollution. However, given the difficulties with access for active survey work in Liberia, it is currently unknown whether the species is still extant.

Eight species in the family Ampullariidae are known in four genera, *Afropomus*, *Saulea*, *Pila* and *Lanistes*. The species from this family are mostly widespread and provide a source of protein, as some are eaten at a subsistence level. The six species from the genera *Pila* and *Lanistes* are all assessed as Least Concern, but *Saulea vitrea* is classified as Data Deficient and *Afropomus balanoidea* as Near Threatened.

Three genera from within the family Bithynidae are found in the western African region. *Gabbiella* is represented by four species, two of which are threatened; *G. tchadiensis* (EN) occurs on the southern shores of Lake Chad and Yobe River at Yo in Cameroon and in Lake Lere in Chad (Brown 1994) and *G. neothaumaeformis* (CR) is known from only four shells from the southern shore of Lake Chad. Both species are being impacted due to increasing levels of water abstraction leading to a decline in the are of Lake Chad and the spread of introduced species such as water hyacinth (*Eichornia crassipes*). The genus *Sierraia* is restricted to the region and is represented by four species, of which *S. expansilabrum* and *S. leonensis* are assessed as Vulnerable and *S. outambensis* as Critical Endangered; all are impacted by pollution, particularly from mining and the changing flow regime caused by dams. These species are endemic to Sierra Leone and have very restricted ranges, found mostly in fast flowing water. A fourth species, *S. whitei*, is more widely distributed and assessed as Least Concern. The third genera is represented by the species *Soapitia dageti* (CR), which is known only from the type locality in Guinea (Konkoure River above Kaleta Rapids). Although there has been no survey work since the initial discovery of this species, there is a possibility that the species is extinct, as at the time of sampling the habitat had been completely drained of water for engineering works.

Irrigation Canal housing pulmonate snails belonging to the genus *Bulinus*, intermediate host for *Schistosaoma haematobium* the parasite causing urinary schistosomiasis. Photo: © H. Madsen.

The family Assimineidae is represented by *Assiminea hessei,* which is assessed as Endangered[RG]. It has a very limited distribution at Port Harcourt in Nigeria, an area that has been impacted by oil drilling, but it is also known from outside the western Africa region in western DRC (the type locality).

The family Thiaridae, with 16 species, is the most common and most numerous in the western African region. Within the five genera, *Cleopatra, Potadoma, Pachymelania, Melanoides* and *Pseudocleopatra*, only one species, *Potadoma vogeli* (VU), is assessed as threatened. However, five species are assessed as Data Deficient, four due to lack of information on the species distribution and one due to taxonomic uncertainty.

The western African region has 26 species of pulmonate gastropods belonging to five families. The family Lymnaeidae is represented by *Lymnaea natalensis* (LC[RG]), a widespread species which is host for the liver fluke (*Fasciola gigantica*), a parasite that infects stock animals and people. However, *L. natalensis* is a very variable species across its area of distribution, and molecular analysis may reveal that it contains a number of species (S. Mas Coma, pers. comm. 2006; Lamb and Appleton, unpublished data 2007).

The family Ancylidae is represented by three species belonging to one genera, *Ferrissia*, all of which are assessed as Data Deficient. Ancylids are very small and are likely to be overlooked by collectors in the field. Currently, identifications are best made on the basis of proximity to the type localities of the described species. One species, *F. leonensis* (DD), is endemic to western

Bulinus umbilicatus (LC). Photo: © H. Madsen.

Africa and only known from the type locality in Sierra Leone. Research on these african ancylids, including a taxonomic revision of the genus, is strongly recommended.

The family Planorbidae comprises two sub-families, the Planorbinae and Bulininae. In the Planorbinae 10 species belonging to six genera are found in the western Africa region. All are well known and assessed as Least Concern, except one, *Biomphalaria tchadiensis* (EN), which is endemic to Lake Chad, where it is impacted by introduced species (such as water hyacinth) and the reduction in the area of the lake due to water abstraction. One species, *Ameriana carinata,* is introduced and assessed as Not Applicable. The genus *Biomphalaria*

includes species that act as intermediate hosts for a blood fluke (*Schistosoma mansoni*) which causes the serious human disease, intestinal schistosomiasis. The sub-family Bulininae includes nine species in two genera, *Indoplanorbis* and *Bulinus*. The single species within the genus *Indoplanorbis*, *I. exustus* is introduced and assessed as Not Applicaple. All species within the genus *Bulinus* are ranked as Least Concern, except *Bulinus obtusus* (VU), endemic to a few locations in Lake Chad, and *B. natalensis* (EN[RG]), which in this region is known from four crater lakes in western Cameroon but which is also found in eastern and southern Africa. However, the relationship with these populations needs to be studied. Within the genus *Bulinus*, several species act as intermediate hosts for a blood fluke (*Schistosoma haematobium*) that causes the debilitating disease urinary schistosomiasis in humans, and the cattle/antelope parasite *S. bovis*.

Two species from the family Physidae occur in the region; *Aplexa waterloti* (LC) is endemic to the region and *Physa acuta* was introduced from the Americas and is assessed as Not Applicable.

The family Ellobiidae is represented by *Melampus liberianus*, primarily a brackish water species which is widespread and assessed as Least Concern[RG].

4.2.2 Bivalves

The bivalves are not as well known as the gastropods in western Africa. Six families are believed to be present including 10 genera and 21 species, four of which are endemic to the region.

Most species (15) are assessed as Least Concern, four species all from the family Mutelidae are assessed as Data Deficient and one species *Pisidium pirothi* is Not Applicable. Only one species, *Mutela franci* (VU), is classed as threatened; it occurs only in the middle part of the River Niger (Mandahl-Barth 1988), where negative effects from dams, mining and the spread of water hyacinth are all impacting the species, along with host fish mobility (mussels use fish as an obligate host for their larvae).

4.3 Patterns of species richness

4.3.1 All mollusc species

An extensive area of the western Africa region supports a high richness of mollusc species, with up to 44 species recorded in some areas (Figure 4.2). The highest densities of species (29-44 species per grid cell) are found in the catchments of the middle

Figure. 4.2 Freshwater mollusc species richness in the western Africa region. Species richness = species per hexaganol grid cell (289 km²).

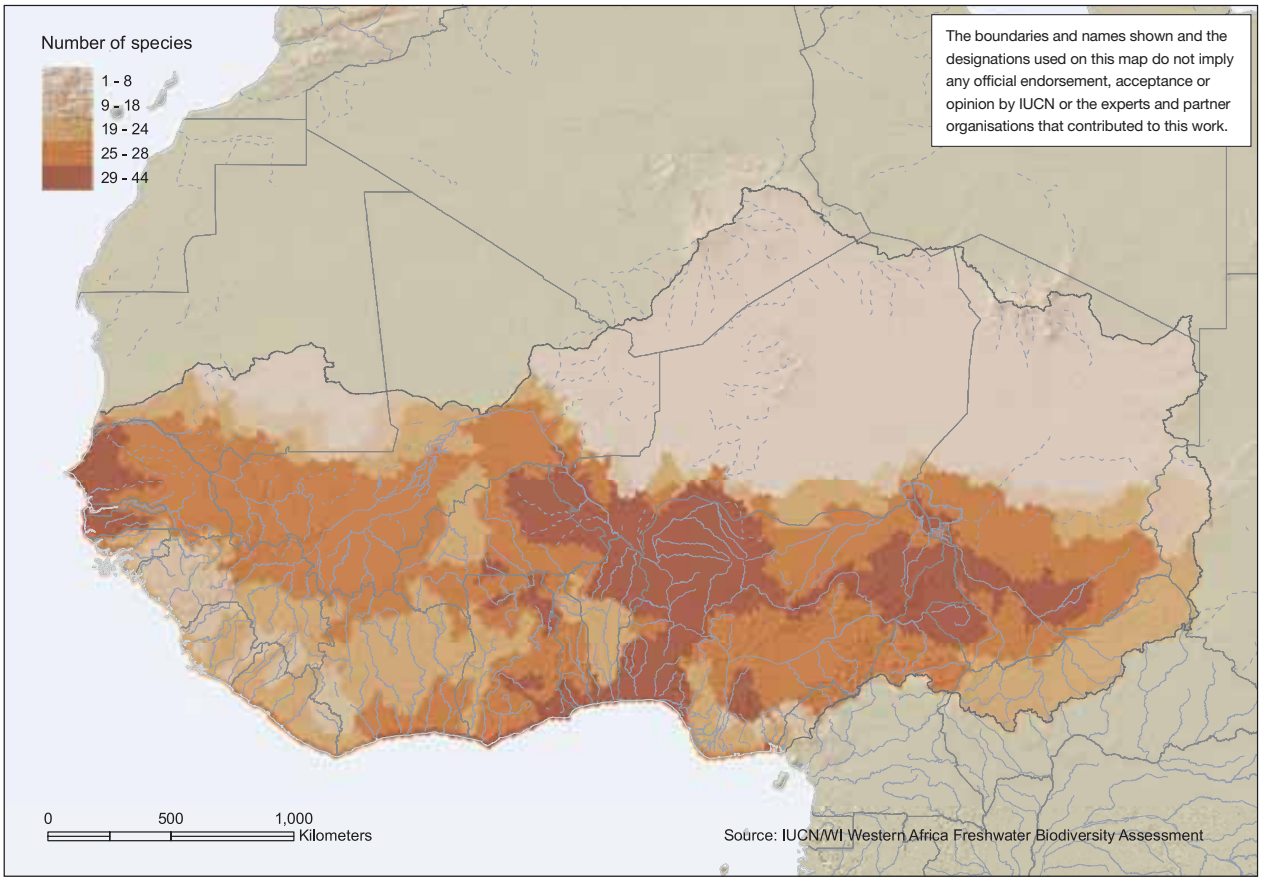


Figure. 4.3. Threatened freshwater mollusc species richness in the western Africa region. Species richness = species per hexaganol grid cell (289 km²).

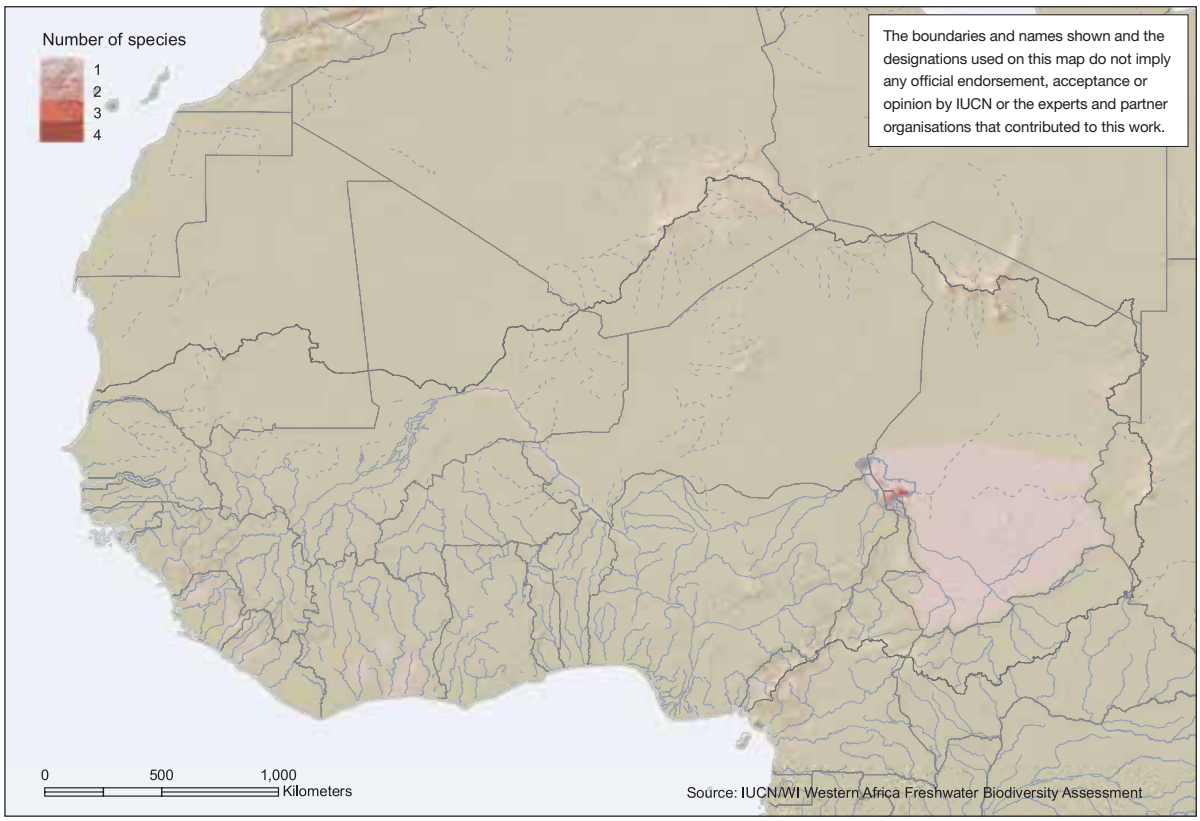
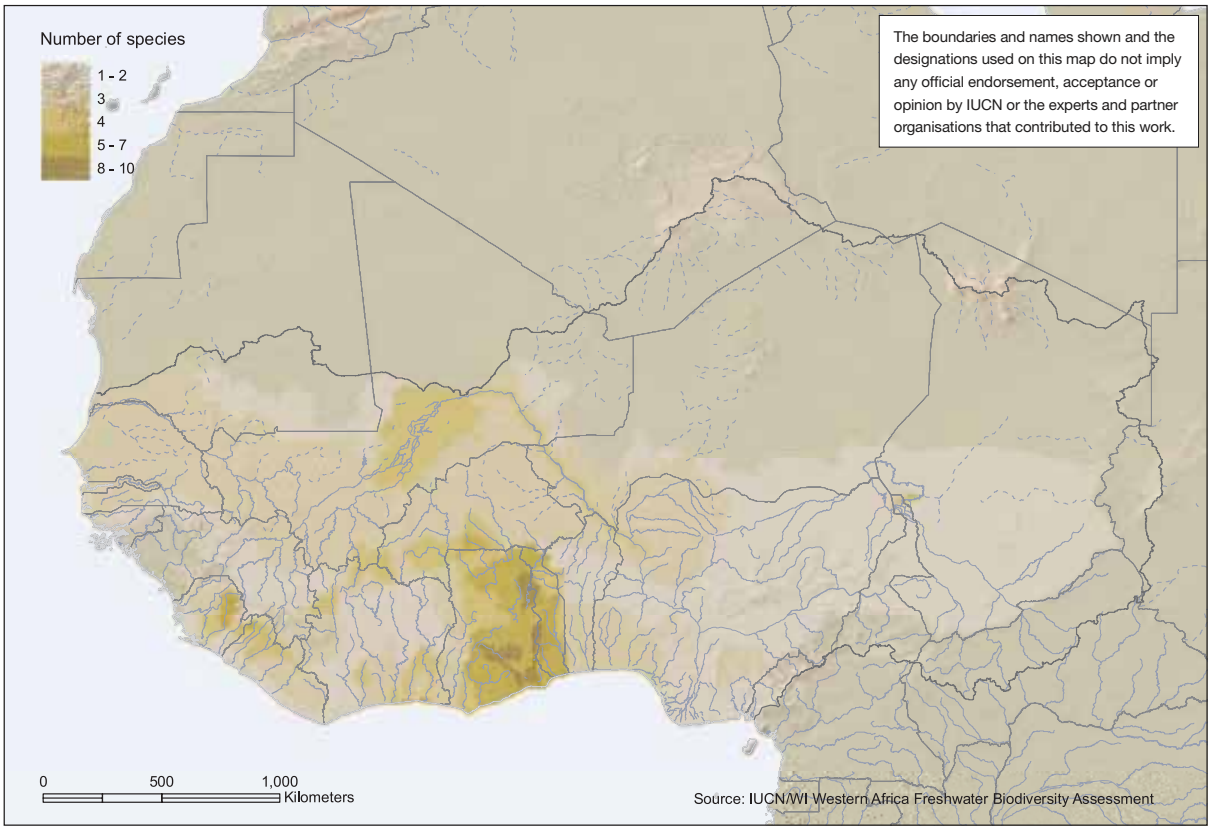


Figure 4.4 Endemic freshwater mollusc species richness in the western Africa region. Species richness = species per hexaganol grid cell (289 km²).



and lower Niger, upper Benue, lower Senegal and Gambia and Chari. High numbers of species (25-28 species per grid cell) are found in much of the rest of the region, except the Upper Guinea region and the Dry Sahel.

The high species richness in parts of the region does not reflect the presence of particular families or genera as was seen in southern Africa (Darwall et al. 2009); on the contrary, a wide representation from several families is seen.

4.3.2 Threatened species

As described in 4.2, 15 species are classified as threatened. These species are mainly concentrated in the very restricted streams of Guinea, Sierra Leone, Liberia and Côte d'Ivoire, and the upper part of the River Niger (one bivalve species, *Mutela franci* is responsible for this assessment in the River Niger). However, the highest concentration of threatened species (four) is found in Lake Chad (see Figure 4.3).

4.3.3 Endemic species richness

A number of species (36) are endemic to the western African region. Figure 4.4 shows that the lower part of the Volta ecoregion has the highest number of endemic species (8-10), along with the eastern part of the Southern Upper Guinea ecoregion and the southern part of Lake Chad (5-7). Medium numbers of endemic species were found in the Inner Niger Delta region.

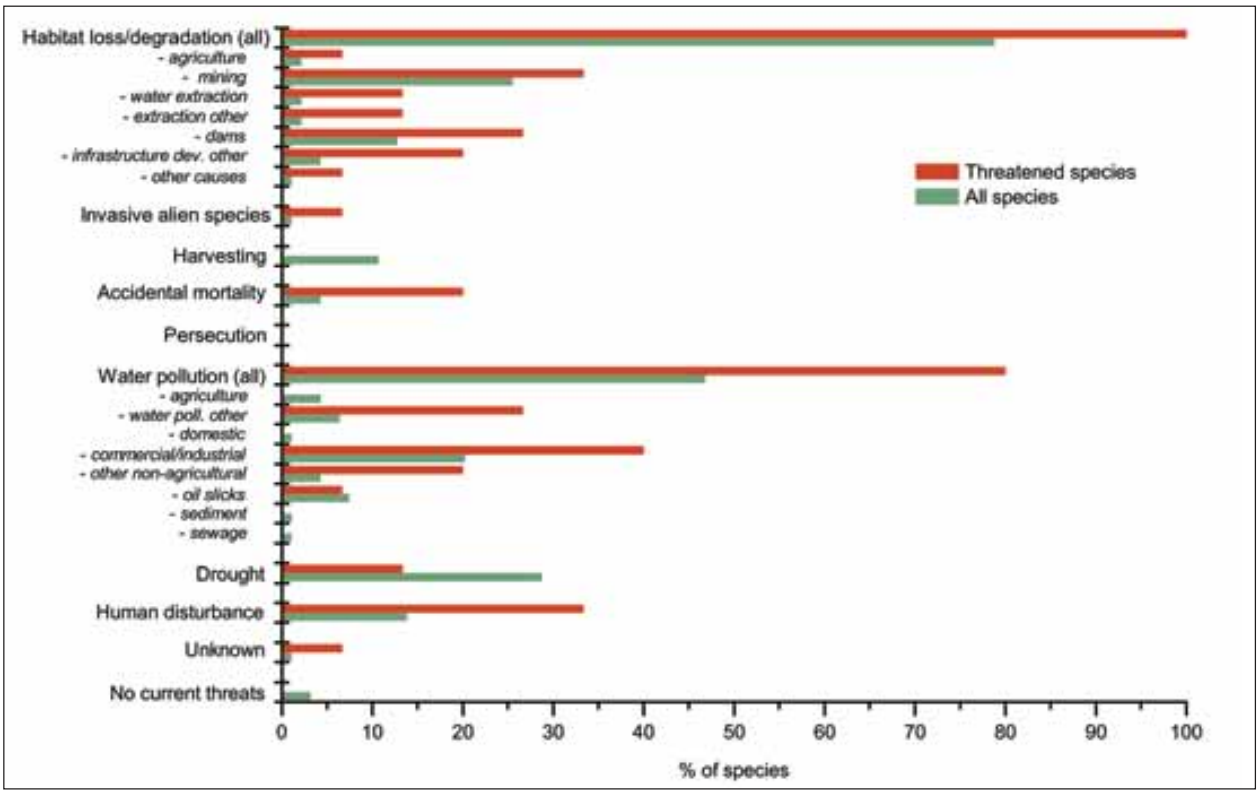
4.4 Major threats to molluscs

Most of the threatened species occur in a restricted number of localities, often needing clean rapid running water, making them susceptible to pollution and the impact from dams. There are many rivers in western Africa that are under development for the construction of dams for electricity or irrigation. This will change the flow regime downstream, flood suitable habitat and may also block the movement of obligate host fish species for bivalves. Industrial pollution and mining activities are also a key threat to freshwater molluscs in the region. In southern Nigeria, and particularly in the delta, oil drilling, chemical seepage, human domestic developments and interference in the seasonal wet-dry cycles of ephemeral habitats are having major impacts on mollusc fauna. Mining activities impact much of the Guinea basin, and while oil exploitation may be most conspicuous, bauxite, gold and diamond mining are also having major impacts in many river systems.

High levels of water abstraction, particularly for irrigation, are having a major impact upon molluscan fauna and their habitats. For example, the area of Lake Chad declined by 63% between 1962 and 1985 (Fishpool and Evans 2001), a trend which continued until at least until 2001 (UNEP 2002). Over this period, irrigation water use increased four-fold.

Information collated through this assessment process has allowed the type of threats to freshwater molluscs across western

Figure 4.5 Percentage of freshwater mollusc species affected by each major threat. Note that many species have more than one threat listed.



Africa to be quantified. Figure 4.5 shows that habitat loss (78% of all species, 100% of threatened species) and pollution (47% and 80%) are impacting the greatest number of species. Within these broad threat categories the major causes can be identified as commercial and industrial pollution, which impacts 40% of threatened species, and habitat loss due to mining and human disturbance, each affecting 33% of threatened species. Only 3% of species have no threats at all.

4.5 Conservation recommendations

Unfortunately, only a minority of the threatened or potentially threatened 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.

4.5.1 Conservation measures

Many of the threatened species occur in only one or a few rapid rivers and streams. These localities should be protected against developments such as dams or irrigation schemes, which would destroy the habitats of the species.

There should be no development allowed on sites known to have threatened species without a full Environmental Impact Assessment, with species specific surveys by an experienced surveyor using appropriate techniques at an appropriate time of the year.

4.5.2 Research action required

Fourteen species are categorized as Data Deficient and several of the threatened species are also poorly known; including *Bulinus obtusus* (VU), *Assiminea hessei* (EN[RG]), *Bellamya liberiane* (CR), *Biomphalaria tchadiensis* (EN), *Gabbiella neothaumaeformis* (CR), *G. tchadiensis* (EN), *Hydrobia guyenoti* (EN) and *Neritina tiassalensisi* (CR). The taxon *Bulinus natalensis* (EN[RG]) is known from four crater lakes in Cameroon and may not belong to the true *B. natalensis* species that occurs in eastern and southern Africa, and therefore needs to be further examined.

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Chapter 5. The status and distribution of dragonflies and damselflies (Odonata) in western Africa

Dijkstra, K-D.B.[1], Tchibozo, S.[2], Ogbogu, S.S.[3]

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

5.1.1 Widespread endemics of western Africa

Of the 311 species known to occur in western Africa, 61 (20%) are considered endemic. Many of these are widespread and therefore of least concern. Only a few endemics occupy open habitats, and of these *Nesciothemis minor* (LC) is most widespread, often occurring at heavily disturbed streams and rivers. *Phyllomacromia amicorum* (LC) is a possible endemic, known only from northern Côte d'Ivoire and northern Nigeria, but it may occur across to Ethiopia in the savannah belt. Its suspected habitat (savannah rivers) is poorly surveyed, and therefore this species is probably under-recorded rather than rare. Although species like *Sapho ciliata* (LC) (see photo), *Chlorocypha luminosa* (LC), *C. radix* (LC), *Pseudagrion malagasoides* (LC), *Chlorocnemis elongate* (LC), *C. flavipennis* (LC), *Elattoneura girardi* (LC), *Prodasineura villiersi* (LC), *Platycnemis guttifera* (LC) and *Phyllogomphus moundi* (LC) are characteristic of forest streams from Guinea all the way to Nigeria (Dijkstra and Lempert 2003), the extensive habitat degradation in the region is a threat whose impacts must be continuously monitored. The same applies for the Upper Guinea endemics (not occurring east of the Dahomey Gap) *Diastatomma gamblesi* (LC), *Lestinogomphus matilei* (LC), *Phyllogomphus aethiops* (LC), *Phyllomacromia sophia* (LC), *Trithemis africana* (LC) and *Zygonyx chrysobaphes* (LC).

Sapho ciliata (LC) male (left) and female (right). This western African endemic is characteristic of running waters with some forest cover throughout the region. Photos: © Piotr Naskrecki.

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Paragomphus sinaiticus (regionally EN) male in the United Arab Emirates. The isolated population in Niger is the only desert dragonfly considered as threatened in western Africa. Photo: © Bob Reimer.

5.1.2 Xeric freshwaters and Lake Chad basin

5.1.2.1 Dry Sahel and Lake Chad Catchment

The dry north of western Africa, which includes the Dry Sahel and Lake Chad Catchment ecoregions, has a very impoverished dragonfly fauna that consists of about 30 widely-dispersing species. Although it ranges east to Arabia, in western Africa *Paragomphus sinaiticus* (EN[RG]) occurs only at permanent still waters in the Air Mountains of Niger (Dumont 1978; Martens and Dumont 1983). This region is suffering major droughts and the species is sensitive to water extraction. Hence it is regionally considered as Endangered. The poorly-known endemic *Phyllomacromia nigeriensis* (DD) has been collected at N'Djamena (see below).

5.1.3 Savannah dry forest rivers and inner Niger delta

5.1.3.1 Senegal-Gambia Catchments

The Gambia is especially well-studied (Gambles *et al*. 1995, 1998; Prendergast 1998). The region has a rather unremarkable fauna of widespread species, with the notable exception of *Mesocnemis dupuyi* (NT) (Legrand 1982b), which is known only from a few sites along the upper course of the Gambia River. A dam upstream of these sites might affect the river's water regime and this endemic damselfly. It might also impact *Elattoneura pluotae* (CR), discussed in the section on the Fouta Djalon below. *Phyllomacromia royi* was only known from the holotype from Senegal, but is considered a synonym of *P. overlaeti* (DD[RG]). This is the only known record from the region (Dijkstra 2005a). *Onychogomphus supinus xerophilus* (DD) was described from Parc National du Niokolo-Koba. It belongs to a taxonomically confused species complex; in western Africa related specimens were collected in Sierra Leone (Carfi and D'Andrea 1994), Guinea (Legrand 2003) and Ghana (Dijkstra 2007c).

5.1.3.2 Lower Niger-Benue and Inner Niger Delta

This huge area has a typical fauna of savannahs and woodlands, but is poorly studied. An exception is the Nigerian Jos Plateau with its greater habitat diversity. This was the work area of Robert M. Gambles, most of whose records still lie undisclosed in the BMNH, London. Gambles (1971) described *Phyllomacromia nigeriensis* (DD) from his home at Vom. The species is otherwise only known from an unpublished record from N'Djamena in nearby Chad (coll. RMNH, Leiden), but belongs to an inconspicuous group of insects. The same applies to another of his species, *Lestinogomphus minutus* (DD) known only from the female holotype collected near Bida in north-west Nigeria (Gambles 1968) and a similar female from adjacent north-east Benin (Tchibozo and Dijkstra 2003). However, the taxonomy of the genus is difficult and based largely on males.

5.1.3.3 Volta

This ecoregion has a reasonably well-known fauna typical of savannahs, a good example of which is Ghana's Mole National Park (Marshall and Gambles 1977). No unusual species have been reported, but extensive potentially valuable habitat has been lost through the damming of the Volta (see below).

5.1.3.4 Bight Coastal

The Beninese part of this region, in particular, has been fairly well studied (Tchibozo and Dijkstra 2003, Tchibozo *et al.* 2008). The only real endemic is *Ceriagrion citrinum* (VU), which inhabits swamp forest in southern Benin, and south-western Nigeria and due to its conspicuous appearance (Dijkstra 2005b) is unlikely to have been overlooked elsewhere, although it may occur in the barely-studied Niger Delta. The eastern slope of the Togo range also falls in the ecoregion. *Chlorocypha jejuna* (CR) is known only from the type material from an unknown location in Missahöhe (Missahoé) – a forested range near present day Kpalimé (Dijkstra 2003a). Although it has been confused taxonomically, it seems unique and it is surprising that such a conspicuous insect has not be rediscovered in this reasonably well-surveyed area (both the Ghanaian and Togolese sides of the mountains). *Phyllomacromia legrandi* (DD) was known only from the type males collected near Kpimé in Togo (Gauthier 1987), but Dijkstra (2007c) collected two males in southern Ghana. Moreover, a third male obtained there suggests synonymy with *P. melania* (LC[RG]), which occurs from Liberia and Guinea to Uganda.

5.1.4 Large river deltas

5.1.4.1 Niger Delta

The dragonfly fauna of this large area of swamp, forest and mangroves is effectively unknown, as is true for this type of habitat throughout Africa. After the Fouta Djalon and the Nigerian part of the Northern West Coastal Equatorial region it is the foremost survey priority in western Africa. An old record from Nigeria (unspecified location) of *Zygonoides occidentis* (DD[RG]), a species known otherwise only from large rivers in the Congo Basin, may indicate its presence on the lower Niger (Dijkstra *et al*. 2006). The globally Vulnerable *Ceriagrion citrinum* may occur in this ecoregion (see section on Bight Coastal region).

The threatened swamp forest of Lokoli, Benin, habitat of Ceriagrion citrinum (VU) Photo: © Séverin Tchibozo

5.1.5 Moist forest rivers

5.1.5.1 Northern Upper Guinea

Almost no dragonfly records are available from western Guinea, but Sierra Leone is comparatively well-studied, with about 134 species recorded (Aguesse 1968, Carfì and D'Andrea 1994, Dijkstra 2007d, Marconi and Terzani 2006). As a probable consequence, several species of interest are known (almost) exclusively from this region. *Pseudagrion mascagnii* (CR) is known only from type material (Terzani and Marconi 2004), despite being a conspicuous insect occurring in a reasonably well surveyed region. The only locality, Regent, lies in the suburbs of Freetown and will certainly deteriorate. *Elattoneura dorsalis* (VU) is known from four sites in Sierra Leone within a 20,000 km^2 area of lowland forest habitat, which is expected to deteriorate in the future due to agricultural expansion. *Agriocnemis angustirami* (VU) was first recorded from this region, but extends somewhat east. It is known only from

Savannah rivers, such as the White Volta flowing below Ghana's Gambaga Escarpment, have a rather similar dragonfly fauna throughout western Africa. Photo: © K.-D.B. Dijkstra.

The dragonfles of large deltas, such as of the Sanaga here in Cameroon, the Niger and Volta, are almost unknown but may harbour specialists of swamp forest and big rivers. Photo: © K.-D.B. Dijkstra.

swampy habitats, possibly on the edge of mangroves, near the regional capitals of Freetown and Monrovia (Lempert 1988, Terzani and Marconi 2003). Various Sierra Leonean species are considered as Data Deficient. Already described in 1876, *Argiagrion leoninum* was listed as Endangered in 2003, but reassessed as Data Deficient in 2006. Though allegedly from Sierra Leone, the only known specimen, a female, does not look like an African species and therefore its geographic origin is doubted (Dijkstra 2003b, Dijkstra and Vick 2004). Similarly, *Lestinogomphus africanus*, *Phyllogomphus bartolozzii* and *P. helenae* (all DD) are all known only from their holotypes which are poorly preserved and of dubious taxonomic standing. *Sleuthemis diplacoides* was short-listed by Dijkstra and Vick (2004) as a western African odonate requiring special attention, being only known from the holotype from Guinea and that of its synonym *Monardithemis leonensis* from Sierra Leone. These specimens belong to the genus *Aethiothemis* (Dijkstra and Vick 2006) and appear identical to another species known only from type material: *A. bella* from north-east Congo-Kinshasa. Rather mysterious is the status of *Orthetrum sagitta* (DD), which belongs to a genus of conspicuous and ecologically tolerant species. Although there are reports from all over Africa, the few reliable records are all from Sierra Leone. The habitat and ecology are unknown, so this species is possibly threatened.

5.1.5.2 Southern Upper Guinea

The Liberian Odonata are reasonably well known, with almost 160 species recorded (Dijkstra 2007d, Lempert 1988). Of conservation significance is *Mesocnemis tisi* (EN) known from one locality, the Sinoe River and a tributary (Lempert 1988; 1992), within a 5,000 km² area of forest habitat, which is expected to deteriorate in the future. The regionally Vulnerable *Porpax bipunctus* is known from eastern Liberia and south-western Côte d'Ivoire, well-separated from the nearest population in south-eastern Nigeria and south-western Cameroon. These populations appear to be restricted to Pleistocene rainforest refugia and are differently marked, possibly representing separate taxa (Dijkstra 2006b). Another more widespread species of special interest is *Pseudagrion cyathiforme* (LC), described simultaneously with *P. malagasoides* (LC) from Liberia (Pinhey 1973). Neither species is typical of that genus and they may belong together in an endemic genus (Dijkstra 2007a, Dijkstra *et al*. 2007). Most records of *P. cyathiforme* are from Liberia and Sierra Leone, but there is an unconfirmed record from Nigeria (Lempert 1988).

5.1.5.3 Eburneo

The fauna of Côte d'Ivoire is fairly well known due to two studies from areas along the Bandama River, in the north at Korhogo (Lindley 1974) and the south at Lamto (Legrand 1982a). Data from the Comoé River are still undisclosed (W. Schneider pers. comm.). Lindley (1970) described the unique genus *Zygonychidium* from the Bandama near Korhogo; *Z. gracile* (CR) has not been recorded again despite seeming fairly conspicuous and occurring in widespread habitat: large savannah rivers. *Phyllomacromia girardi* (DD) is known only from the type series from two sites in the south of the region. The single males known of *Neurogomphus carlcooki* (DD) and *N. chapini lamtoensis* were collected in the same area, but both may represent varieties of more widespread species (Cammaerts 2004). *Phyllomacromia occidentalis* (DD) is only known from the Ivorian holotype (precise locality unknown) and a male compared with it by Lempert (1988) from Liberia. The confusingly similar-named *Phyllogomphus occidentalis* (DD) was described from 'Bwake' (= Bouaké?) and has since been found only at Korhogo (Lindley 1974) and in northern Benin (S. Tchibozo pers. comm.). Lindley (1972) described a related species, *Ph. pseudoccidentalis* (LC), from Korhogo. No records have been published since, but apparently it is widespread in the Sahel, with unconfirmed reports from The Gambia, Mali, Togo and Niger.

Ceriagrion ignitum (DD[RG]) (top photo) was rediscovered in the central Congo Basin almost a century after being described from Ghana, although it does not seem to occupy a special habitat (bottom right) Photos: © K.-D.B. Dijkstra.

5.1.5.4 Ashanti

The forests of southern Ghana have a rich and rather well-known dragonfly fauna; nationally 177 species are known (Dijkstra 2007c). However, it does not harbour many endemic or threatened species. *Ceriagrion ignitum* (DD[RG]) (left photo) was described from Aburi, Ghana, in 1914 but has not been seen in western Africa since. The species must be extant and more widespread, as it was rediscovered in the central DRC in anthropogenic habitat (Dijkstra 2005b, 2007b). Of some interest is the fauna of the Atewa Range, threatened by bauxite mining and human encroachment, that was surveyed after completion of the assessments (Dijkstra 2007c). *Africallagma vaginale* (NA) and *Orthetrum saegeri* (DD[RG]) inhabit rainforest swamps and had not previously been found reliably west of Cameroon. Also noteworthy is the presence of the regionally Vulnerable *Atoconeura luxata*, which occurs at fast sections of forest streams (Dijkstra 2006a, 2007c). Unlike the five eastern African *Atoconeura* species, this one does not occur on top of highlands (above 1000 m), but at their base, including the highlands to the east (Nigeria, Cameroon) and west (Guinea, Sierra Leone). The discovery demonstrates Atewa's isolated highland character, despite its modest elevation. It is, for instance, also the only place in Ghana where brambles (*Rubus*) grow. The valley in Atewa where *A. luxata* occurs is notable for the presence of treeferns (*Cyathea*), a typical plant of Afro-montane forests. The non-assessed *Neurogomphus fuscifrons* was also discovered in Ghana recently. A female at Kintampo is only the fifth specimen known and the first outside Cameroon.

5.1.5.5 Northern West Coastal Equatorial

One of the richest odonate faunas in Africa in terms of species numbers, and probably the richest in terms of restricted range species and relicts, is centred on the southern Cameroon highlands, on the border of the western and central African assessment areas. This artificial division has hampered

Chlorocypha centripunctata (left; regionally EN) and *Pseudagrion risi* (right; LC), both photographed near Bamenda in Cameroon, are Cameroon highland endemics that occur only on the south-eastern fringe of the assessment area. Photos: © Kai Schütte (left) and K.-D.B. Dijkstra (right).

the proper assessment of this unique diversity (but this will be rectified through the pan-African assessment stage of this project where species are assessed across their full distribution ranges in Africa). Many of the endemic species (e.g. *Pseudagrion risi;* see photo) are probably not threatened globally, but are regionally considered Vulnerable (*Pentaphlebia stahli*, *Africocypha lacuselephantum*, *Nubiolestes diotima*, *Neurolestes trinervis*, *Chlorocnemis contraria*, *Platycnemis rufipes*, *Stenocnemis pachystigma*, *Aeshna scotias*, *Phyllomacromia caneri*) or Endangered (*Sapho puella*, *Umma purpurea*, *Chlorocypha centripunctata*; see photo) due to deforestation, especially in Nigeria. Most of the current knowledge is from the Cameroon part of the Cross River basin. The Takamanda Forest in the north of this area is the locality of the only known specimen of *Neodythemis takamandensis* (CR) (Vick 2000). Despite occurring in a reasonably well surveyed area, its recent discovery, and it being a conspicuous insect, suggests it is rare and restricted in range. The Nigerian part of the ecoregion is very poorly known. An exception, and a site of special concern, is the Obudu Plateau (Gambles 1970, 1975). This is the type locality of *Nesolestes nigeriensis* (CR), otherwise known only from a single site in Cameroon just inside the central African assessment area (G.S. Vick pers. comm.). *Pentaphlebia gamblesi* (CR) is even known only from the holotype from this locality and is globally considered Critically Endangered (Parr 1977).

5.1.6 Highland and mountain systems

There are only a few upland areas in western Africa. Aside from the Cameroon highlands, which lie on its eastern border, the most notable highlands are in the far west, including the Fouta Djalon, Loma and Nimba mountains. Very few records are available from the Upper Niger region (Dumont 1977, Legrand and Girard 1992), which is not discussed further. *Sapho fumosa* (NT), of which *Umma infumosa* is a synonym (K.-D.B. Dijkstra unpublished), is the characteristic endemic of the Upper Guinea highlands that, although localised, is too widespread to qualify for a threatened Red List Category (see photo). It is known from a few sites in Senegal and Guinea-Bissau near the border with Guinea, through Sierra Leone to Mt Nimba. Three closely-related but widespread demoiselles can occur with it, but are ecologically segregated. *Sapho ciliata* (LC), *S. bicolor* (LC^{RG}) and *Umma cincta* (LC^{RG}) favour sandy streams, occurring on the sunniest, shadiest and intermediate sections respectively. *S. fumosa* (DD) was found only where streams were rather shaded and dominated by rocks, a preference that explains why the species is more localised and confined to the more hilly parts of Upper Guinea (Dijkstra 2007d). Dijkstra (2005a) recommended a taxonomic reassessment of Gambles's (1979) forms of *Phyllomacromia aeneothorax* (LC^{RG}) as these may be disjunct restricted-range species. The true *P. aeneothorax* may occur only in the Upper Guinea highlands (Sierra Leone, Guinea, Liberia, Côte d'Ivoire), while another species may occupy highlands in Nigeria, Cameroon and Bioko, 1500 km further east. *Neodythemis campioni* (LC) has a similar distribution as these species, and although it is localised, sufficient habitat appears to be present, especially in Liberia (Lempert 1988).

5.1.6.1 Mount Nimba

The Guinean part of the mountain has been well-studied (Legrand 1983, 1985, 2003; Tchibozo 2008) and is consequently the type locality for nine species, but only *Paragomphus kiautai* (DD) has not also been found elsewhere. *Diastatomma gamblesi* (found also in Sierra Leone, Liberia, Côte d'Ivoire, Ghana and Togo), *Microgomphus jannyae* (Mali) and *Zygonyx geminunca* (Ghana) appear widespread in western Africa (though endemic) and are of Least Concern. Material agreeing with *Onychogomphus mariannae* (first described in *Paragomphus* and probably close to the mysterious *Cornigomphus guineensis* from Rio Muni), *Paragomphus tournieri*, *Tragogomphus christinae* and *Phyllomacromia lamottei* (all DD), were collected by Lempert (1988) in nearby parts of Liberia (Dijkstra 2007d); the latter may also occur in Sierra Leone (F. Terzani pers. comm.). These species are inconspicuous and difficult to survey and thus considered Data Deficient. This latter category may also better suit *Phyllomacromia funicularioides* (NT), which is also known from a few specimens from nearby Liberia (Lempert 1988).

Males of the Upper Guinea highland endemic *Sapho fumosa* (LC) at Dindéfélou Falls, Senegal. Due to variability (old male on left, younger on right) this species was for long also known as *Umma infumosa*. As is apparent from these photographs, the species favour streams with big rocks, unlike its nearest relatives. Photos: © Wulf Kappes.

5.1.6.2 Fouta Djalon

This isolated highland area in western Guinea has never been studied for Odonata. The streams in its forested valleys may harbour important populations of threatened species. *Elattoneura pluotae* (CR), for instance, is known only from the type locality, a stream near Kedougou in south-eastern Senegal on the northern fringes of these highlands (Legrand 1982b). Also some (possibly) threatened Sierra Leonean species, like *Elattoneura dorsalis* (VU) and *Orthetrum sagitta* (DD), may occur here, as well as important populations of *Sapho fumosa* (see above). These prospects make a survey of the Fouta Djalon one of the highest priorities for western African dragonfly conservation.

5.2 Conservation status

The summary presented here is based on a regional species assessment applying the IUCN Red List Categories and Criteria and Regional Guidelines. The regional Red List status of any species which is endemic to western Africa will be equivalent to its global status. Because most species are widespread and/or are tolerant to some habitat degradation, only 27 (9.4%) of the species assessed in western Africa are regionally threatened (Figure 5.1). However, 15 of 61 endemics (i.e., one in four) are deemed under threat (Table 5.1). Moreover, 13.9% of all species, as well as of the endemics, are considered too poorly known

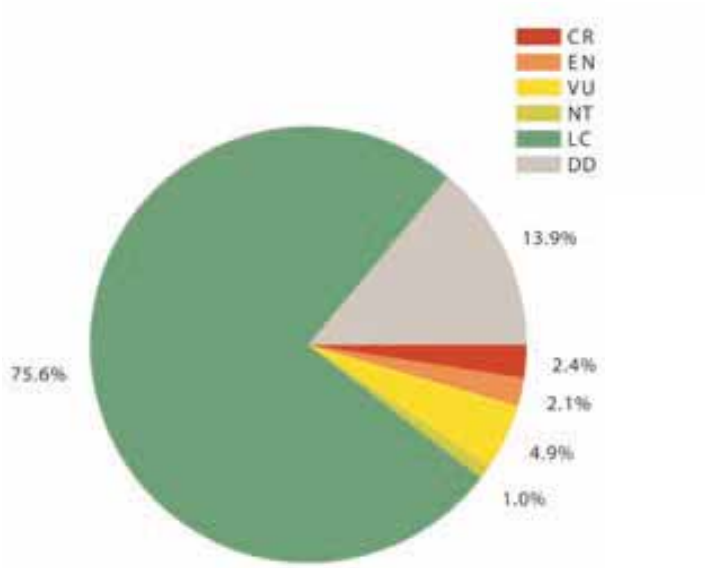
Mining impacts upon Mount Nimba. Photo: © Séverin Tchibozo.

Table 5.1. The number of dragonfly species in each regional Red List Category in the western Africa region.

	Regional Red List Category	Number of species	Number of regional endemics
	Extinct	0	0
	Regionally Extinct	0	-
	Extinct in the Wild	0	0
Threatened categories	Critically Endangered	7	7
	Endangered	6	3
	Vulnerable	14	5
	Near Threatened	3	3
	Least Concern	217	24
	Data Deficient	40	19
	Not Applicable	24	-
	Total	287	61

Note: The total figure does not include NA (Not Applicable) species. All species assessed as regionally threatened which are endemic to the region are also globally threatened.

Figure 5.1 The proportion of dragonfly species in each Regional Red List Category in the western African region. CR: Critically Endangered, EN: Endangered, VU: Vulnerable, NT: Near Threatened, LC: Least Concern, DD: Data Deficient.



for an assessment of threat. Including Near Threatened species, 24.4% of all western African species and 61% of its endemics require further attention (particularly research) because they are either threatened or poorly known (Data Deficient).

5.3 Patterns of species richness

Overall odonate diversity in western Africa (Figure 5.2) shows a sharp north-south gradient from the extremely impoverished Sahara and Sahel, where at most 30 species may occur together (per 289 km² grid cell), to the forested areas from Sierra Leone to Ghana and in Nigeria, where five-to-six times as many species coexist (124-173 species). Where forest is interrupted by woodland there is the notable so-called 'Dahomey Gap' and the number of species drops to between 98-123 species. The diversity of endemic species (Figure 5.3) shows a similar pattern, but there is a sharp transition between the open habitats, where no endemics occur, and the forested south. The endemics constitute about one fifth of the fauna and are concentrated in the Upper Guinea from Sierra Leone to Ghana (21-26 species). The Lower Guinean and Cameroon Highland forests, which occur in the extreme south-east of western Africa, also harbour numerous endemics. Because the delimitation of the western and central African assessment regions runs right through these species' ranges, they are not classified as endemics, although they are highly localised and sometimes threatened. Indeed, the only concentration of threatened species in western Africa (Figure 5.4) is on the Cameroon border (13-14 species), in the periphery of these endemics' ranges. Otherwise, threatened species are scattered throughout the region, e.g. *Mesocnemis tisi* (EN) in Liberia, *Paragomphus sinaiticum* (EN^{RG})in Niger and *Ceriagrion citrinum* (VU) in Benin.

5.4 Major threats to dragonflies

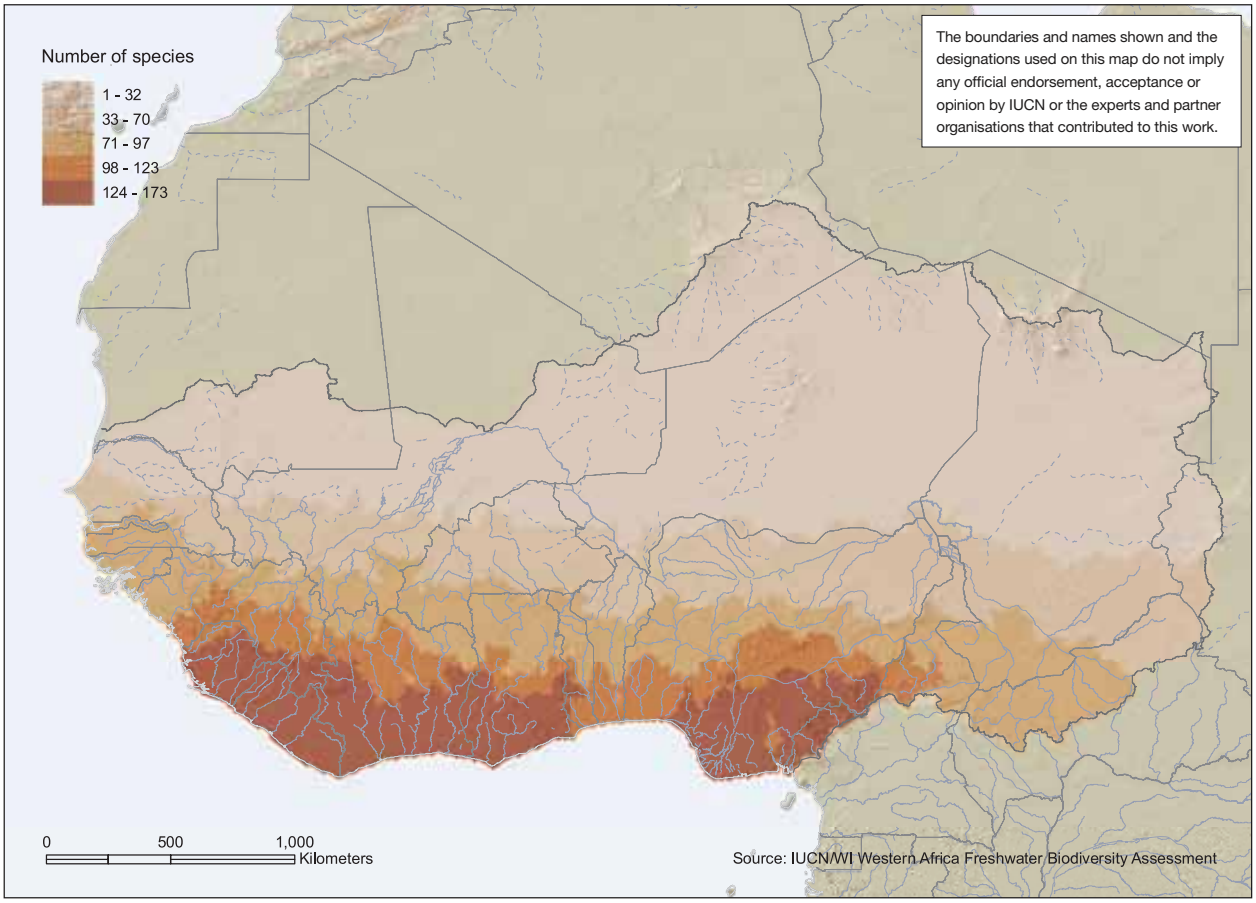
The assessment process enables the major threats to the Odonata of western Africa to be quantified in terms of proportion of species affected by each threat. Figure 5.5 shows that habitat loss due to agriculture, impacting 41% of all species and 56% of threatened species, and deforestation, 42% of all species and 67% of threatened species, is by far the greatest threat to odonate species in the region. Infrastructure development, which includes human settlements, tourism and dams, impacts nearly 20% of threatened species. There are also 17% of species where the threats are unknown, which reflects the high levels of species assessed as Data Deficient.

5.4.1 Habitat degradation

As human populations grow explosively, the general alteration of the natural landscape (especially through deforestation, urbanisation and agricultural encroachment) and the subsequent alteration of water bodies (e.g. by erosion, eutrophication and siltation) is the main threat to Odonata in western Africa and indeed the tropics worldwide. These concerns not only involve species of the once extensive lowland rainforests. The rapid growth of large cities in the coastal zone such as Freetown and Monrovia may endanger species like *Agriocnemis angustirami* (VU) and *Pseudagrion mascagnii* (CR). Gallery forests along rivers in savannah and woodland are especially vulnerable and with them the species that may rely on them, such as *Zygonychidium gracile* (CR) and *Ceriagrion citrinum* (VU).

Participants of the freshwater biodiversity assessment in western Africa overlook Lake Volta from Ghana's Akosombo Dam. Such artificial lakes inundate huge tracts of valuable dragonfly habitat, and their habitat monotony and fluctuating water levels offer no replacement. Photo: © K.-D.B. Dijkstra.

Figure 5.2 Odonata species richness in the western Africa region. Species richness = species per hexaganol grid cell (289 km²).



5.4.2 Damming large rivers

Huge areas of dragonfly habitat have already been inundated by damming, most notably in Ghana by Lake Volta, the largest reservoir by surface in the world at over 8,500 km². No data exist from the area before 1965 when the Akosombo Dam (see photo) was built. O'Neill and Paulson (2001) did obtain records from the another site in Ghana, the Bui Gorge on the Black Volta, which is now under threat by the Bui Dam. Damming in the Upper Gambia catchment may be detrimental to *Elattoneura pluotae* (CR) and *Mesocnemis dupuyi* (NT), either by allowing erratic water level fluctuations downstream or by flooding of habitat upstream.

5.4.3 Mining

Western Africa holds important deposits of aluminium (bauxite), gold and iron ore. These are typically extracted by open-pit mining, leading to extensive damage and even complete removal of the landscape. This is especially problematic in several highlands, such as Nimba, that are entirely composed of economically valuable deposits. The importance of preserving highlands as freshwater catchments was observed in the Atewa Range, Ghana, which has a bauxite cap (Dijkstra 2007c). Three major rivers in this densely populated region have their headwaters there. Of these, the Densu supplies one third of Accra's water. Torrential downpours did not alter the level of the streams and rivers flowing off the range, demonstrating its capacity to absorb and gradually discharge water. Moreover, while the Densu was heavily disturbed, with trees almost completely removed, it still hosted many typical forest dragonflies. This suggests that the water quality was sufficient to support these species despite extensive damage to the surrounding landscape. The steady flow of clean water off the range is determined by the capacity of the soil, swamps and forest on the plateaus and in the valleys to store and filter rainwater, and to buffer for spates and droughts. If the vegetation and deposits are stripped off the range, this would jeopardise the availability of freshwater for millions of Ghanaians and imperil nationally unique biodiversity.

Small-scale mining may also affect dragonfly populations (see photo). Dijkstra (2007d) observed the effects of diamond mining in Gola National Forest, western Liberia. Small-scale activities that do not open up the canopy appear beneficial. Stagnant water bodies are comparatively scarce in rainforest, and partly overgrown pits filled with leaf-litter create new habitat. The scarce near-endemic *Tetrathemis godiardi* (LC[RG]) is an obvious beneficiary; both territorial and emerging

Figure 5.3 Endemic Odonata species richness in the western Africa region. Species richness = species per hexaganol grid cell (289 km²).

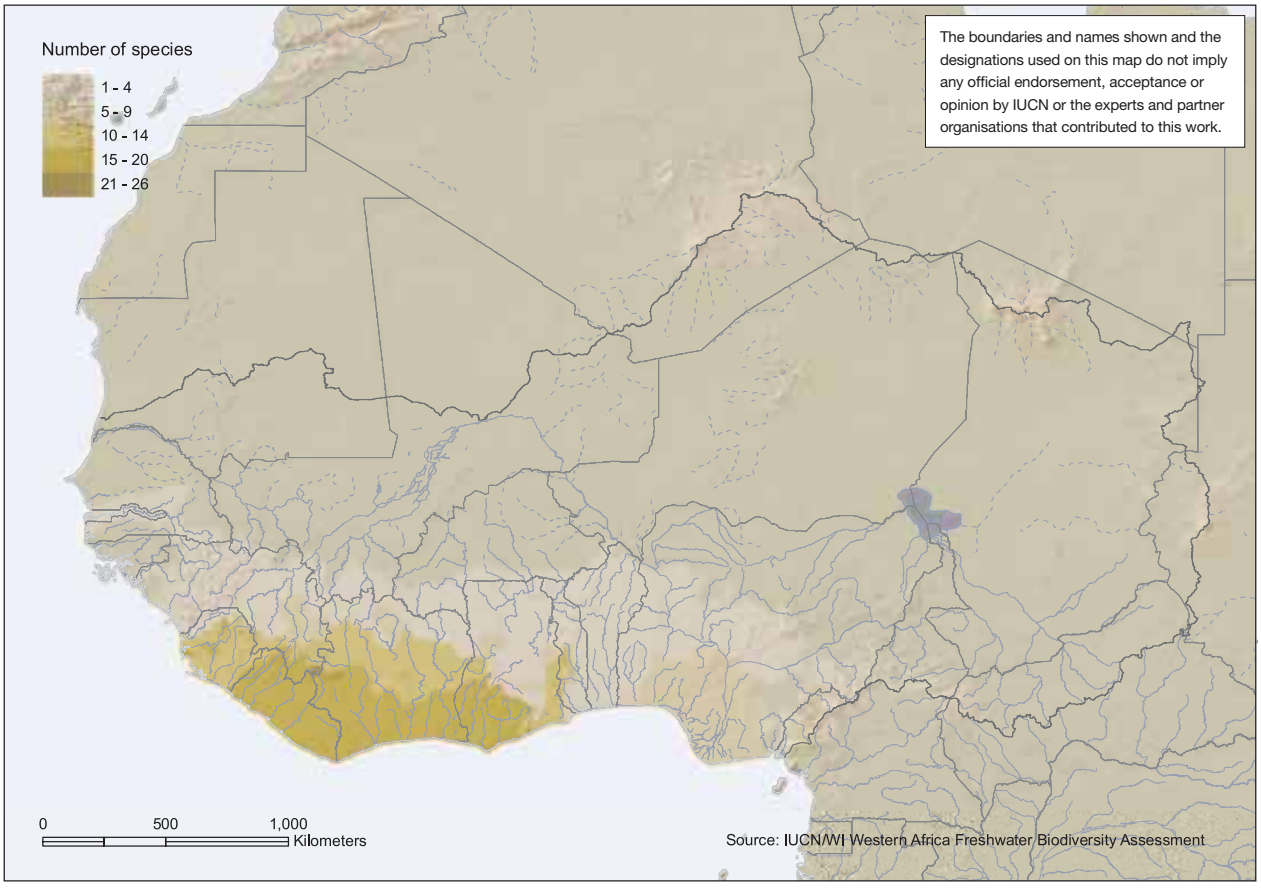


Figure 5.4 Threatened Odonata species richness in the western Africa region. Species richness = species per hexaganol grid cell (289 km²).

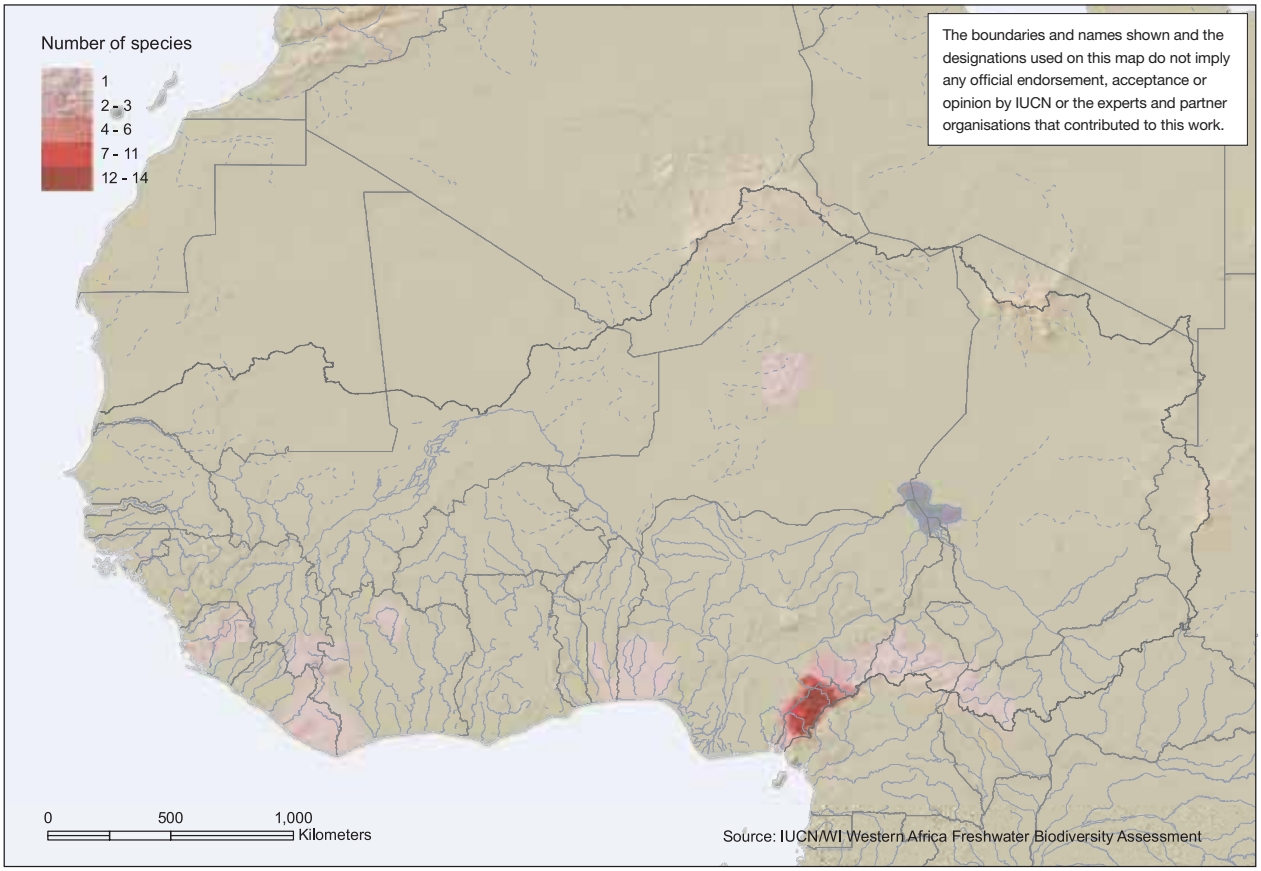
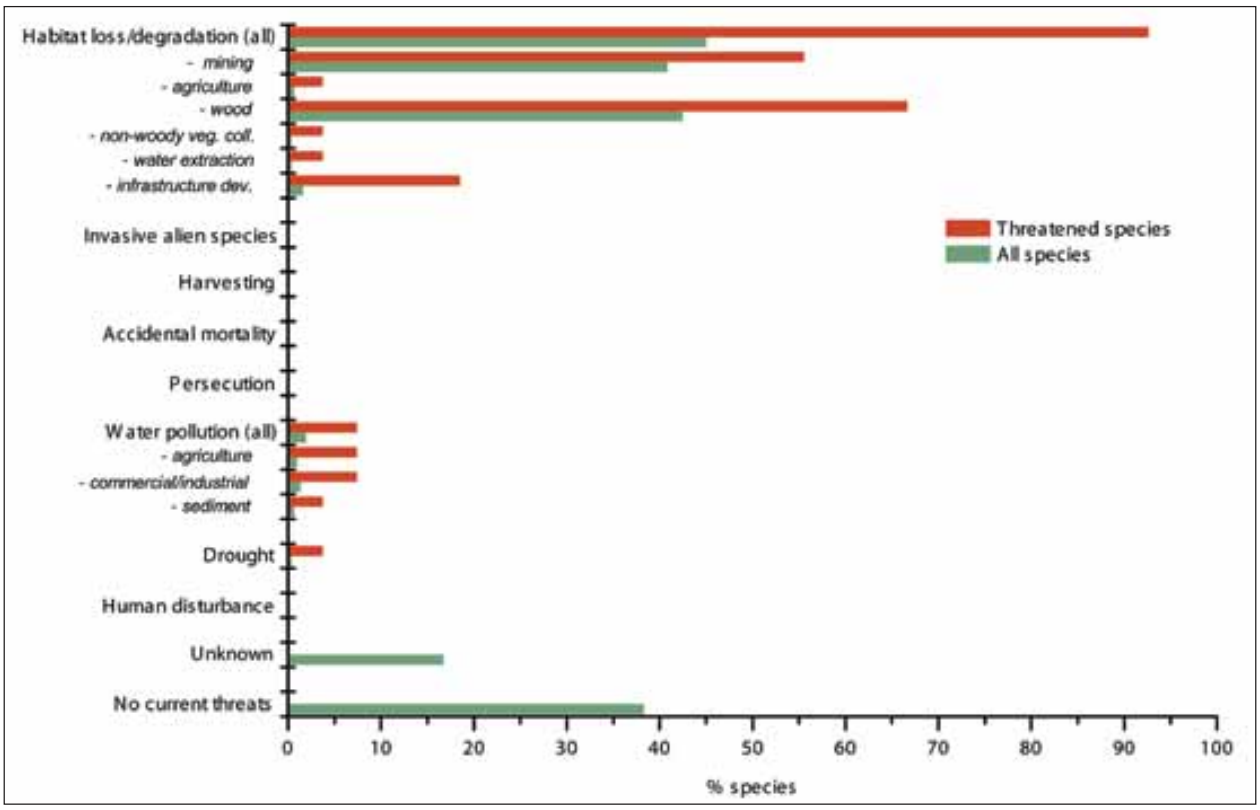


Figure 5.5 Percentage of Odonata species affected by each major threat. Note that many species have more than one threat listed.



Mining, such as for gold on the fringes of Ghana's Atewa Forest Reserve, increases landscape heterogeneity and thus welcomes dragonfly species that might otherwise be absent. However, these are well-dispersing species of open habitats that already have large ranges. More worryingly, mining alters the temperature, chemistry, oxygenation and silt-load of adjacent rivers. Photo: © K.-D.B. Dijkstra.

individuals were found at abandoned pits under closed canopy. Open pits are colonised by many species that would otherwise find no or almost no habitat in the area, but these are all well-dispersing species that dominate savannah faunas throughout Africa. The drainage of the mines leads to increased turbidity, and probably siltation of streams, the former reducing visibility for larvae, the latter changing the substrate. Reduced motion and increased sunning of water in open pits also affects the flow, oxygen and temperature regimes of drainage streams. One such stream was rocky and therefore suitable for the sensitive *Sapho fumosa* (DD) (see above), but held low numbers of that species in comparison to a pristine stream.

5.5 Conservation recommendations

5.5.1 Conservation measures

5.5.1.1 Habitat degradation

For now, most western African endemic dragonflies appear to survive in the small fragments of natural forest that remain. Because deforestation has led to the demise of virtually all forest in the region, the survival of the remnants, especially the large tracts in Liberia, is vital.

5.5.1.2 Damming large rivers

The impact of dams, at least downstream, can be reduced if a natural water regime with normal seasonal fluctuations is retained. Otherwise, breeding habitats and life cycles of dragonflies and other aquatic fauna will be seriously disturbed.

5.5.1.3 Mining

Where mining takes place it is of the utmost importance that minimal damage to the watershed is ensured by leaving broad buffer zones around water bodies (rivers, inundation zones) untouched. Also, minimising the outflow of mining water into the river systems will reduce the possible negative effect of those activities.

5.5.2 Research action required

Many areas have never been studied for Odonata or require further surveys. The most important areas are western Guinea, especially the Fouta Djalon, and south-eastern Nigeria, especially the Cross River State and Niger Delta. Targeted surveys to determine the status and ecologies of (potentially) threatened species should be undertaken in the Upper Gambia catchment (*Elattoneura pluotae* (CR), *Mesocnemis dupuyi* (NT)), Sierra Leone and Liberia (*Agriocnemis angustirami* (VU), *Pseudagrion mascagnii* (CR), *Mesocnemis tisi* (EN), *Elattoneura dorsalis* (VU), *Orthetrum sagitta* (DD)), nothern Côte d'Ivoire (*Zygonychidium gracile* (CR)), Togo (*Chlorocypha jejuna* (CR)), Benin (*Ceriagrion citrinum* (VU)) and south-eastern Nigeria (*Pentaphlebia gamblesi* (CR), *Chlorocypha centripunctata* (EN), *Nesolestes nigeriensis* (CR)). A study of the impact of mining on stream systems and their dragonflies would be insightful.

Waterfalls, such as at Kintampo in Ghana, not only give relief to humans – these Burkinese children will never have seen this spectacle in their Sahelian homeland – but are also the habitat of specialised dragonflies, particularly the Cascaders (*Zygonyx*). Kintampo is only the second site where the western African endemic *Z. geminunca* (LC) was found after its description from Mt Nimba in Guinea. Photo: © K.-D.B. Dijkstra.

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Chapter 6. The status and distribution of freshwater crabs

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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). Many species from the western African region are represented by only a handful of individuals, while those species that are more plentiful have often proved problematic to identify. These large and conspicuous crustaceans are present in almost all freshwater habitats in western Africa, from montane habitats with mountain streams to large lowland rivers and small water bodies (Cumberlidge 1999). In addition, species that live in seasonally arid areas tend to be semi-terrestrial, live in burrows, and move about on land at night (Cumberlidge 1999). Isolation related to complicated topography and the fragmentary nature of wetland habitats in much of western Africa, and limited dispersal abilities due to reproduction by direct development, are probably responsible for much of the diversity and endemism of these crabs (Cumberlidge *et al.* 2009). Distribution data have been derived from specimen records, but are still likely to be incomplete. Some species are either known only from the type locality or from only a few localities, and further collections are necessary to ascertain their actual distribution. Distributional ranges include point endemics (such as *Potamonautes senegalensis* and *Liberonautes nimba* from Senegal and Mt Nimba respectively), localised taxa (such as *Sudanonautes kagoroensis*, *S. nigeria*, and *Potamonemus sachsi* from Nigeria and Cameroon), and wide ranging species (such as *Liberonautes latidactyus*, which is found from Senegal to Ghana, *S. africanus*, which is found from Nigeria to the DRC and Gabon, and *S. floweri*, which found from Togo to the DRC, and as far east as Sudan and Uganda).

6.1 Overview of western Africa freshwater crab fauna

The 32 species of freshwater crabs found in west African countries dealt with by Cumberlidge (1999) represent about one-quarter (23%) of the species presently known from the entire Afrotropical region (Bott 1955, 1959, 1960, 1964, 1969, 1970; Monod 1977, 1980; Cumberlidge 1985a, 1997, 1999). The afrotropical region hosts 134 species of freshwater crabs in 20 genera and two families: Potamonautidae Bott, 1970, and Potamidae Ortmann, 1896 (Cumberlidge 1999, Cumberlidge and Sternberg 2002, Daniels *et al.* 2006, Cumberlidge *et al.*

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Liberonautes latidactyus LC. Photo: © Piotr Naskrecki.

2008, Yeo *et al.* 2008). The western African region as defined in the present work includes 25 species of freshwater crabs that belong to six genera: *Liberonautes*, *Sudanonautes*, *Globonautes*, *Afrithelphusa*, *Potamonemus*, and *Potamonautes* (Cumberlidge 1999). All of these genera are in the Potamonautidae and all are endemic to western Africa, except for *Sudanonautes* (which ranges into central Africa) and *Potamonautes* (which is poorly represented in western Africa, with the majority of species widely distributed elsewhere in continental Africa (Bott 1955, Cumberlidge 1999) but not in Madagascar (Cumberlidge and Sternberg 2002). Western Africa's freshwater crab fauna is slightly less diverse than that of eastern Africa (35 species, three genera) (Bott 1955; Cumberlidge 1997, 1998, Corace *et al.* 2001, Cumberlidge and Vannini 2004, Reed and Cumberlidge 2004, 2006a), but similar to central Africa (24 species, five genera) (Bott 1955, Cumberlidge *et al.* 2002, Cumberlidge and Boyko 2000, Cumberlidge and Reed 2004), and relatively rich in comparison to southern Africa (19 species, one genus) (Cumberlidge and Daniels 2008), and Madagascar (only 14 species, but seven genera) (Cumberlidge and Sternberg 2002, Reed and Cumberlidge 2006b, Cumberlidge *et al.* 2008). Four additional species of freshwater crabs, *Potamonemus mambilorum*, *P. asylos*, *Sudanonautes chavanesii* and *S. faradjensis*, have a small part of their range within the western Africa region in south-west Cameroon but are not included in this report and will be assessed as part of the central Africa assessment.

6.1.1 Freshwater crab distribution and freshwater ecoregions

Freshwater crab distribution patterns do not conform closely to the majority of the 17 freshwater ecoregions found in the western Africa region (Figure 1.1). Only three ecoregions have endemic species: Northern Upper Guinea, Southern Upper Guinea, and Nimba. Otherwise there is little correspondence between freshwater crab distributions and the ecoregion boundaries. The Northern Upper Guinea ecoregion (Guinea and Sierra Leone) and the Southern Upper Guinea ecoregion (Liberia), which consist mainly of tropical and subtropical coastal rivers and together comprise the Upper Guinea Forest of west Africa, are both home to endemic species of freshwater crabs. Four species of *Afrithelphusa* are found only in Northern Upper Guinea, while *Globonautes macropus* is an Upper Guinea endemic. The Southern Upper Guinea ecoregion in Liberia is home to three endemic species of *Liberonautes* (*L. nanoides*, *paludicolis*, *L. grandbassa*) and two non-endemic species (*L. latidactylus* and *L. rubigimanus*). The small upland ecoregion of Mount Nimba, situated where the borders of Liberia, Guinea and Côte d'Ivoire meet, is characterized by montane freshwaters and is home to one endemic species of freshwater crab, *L. nimba*, and a second non-endemic species (*L. rubigimanus*) (Cumberlidge and Huget 2003).

All remaining ecoregions in western Africa exhibit little correspondence between freshwater crab distribution patterns and ecoregion boundaries. For example, there are no endemic species of freshwater crab found in any of the four ecoregions included in the Niger River drainage basin that dominates western Africa. The Niger River basin is characterized by *P. ecorssei*, a widespread and common species of freshwater crab found along its entire length. The Upper Niger River and the Inner Niger Inland delta ecoregions are both home to *L. latidactylus*, another common and widespread species found in western west Africa (but not east of Mali). The Lower Niger-Benue River ecoregion in Nigeria comprises a tropical and subtropical floodplain river with wetland complexes that are home to *P. ecorssei* in the Niger in Nigeria, and *S. floweri* and *S. aubryi* in the Benue River basin in Nigeria and western Cameroon. All of these are widely distributed and common species of freshwater crabs. The Niger River delta in the coastal region of Nigeria is tidal with brackish water, where freshwater is absent, and no species of freshwater crabs are found there (Cumberlidge 2008). It should, however, be noted that the Niger delta is important for its four rare endemic species of camptandrine marine crabs and several rare endemic species of shrimps (Powell 1976, Manning and Holthuis 1981).

The Senegal River/Gambia River ecoregion in Senegal and The Gambia is a largely arid region interspersed with tropical and subtropical floodplain rivers and wetland complexes. There is only one endemic species, *Potamonautes senegalensis*, known from this region, and this is found in the Senegal River near Mauritania. The Gambia River and its drainage basin in western Guinea and Senegal have no endemic species, and only *Liberonautes latidactylus*, a common and widespread species, is found there. The Ebumeo ecoregion (Côte d'Ivoire and Ghana) consists of tropical and subtropical coastal rivers and lies in the overlap zone between *Liberonautes* (at its easternmost limit) and *Sudanonautes* (at its westernmost limit), but there are no endemic species in this region. One species of *Potamonautes*, *P. triangulus*, is endemic to the Volta ecoregion in Ghana. Both the Ashanti ecoregion in coastal Ghana and Togo, and the Bight Drainage ecoregion in coastal Benin and western Nigeria consist of tropical and subtropical coastal rivers but neither has any endemic species of freshwater crabs.

Lake Chad, classified as a xeric freshwater inland lake with an endorheic (closed) basin, is supplied by the Hadejia-Jamaare River in northern Nigeria and the Chare River in Cameroon and the Central African Republic. There are no recorded species of freshwater crabs from the lake itself, although *Sudanonautes monodi*, a dry savanna species, is found in the Hadajia-Jaamare river basin in Nigeria, and Cameroon, but is not endemic to the system (Cumberlidge 1999).

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

The conservation status of western Africa's freshwater crab fauna was assessed using the IUCN Red List Categories and Criteria at the regional scale (IUCN 2001, 2003, Cumberlidge *et al.* 2009). Although there is a need to collect more comprehensive information, the available data were sufficient to make valid assessments of the conservation status of most species. Of the 25 species of freshwater crabs found in the western African region defined herein, five species (*Afrithelphusa afzelii, A. gerhildae, A. leonensis, Potamonautes senegalensis,* and *Sudanonautes nigeria*) from Guinea, Sierra Leone, Senegal and Nigeria were assessed as Data Deficient (DD, Table 6.1) on account of a lack of sufficient information on their distributions. Of the remaining 20 species, four species (*Liberonautes nimba, Potamonautes triangulus, P. reidi*, and *Potamonemus sachsi*) (Figure 6.1 and Table 6.1) were listed as Vulnerable (VU), four species (*Afrithelphusa monodosa, Globonautes macropus, Liberonautes nanoides*, and *L. rubigimanus*) as Endangered (EN), and two (*Liberonautes grandbassa* and *L. lugbe*) as Critically Endangered (CR). Only 10 species, representing 40% of all species of freshwater crabs in western Africa, were assessed as LC. The majority of these LC species live in rivers, marshy lowlands, or mountain streams (Cumberlidge 1999). The relatively low proportion of LC species is due to much of western Africa being affected by agricultural and industrial development and its associated aquatic habitat degradation and pollution. Some 20% of the regions species are Data Deficient, reflecting the lack of collection material, a scarcity that continues to fuel uncertainty about the distribution of little-known species (Bott 1955, Cumberlidge 1999). The presence of DD species means that the current 40% figure for threatened species will be found to be an underestimate should any of these species later be found to be threatened (Cumberlidge *et al.* 2009). No species of freshwater crabs from western Africa could be confirmed Extinct or Extinct in the Wild. However, the DD species from Guinea (*Afrithelphusa afzelii* and *A. gerhildae*) have not been found in recent years and are of concern. These species cannot be formally classified as Extinct until exhaustive surveys probing their disappearance have been carried out.

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

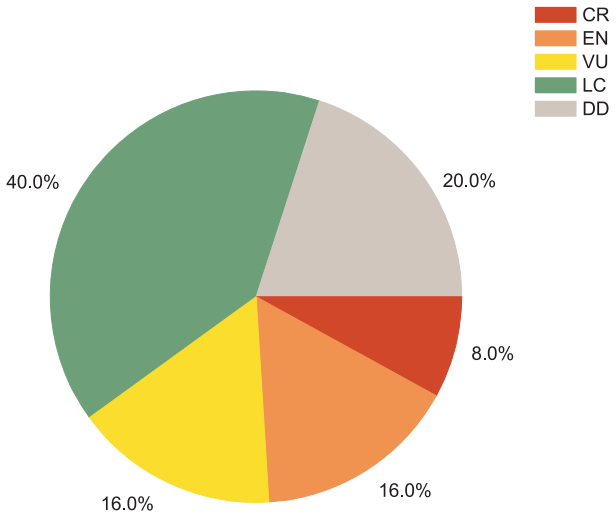


Table 6.1 The number of crab species in each regional Red List Category in the western African region.

	Regional Red List Category	Number of species	Number of regional endemics
	Extinct	0	0
	Regionally Extinct	0	-
	Extinct in the Wild	0	0
Threatened categories	Critically Endangered	2	2
Threatened categories	Endangered	4	4
Threatened categories	Vulnerable	4	4
	Near Threatened	0	0
	Least Concern	10	6
	Data Deficient	5	5
	Not Applicable	0	-
	Total	25	21

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

Given the relatively low number of species of freshwater crabs found within western Africa as compared to the other taxonomic groups treated in this report, the conservation status for each species of freshwater crab is dealt with briefly below.

6.2.1 Species assessed as Critically Endangered

***Liberonautes grandbassa* (Cumberlidge, 1999), (CR)**
This species is endemic to central Liberia where it is known from a single rainforest locality. *L. grandbassa* is only known from a few specimens and there is no information on its population size or abundance. There are no known conservation measures in place for this species, and it is not found within a protected area. The Red List assessment for this species is CR B1ab(iii)+2ab(iii) because its extent of occurrence is less than 100km^2 and area of occupancy less than 10km^2, it is

restricted to a single locality, and it is threatened by the habitat disruption associated with deforestation driven by expanding human populations and periods of political unrest.

***Liberonautes lugbe* (Cumberlidge, 1999), Lugbe River Crab (CR)**

Liberonautes lugbe is endemic to Liberia where it is known from only two specimens collected in Lugbe in Nimba County. The specimens were captured in rainforest by hand when the crabs were walking on land close to a stream. The species is assessed as CR B1ab(iii) because its extent of occurrence is less than 100 km² and it is restricted to freshwater streams in the rainforest where it is subject to habitat disruption associated with deforestation driven by expanding human populations and periods of political unrest.

6.2.2 Species assessed as Endangered

***Afrithelphusa monodosa* (Bott, 1959), Monod's Crab (EN)**

Afrithelphusa monodosa is one of only five species in two genera belonging to a rare group of freshwater crabs endemic to the Upper Guinea forest block of western Africa. This species is endemic to Guinea where it is known from less than 20 specimens from two localities. *A. monodosa* lives in farmland, swamps, and year-round wetland habitats in the semi-deciduous moist forest Guinea savanna zone of north-western Guinea (Cumberlidge 1999, 2006). Specimens were collected from cultivated land from burrows dug into permanently moist soil, each with a shallow pool of water at the bottom. The natural habitat of *A. monodosa* is still unknown but presumably this cultivated land was originally a permanent freshwater marsh. There were no nearby sources of surface water and it is evident that these crabs do not need to be immersed in water (as do their relatives that live in streams and rivers), and that they can meet their water requirements with the small amount of muddy water that collects at the bottom of their burrows. The species is clearly a competent air-breather. Despite the recent discovery of a new subpopulation of this species, it is still currently known from only a few specimens from two localities. Threats to the species include habitat loss/degradation (human induced) due to human population increases, deforestation, and associated increased agriculture in north-west Guinea. It is not found within a protected area. The recent discovery of new subpopulations (and the promise of finding others) has led to its Red List status being recently downgraded from CR to EN.

***Globonautes macropus* (Rathbun, 1898), Tree Hole Crab (EN)**

Globonautes macropus is endemic to the Upper Guinea rain forests of western Liberia (Bong, Lofa, and Mesurado Counties) and Guinea, and is presumably also found in the forested parts of Sierra Leone that lie between these two subpopulations. The species is restricted to rainforests where it requires a specialised habitat of rainwater-filled natural holes found in suitably sized trees within closed canopy rainforest. Despite the recent discovery of new subpopulations, it is still currently known from only a handful of specimens and a few localities. In pre-civil war Liberia (before 1989) the species range was estimated to be only 5-10 per km² of closed canopy rainforest, which may well be declining as deforestation linked to the civil war progresses. Threats to its rainforest habitat are ongoing due to human population increases, deforestation, regional wars, political instability and increased agriculture in Liberia. It is not found within a protected area. The recent discovery of new subpopulations (and the promise of finding others) has led to its Red List status being recently downgraded from CR to EN.

Afrithelphusa monodosa EN. Photo: © Piotr Naskrecki.

***Liberonautes nanoides* (Cumberlidge and Sachs, 1989), Dwarf River Crab (EN)**

Liberonautes nanoides is endemic to Liberia where it is known only from one locality in Bong County (the St. Paul River at the Bong Mine Fishing Club near Haindi). It is only found in the rocky parts of the fast-flowing waters of the St. Paul River in the rainforest zone of Liberia, and is never found in small streams. The species serves as the second intermediate host to the lung fluke *Paragonimus uterobilateralis* but the incidence of infection is low, indicating that the species does not play an important role in the transmission of the parasite to humans. Threats to its river habitat are ongoing due to human population increases, deforestation, regional wars, political instability and increased agriculture in Liberia. It is not found within a protected area. The species is a locally important food source and is subject to a small local fishery.

***Liberonautes rubigimanus* (Cumberlidge and Sachs, 1989), Lobster Claw Crab (EN)**

*Liberonautes rubigimanu*s is endemic to the Upper Guinea Forest zone where it is known from only three localities: two in Liberia and one in Guinea (Cumberlidge and Huguet 2003). It is found in fast-flowing mountain streams in Liberia (Mount Gibi) and Guinea (Mount Nimba, 600m asl), and at lower elevations in forest streams in Grand Gedah County, Liberia. This is a large species living sympatrically with *L. latidactylus* and *L. paludicolis*. Threats to the species include loss/degradation (human induced) of its mountain stream habitat associated with deforestation and human population increases. Parts of its range lie within a protected area, the Mont Nimba National Park.

6.2.3 Species assessed as Vulnerable

***Liberonautes nimba* (Cumberlidge, 1999), Nimba Crab (VU)**
Liberonautes nimba is endemic to the slopes of Mount Nimba in Guinea and in Liberia where it is known from several localities. Threats to this species include a decline in the extent and quality of its stream habitat from mining disturbance and pollution, plus deforestation associated with farming and human population increases. Some parts of its range may be protected as they lie within the Mont Nimba National Park.

***Potamonautes reidi* (Cumberlidge, 1999), Reid's River Crab (VU)**
Potamonautes reidi is endemic to the rainforest zone of south-east Nigeria near Calabar, Cross River State, where it is known from only a few specimens from less than ten localities. It lives in the overhanging vegetation at the sides of small slow-flowing streams. Threats to this species include a decline in the extent and quality of its stream habitat from deforestation associated with farming and human population increases. No conservation measures are in place for this species and it is not found in a protected area.

***Potamonautes triangulus* (Bott, 1959), (VU)**
Potamonautes triangulus is a small species of freshwater crab endemic to Ghana where it is known from six localities within the same stream, located about 90 km north of Accra. Threats to this species include a decline in the extent and quality of its stream habitat from deforestation associated with farming and human population increases. No conservation measures are in place for this species and it is not found within a protected area. It was last collected in 1950.

***Potamonemus sachsi* (Cumberlidge, 1993), Sachs's Stream Crab (VU)**
Potamonemus sachsi is known only from the Bamenda highlands in south-west Cameroon, and from the neighbouring Obudu plateau in south-east Nigeria, a steep-sided plateau 1,000 m asl that rises steeply out of the rainforest. The climate on top of the plateau is cool and humid, and supports a tropical montane vegetation, including extensive grasslands. The streams and rivers drain south into the Cross River, just to the east of the Nigeria-Cameroon border. These crabs live under boulders in stretches of the stream shaded by overhanging vegetation and the forest canopy. Threats to this species include a decline in the extent and quality of its stream habitat from deforestation associated with farming and human population increases. No conservation measures are in place for this species and it is not found in a protected area.

6.2.4 Species assessed as Least Concern

***Liberonautes chaperi* (A. Milne-Edwards, 1887), Chaper's River Crab (LC)**
Liberonautes chaperi is a large widespread species common in the major rivers in Ghana, Côte d'Ivoire and Liberia, and is endemic to this part of the Upper Guinea forest block; it has never been found in small streams (Cumberlidge 1985, Cumberlidge and Sachs 1989). *L. chaperi* serves as second intermediate host to the human lung fluke (*P. uterobilateralis*) in Liberia (Sachs and Cumberlidge 1990). However, the incidence of infection of these crabs in Liberia is low, indicating that this species may not play an important role in the transmission of the parasite to humans. The species is listed as LC in view of its wide distribution, estimated stable population size, abundance, and the lack of known widespread threats.

***Liberonautes latidactylus* (De Man, 1903), Common Creek Crab (LC)**
Liberonautes latidactylus is the most common and most frequently caught freshwater crab throughout the rainforest and savanna zones of western Africa with a distributional range from Senegal and Mauritania to Ghana, in a vast area bounded to the north by the Sahara desert and to the south and west by the Atlantic Ocean. The species lives in rivers and streams in rainforest in Sierra Leone, Liberia, Guinea, Côte-d'Ivoire and Ghana, as well as in savanna in Senegal, Mauritania, Guinea, Sierra Leone, Liberia, and Côte-d'Ivoire. During the day these crabs remain inactive, lying hidden under stones or in crevices in the streambed and at night they leave their resting places to feed on dead organic material or on small aquatic animals, such as molluscs. They also eat vegetable matter, and are attracted into traps baited with cassava, palm nuts, red papaya, or meat. This species is economically important, forming part of the diet of many people in western Africa. It is also medically important as the predominant second intermediate host of *P. uterobilateralis*, the human lung fluke that causes human paragonimiasis in Liberia, Guinea (Sachs and Voelker 1982) and Côte-d'Ivoire (Nozais *et al*. 1980). *L. latidactylus* also serves as the host of the larvae of biting blackflies (*Simulium*) that are the vectors of *Onchocerca volvulus*, the parasite that causes river blindness (onchocerciasis) in parts of Liberia and Guinea and elsewhere in western Africa.

***Liberonautes paludicolis* (Cumberlidge and Sachs, 1989), Pale Swamp Crab (LC)**
Liberonautes paludicolis is a fairly common species known only from the rainforest zone in Liberia and Côte d'Ivoire, and is endemic to this part of the Upper Guinea forests of western Africa. It is found in or near forest streams, or in low-lying areas of cleared forest that have permanent surface water, such as fish farm excavations, swamp rice farms, and ditches. The species also occurs in sites that become inundated with shallow water during the rainy season (May to October). These crabs spend a good deal of time resting in burrows dug into the banks of streams, swamps, marshland, or the forest floor. Burrows are usually sited next to, or in the vicinity of, water and are usually absent from those parts of the forest where there is no nearby surface water. Swamp crabs have often been encountered crossing the road during daytime rainstorms or at night, when they leave their resting places to look for food on the nearby land and occasionally venture into streams. The ecology of

the swamp crab is distinct from that of *L. latidactylus*, but there is an area of geographic overlap, because the two species occur together in the small streams of the rainforest zone of Liberia. *L. paludicolis* is also an important second intermediate host to *P. uterobilateralis* in Liberia and therefore also plays a key role in the transmission of the human lung fluke parasite to humans.

***Potamonautes ecorssei* (Marchand, 1902), Ecorsse's River Crab (LC)**

Potamonautes ecorssei is a widespread species common in the major rivers in the western part of western Africa with a distributional range including Mauritania (Guidimaka), eastern Senegal, The Gambia, Mali (river Niger and Mali, Lac Télé, near to Goundam), Burkina Faso, Côte-d'Ivoire, Ghana, Togo, and Nigeria. It is the subject of small-scale local fisheries in Mali, where it is captured in nets or in baited fish traps. This species is found within the Parc National de Niokolo-Koba in Senegal.

***Sudanonautes africanus* (A. Milne-Edwards, 1869) African River Crab (LC^{RG})**

Sudanonautes africanus is a widespread and abundant large-bodied species common in the eastern part of western Africa, with a distributional range which includes the more humid areas of the coastal rainforest belt from south-east Nigeria, Cameroon, and central Africa. The western boundary of its distributional range is east of the Niger River in south-east Nigeria. The species is not known from the rest of the western African region (from western Nigeria to Senegal). *S. africanus* occurs in a range of permanent aquatic habitats including large rivers and small streams (with both fast- and slow-flowing water), draining mature forest shaded by overhanging climbing palms or by emergent vegetation, and ponds and temporary water sources such as drainage culverts and ditches. It is capable of breathing air and is often found on land at night where it digs burrows near waterways. *S. africanus* also serves as an important second intermediate host to the human lung flukes *P. uterobilateralis* and *P. africanus* in Nigeria and Cameroon (Voelker and Sachs 1977).

***Sudanonautes aubryi* (H. Milne Edwards, 1853), Aubryi's River Crab (LC^{RG})**

Sudanonautes aubryi is a widespread and abundant large-bodied species common in western and central Africa, with a distributional range that includes Côte-d'Ivoire, Ghana, Togo, Benin, and the humid coastal areas of Nigeria, Cameroon, Gabon, and Equatorial Guinea. The western boundary of its distributional range is in Côte-d'Ivoire and it is not known from the rest of the western African region (from Liberia to Senegal). *S. aubryi* is found in the Guinea and woodland savanna regions, where it inhabits streams, rivers, and ponds, and digs burrows near waterways; at night and during rainstorms it is often found on land and is capable of breathing air. This species also serves as an important second intermediate host to the human lung flukes *P. uterobilateralis* and *P. africanus* in Nigeria and Cameroon (Voelker and Sachs 1977).

***Sudanonautes floweri* (De Man, 1901), Flower's Stream Crab (LC^{RG})**

Sudanonautes floweri is a widespread and abundant large-bodied species common in western and central Africa, with a distributional range that includes Nigeria, Cameroon, Bioko, Central African Republic, Chad, Sudan, Uganda, DRC, Congo, Gabon, Cabinda (Angola) and Equatorial Guinea. The wide range of this species includes localities in the Nile River system, the Congo River system, and the Chari River system, including Lake Chad. *S. floweri* is found in the Guinea and woodland savanna regions where it inhabits streams, rivers, and ponds, and digs burrows near waterways; at night and during rainstorms it is often found on land either next to water or some distance away, since it is capable of breathing air, and functions well for long periods out of water. This is another species which serves as an important second intermediate host to the human lung flukes *P. uterobilateralis* and *P. africanus* in Nigeria and Cameroon (Voelker and Sachs 1977).

Sudanonautes granulatus (Balss, 1929), Granulated River Crab (LC^{RG})

Sudanonautes granulatus is a widespread and abundant large-bodied species common in the tropical rainforest zone of western and central Africa, with a distributional range that includes Côte-d' Ivoire, Ghana, Togo, Nigeria, Cameroon, including the island of Bioko (Equatorial Guinea), and the Central African Republic. The distribution of this species is fragmented, divided by the drier savannas of the Dahomey Gap. In the Oban Hills in south-east Nigeria, north-east of Calabar, this species is found in small streams flowing through mature rainforest, where it lives among grass, under stones, and among root material.

***Sudanonautes monodi* (Balss, 1929), Monod's Savanna Crab (LC)**

Sudanonautes monodi is a widespread and abundant large-bodied savanna species found only in the Sudan and Guinea savanna zone of western Africa in Chad, Cameroon, Nigeria, Republic of Benin, and Togo, where it is locally common. The western boundary of its distributional range is in Togo and it is not known from the rest of the western African region (from Ghana to Senegal). This species is not found in the Sahel savanna regions or in the tropical rainforest zone. In Nigeria, *S. monodi* is associated with three major river systems draining the savanna region: the Benue River basin, the Hadejia-Jama'are River/Lake Chad basin, and the Kaduna River/Niger River basin. The most northerly record is from Hadejia in northern Nigeria, a locality close to the border between the Sudan savanna and Sahel regions. In Togo and Benin, *S. monodi* occurs in the upper reaches of the Volta River basin that drains savanna country. The southern boundary of the distribution lies between the Guinea savanna and woodland savanna zones, and it is found from Togo to Cameroon. This species is found in seasonal wetlands in Sudan savanna and it's respiratory physiology and ecology are modified for a semi-terrestrial existence (Cumberlidge 1986). In the Guinea and

Sudan savanna regions of western Africa the dry season lasts from October to April, so to survive in this arid environment, each crab digs a burrow. Tunnels and burrows up to one meter long are dug into dried stream banks, waterless swamp beds and cracked water holes, which are all sited in low-lying areas where the water table is close to the surface. This species is found living in colonies of up to a hundred, with one crab per burrow. During the dry season this species is inactive in its burrow by day and active on land at night.

***Sudanonautes kagoroensis* (Cumberlidge, 1991), Kagoro Stream Crab (LC)**
Sudanonautes kagoroensis is a large-bodied species that is locally common in central Nigeria, where it is endemic. It lives in streams and rivers of the Guinea savanna zone of western central Nigeria draining the western slopes of the Jos plateau, and in the rivers close to the western base of the plateau. *S. kagoroensis* is known only from the Mada River and its tributaries, which collect water from the Jos plateau before joining the Benue/Niger River. This species is known from a series of specimens collected in 1984 as part of the national biodiversity survey, from seven sites in central Nigeria.

6.2.5 Species assessed as Data Deficient

***Afrithelphusa afzelii* (Colosi, 1924), Afzeli's Crab (DD)**
Afrithelphusa afzelii is one of only five species in two genera that belong to a rare group of freshwater crabs endemic to the upper Guinea forest block of western Africa. The habitat and ecology of this species are not known because the information on the single collection locality is vague, and is listed only as "Sierra Leone". It is listed here as Data Deficient in view of the absence of recent information on its extent of occurrence, ecological requirements, population size, population trends, and long-term threats. It is of great concern that this species is known only from two specimens that were collected in 1790-1800 from the same locality in Sierra Leone, and that no new specimens have come to light since then. However, there is not enough known about this species to make a thorough assessment at this time, so the Red List status of this species was recently changed from CR to DD.

***Afrithelphusa gerhildae* (Bott, 1969), Gerhilda's Crab (DD)**
Afrithelphusa gerhildae also belongs to the group of freshwater crabs endemic to the upper Guinea forest block of western Africa. As for *A. afzelii* above, the habitat and ecology of this species are not known because the information on the single collection locality is vague, and is listed only as "Kindia, Guinea". It is also listed as Data Deficient in view of the absence of recent information on its extent of occurrence, ecological requirements, population size, population trends, and long-term threats. This species is also known from only a very few specimens (three), collected in 1957 from the same locality in Guinea. No new specimens have come to light since then. There is not enough known about this species to make a thorough assessment at this time, so the conservation status of this species was changed recently from CR to DD.

***Afrithelphusa leonensis* (Cumberlidge, 1987), (DD)**
Afrithelphusa leonensis is endemic to Sierra Leone in freshwater habitats in the Upper Guinea Forest zone. This species is still currently known from specimens collected from the same locality in Sierra Leone. *A. leonensis* is also listed here as Data Deficient in view of the absence of recent information on its extent of occurrence, ecological requirements, population size, population trends, and long-term threats. It is known only from three specimens all collected in 1955, and no new specimens have come to light since then.

***Potamonautes senegalensis* (Bott, 1970), Senegal River Crab (DD)**
Potamonautes senegalensis is known only from one locality in the Senegal River, Senegal, and is endemic to that country. In 1970, when the species was collected, the Senegal River was saline for more than 250 km inland. In 1985, a dam was built at Diama to prevent the invasion of saltwater upstream of the dam. The collection locality is not specific but it seems likely that it was collected in the freshwater zone of the river that was, at that time, upstream of Podor. The locality was probably somewhere between Podor and the border with Mali. The highly arched and rounded carapace of this species is typical of freshwater crabs that live a semi-terrestrial life and breathe air as well as water (Cumberlidge 1999). *P. senegalensis* is listed here as Data Deficient in view of the absence of recent information on its extent of occurrence, ecological requirements, population size, population trends, and long-term threats. It is of concern that this species is known only from two specimens collected in 1960, and that no new specimens have come to light since then.

***Sudanonautes nigeria* (Cumberlidge, 1999), (DD)**
Sudanonautes nigeria is known only from one locality in southern Nigeria and it is endemic to the rainforest zone of south-east Nigeria in the western part of the Lower Guinea forest block. *S. nigeria* is listed here as Data Deficient in view of the absence of recent information on its extent of occurrence, ecological requirements, population size, population trends, and long-term threats. It is of concern that this species is known only from four specimens collected in 1973, and that no new specimens have come to light since then.

6.3 Patterns of species richness

Most of the species dealt with in the present study occur exclusively in western Africa (from Senegal to Nigeria), while the range of several species of *Sudanonautes* also extends into central Africa. This latter area includes Cameroon, Chad, southern Sudan, Uganda, the Central African Republic, the DRC north of the Congo River, the Republic of the Congo, Gabon, and Equatorial Guinea (including the island of Bioko). The taxonomic diversity of the western African region at the

genus level (six genera) is higher than that of the whole of the rest of continental Africa (five genera) and is comparable with Madagascar (seven genera). Species diversity within the western African region clearly depends on vegetation cover, with the highest number of species occurring in rainforest ecosystems, and the fewest in savanna ecosystems. One species (*Potamonautes ecorssei*) is even found in the desert zone in Mali, but only where the river Niger flows through Timbuktu. Eight of the 29 species of western African freshwater crabs have a wide distribution over an extensive area, while most (21 out of 29 species) have a restricted distribution. Three species (*Sudanonautes aubryi, S. granulatus*, and *Potamonemus sachsi*) have a fragmented distribution pattern, occurring in two geographically separated forested areas, but not in the savanna zone between them.

6.3.1 All freshwater crab species

The western African region has a distinctly recognisable freshwater crab fauna, whereby only three species (*S. africanus, S. floweri* and *S. aubryi*) have a distribution that extends significantly outside of the region (Cumberlidge 1999). *S. granulatus* occurs just outside the region, in Bioko (Equatorial Guinea) and parts of Cameroon. The tropical rainforest zone in the western African region supports the richest freshwater crab fauna, and consists of two main parts, the Upper Guinea forest block (in Guinea, Sierra Leone, Liberia, Côte-d'Ivoire, Ghana and Togo) and the Lower Guinea forest (a much larger forest block in south-east Nigeria, south Cameroon, Gabon, Congo, Central African Republic and DRC). These two forests are separated by the Dahomey Gap, a stretch of coastal savanna in Ghana, Togo and Benin. Each forest block supports its own distinct freshwater crab fauna (Figure 6.2). The freshwater crab fauna of the Upper Guinea forest (15 species in five genera) is completely different from that of the Lower Guinea forest (18 species in five genera), and only two species (*Sudanonautes aubryi* and *S. granulatus*) occur in both areas.

The western Lower Guinea forest in Nigeria falls within the western African region as considered here, and its freshwater crab fauna consists of seven species (four of which are not included in the assessment, see section 6.1) in three genera (*Sudanonautes, Potamonautes* and *Potamonemus*), and includes two endemic species (*Sudanonautes nigeria* and *Potamonautes reidi*). This forest completely lacks representatives of *Liberonautes, Globonautes* and *Afrithelphusa*.

The Upper Guinea forest is the largest forest in western Africa, and extends along the coast from Guinea to southern Togo. The distribution of the flora and fauna of the Upper Guinea forest is not entirely uniform, and there is a notable faunal division between the western Upper Guinea forest (the 'Liberian' zone, from western Côte-d'Ivoire west of the Bandama River to Guinea) and the eastern Upper Guinea forest (the 'Ghanaian' zone, from eastern Côte-d'Ivoire east of the Bandama River to Togo). The freshwater crab fauna of the **western part of the Upper Guinea forest** (in Guinea, Sierra Leone and Liberia) consists of 13 species in three genera (*Liberonautes, Globonautes* and *Afrithelphusa*), of which 11 species and two genera (*Globonautes* and *Afrithelphusa*) are endemic. This forest is dominated by species of *Liberonautes* but also includes representatives of the rare and threatened species that belong to *Globonautes* and *Afrithelphusa.* Notably, *Potamonautes* and *Sudanonautes* are absent from this part of the forest. Two species (*Liberonautes latidactylus* and *L. chaperi*) range east of this area, but only as far as south-west Ghana in the eastern Upper Guinea forest. Here, freshwater crabs are found in lowland forest streams, large rivers, swampy regions of the forest floor and mountain streams, while in Liberia and Guinea *Globonautes macropus* lives in holes in trees. The freshwater crab fauna of the **eastern part of the Upper Guinea forest** (in Côte-d'Ivoire, Ghana and Togo) consists of six species in three genera (*Liberonautes*, *Potamonautes* and *Sudanonautes*) and only one species, *Potamonautes triangulus*, is endemic. This part of the forest supports two species in each of these three genera, while *Globonautes* and *Afrithelphusa* are absent. The fauna of the eastern Upper Guinea forest includes elements of both the western Upper Guinea forest and of the Lower Guinea forest, and its species diversity is probably a function of its being an area of faunal overlap.

The moist savanna zone in western Africa bounded by the Niger River in Nigeria and the Volta River in Ghana represents an area of species paucity as far as the freshwater crabs are concerned, as does the drier more northern Sudan savanna, which stretches from Burkina Faso to southern Sudan. Forest and savanna ecosystems in western Africa support different freshwater crab faunas, and there is little overlap between the species found in these two regions. The highest numbers of species of freshwater crabs in western Africa are found in rainforest ecosystems despite the fact that the savanna zone covers by far the largest area in the region. The western part of the savanna zone, from northern Côte-d'Ivoire, Guinea, Mali, to Senegal and The Gambia, is home to only three species of freshwater crabs (*Liberonautes latidactylus, Potamonautes ecorssei* and *P. senegalensis*); the former two species are widespread, the latter species is endemic to Senegal.

The rivers of western Africa and the northern part of central Africa are home to a distinct freshwater crab fauna that includes species of *Potamonautes*, *Sudanonautes* or *Liberonautes*. The Niger and the Volta Rivers that flow through the savanna regions of western Africa support two species of river crabs, *Potamonautes ecorssei* and *P. triangulus*, with the latter species being endemic to the rivers of Ghana.

In conclusion, the distributional data indicate that there is a high degree of endemism in western Africa's freshwater crab fauna at the species level (21 out of 25 species are endemic, 84%), and the genus level (five out of six), but this is not the case at the family level (all belong to the Potamonautidae (Cumberlidge *et al.*, 2008)). Thirteen species occur within the

Figure 6.2 Freshwater crab species richness in western Africa. Species richness = species per hexagonal grid cell (289 km²).

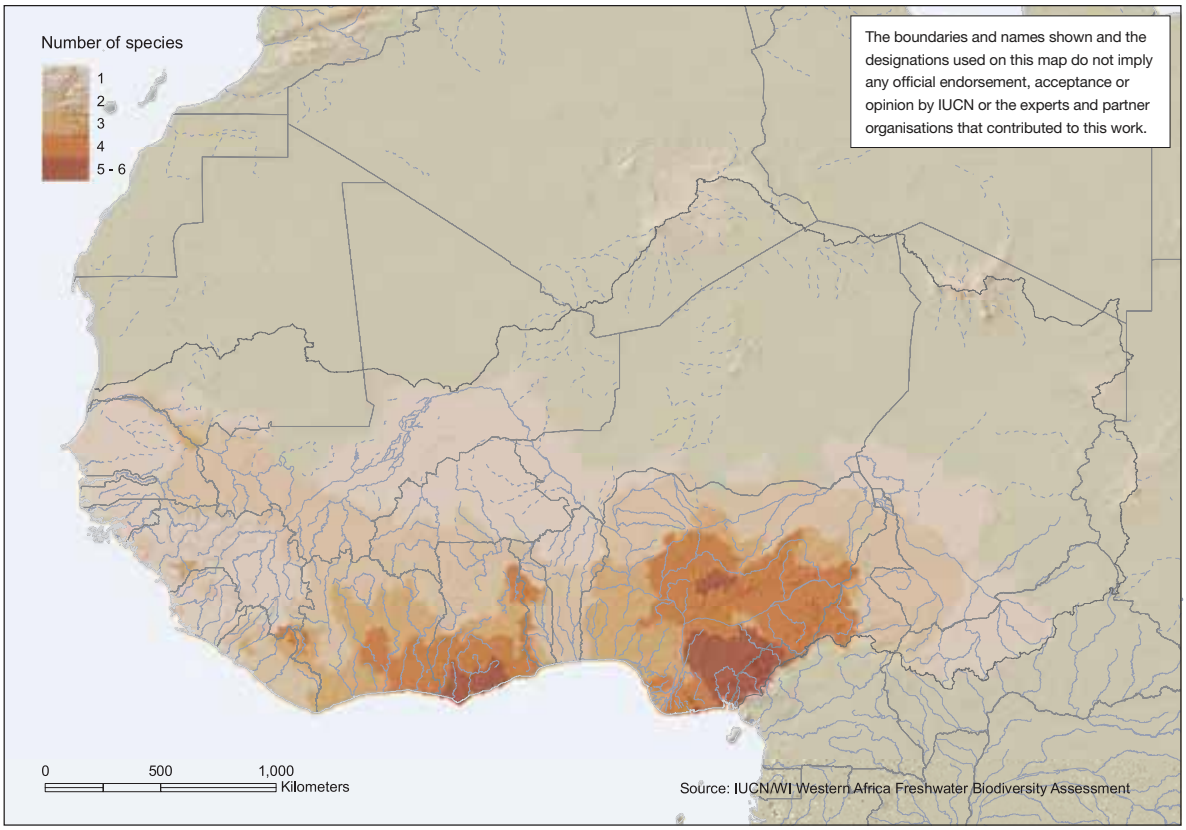
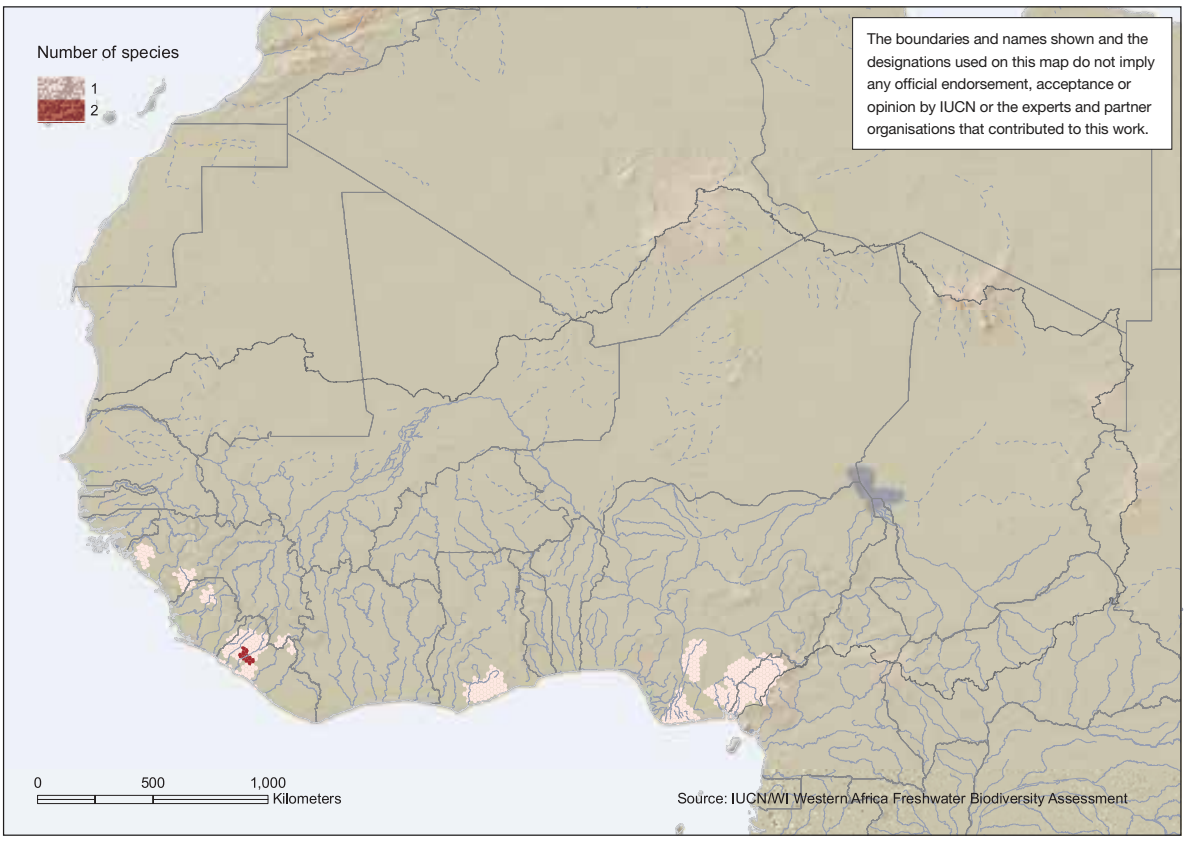


Figure 6.3 Threatened freshwater crab species richness in western Africa. Species richness = species per hexagonal grid cell (289 km²).



whole of Cameroon, but only seven of these fall within the region covered in the present work. After this, Nigeria hosts the most species (10 out of 24, 40%), of which four are endemic. Three of the Nigerian endemics (*P. reidi, S. nigeria*, and *P. sachsi*) are found in the streams and rivers associated with the rainforest zone of the Oban Hills. This endemism may reflect the past isolation of this region, and the relatively easy isolation of crab populations in the rivers that drain these hills. The other Nigerian endemic species, *S. kagoroensis*, is associated with the streams draining the Jos Plateau. Liberia is the second most speciose country in the western African region (nine out of 25 species, 36%) and with a rate of endemism of 56% (five out of nine species). The lowest species richness (one to three species) is found in a vast arid area of the region that includes Mauritania, Mali, Burkina Faso, Niger and Chad, none of which have any endemic species of freshwater crabs. Here crabs are restricted to permanent water sources (such as the Senegal, Niger and Hadejia-Jama'are River basins) on the margins of these arid lands (Cumberlidge 1999).

The areas that contain the highest freshwater crab species richness in western African region are found in Nigeria, Cameroon, Ghana and Côte D'Ivoire. Liberia also contains high numbers of crab species but many of them have very restricted ranges that do not overlap, so that the species richness shown in Figure 6.2, where species richness is measured using a hexagonal grid and not by country, is relatively low. The lowest areas of species richness are in the more arid savanna areas. Nigeria, Cameroon and Liberia are the most thoroughly surveyed in the region, which no doubt accounts for the recent increase in species descriptions and new distribution records, while the freshwater crab faunas of the other countries in the region have only been lightly sampled by comparison. Nevertheless, the general pattern of species-rich faunas in the Upper Guinea and Lower Guinea rainforests, and low species richness in the more arid parts of the savanna from Senegal to Chad, is probably real, rather than an artefact resulting from under-collection. The low species richness in the savanna countries with large areas of Sahel and desert ecosystems 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 Guinea and Sierra Leone (and it is likely that at least some of this may be due to under-sampling). Further exploration is needed throughout western 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.

6.3.2 Threatened species

Ten species of freshwater crabs were placed in threatened categories (see section 6.2). The two CR species, the four EN species, and one of the VU species are all from the Upper Guinea forest, notably the rainforests of Liberia and Guinea, while two of the VU species are from the rainforests of south-east Nigeria, and one VU species from southern Ghana (Figure 6.3).

6.3.3 Restricted range species

Species with restricted ranges are irregularly distributed in the region (Figure 6.4). Excluding Data Deficient species, 11 species of freshwater crab from western Africa have a restricted range (<20,000 km^2), and the majority of these (eight) are found in the Upper and Lower Guinea forest zones (Table 6.2). These species fall into three groups: (1) eight endemic species from the Upper Guinea forest zone;(2) two species from the Lower Guinea forest zone; and (3) one species in the savanna zone. The limited distribution of these species is likely not an anomaly because a great deal of collecting has been done throughout the region

Table 6.2 Freshwater crabs of western Africa restricted to single river basins, excluding those considered to be Data Deficient.

Species	RL Category	Range (km2)	Loc	PA	Zone
Potamonautes reidi	VU	**< 20,000**	<10	Y	LG
Potamonemus sachsi	VU	**< 20,000**	<10	Y	LG
Sudanonautes kagoroensis	LC	**< 5,000**	7	N	SAV
Liberonautes nimba	VU	**< 20,000**	4	Y	UG
Potamonautes triangulus	VU	**< 20,000**	6	N	UG
Afrithelphusa monodosa	EN	**< 5,000**	2	N	UG
Globonautes macropus	EN	**< 5,000**	5	N	UG
Liberonautes nanoides	EN	**< 5,000**	1	N	UG
Liberonautes rubigimanus	EN	**< 20,000**	3	Y	UG
Liberonautes grandbassa	CR	**~ 100**	1	N	UG
Liberonautes lugbe	CR	**~ 100**	1	N	UG

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, LG = Lower Guinea forest zone, UG = Upper Guinea forest zone, SAV = savanna zone.

Figure 6.4 Freshwater crab species with severely restricted ranges (<20,000 km²) in western Africa. Species richness = species per hexagonal grid cell (289 km²).

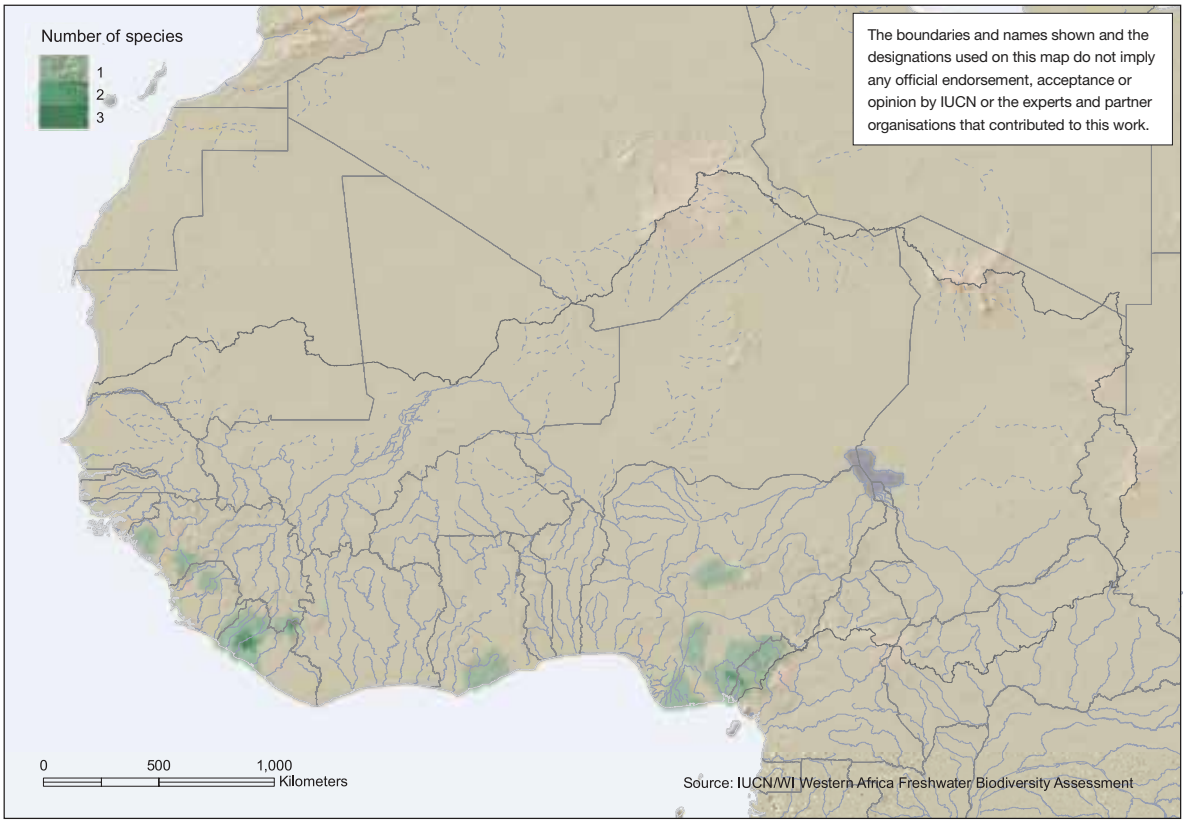


Figure 6.5 Data Deficient freshwater crab species richness in western Africa. Species richness = species per hexagonal grid cell (289 km²).

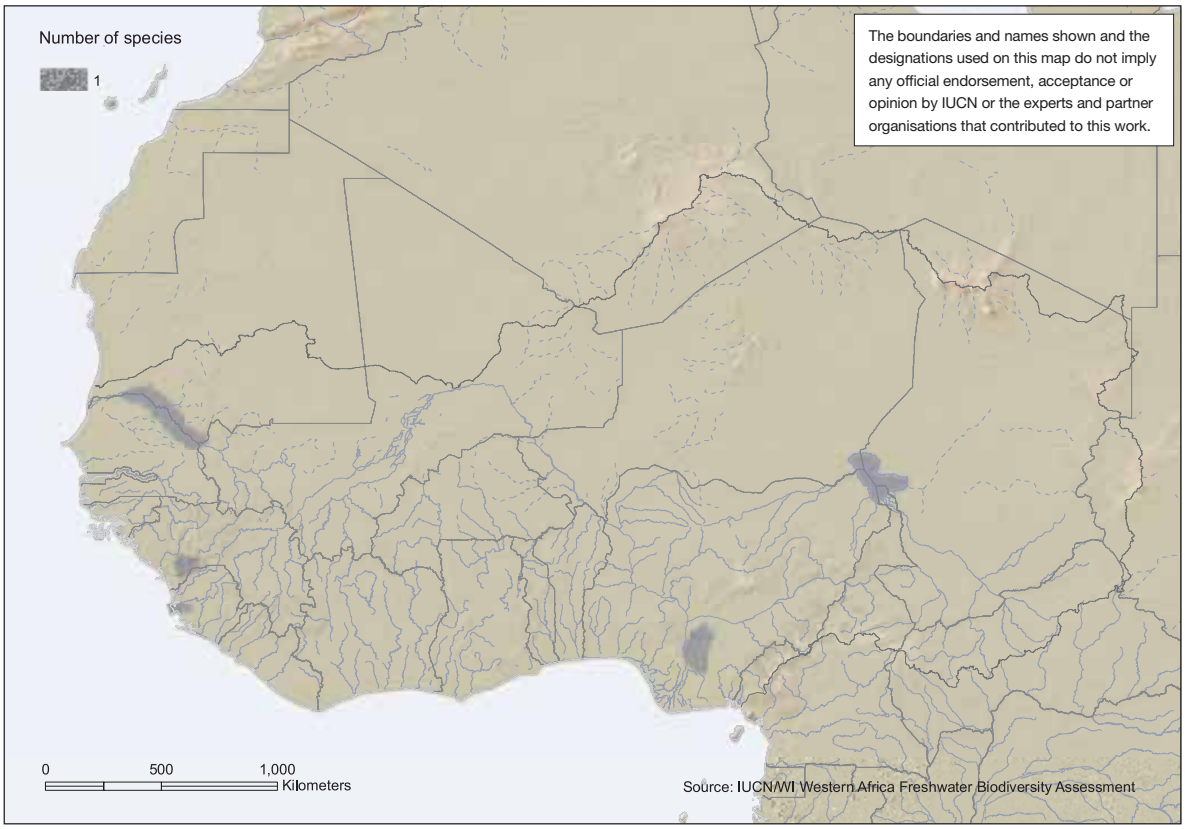


Table 6.3 Summary of the most important threats to freshwater crab species in the western African region.

	Species	Main threats	Conservation Status: Category
1	*Liberonautes nimba*	**Habitat destruction**	VU
2	*Potamonautes triangulus*	**Habitat destruction**	VU
3	*Potamonautes reidi*	**Habitat destruction**	VU
4	*Potamonemus sachsi*	**Habitat destruction**	VU
5	*Liberonautes chaperi*	**No major threats**	LC
6	*Liberonautes latidactylus*	**No major threats**	LC
7	*Liberonautes paludicolis*	**No major threats**	LC
8	*Potamonautes ecorssei*	**No major threats**	LC
9	*Sudanonautes africanus*	**No major threats**	LC^{RG}
10	*Sudanonautes aubryi*	**No major threats**	LC^{RG}
11	*Sudanonautes floweri*	**No major threats**	LC^{RG}
12	*Sudanonautes granulatus*	**No major threats**	LC^{RG}
13	*Sudanonautes kagoroensis*	**No major threats**	LC
14	*Sudanonautes monodi*	**No major threats**	LC
15	*Afrithelphusa monodosa*	**Habitat destruction**	EN
16	*Globonautes macropus*	**Habitat destruction**	EN
17	*Liberonautes nanoides*	**Habitat destruction**	EN
18	*Liberonautes rubigimanus*	**Habitat destruction**	EN
19	*Afrithelphusa afzelii*	**Unknown**	DD
20	*Afrithelphusa gerhildae*	**Unknown**	DD
21	*Afrithelphusa leonensis*	**Unknown**	DD
22	*Potamonautes senegalensis*	**Unknown**	DD
23	*Sudanonautes nigeria*	**Unknown**	DD
24	*Liberonautes grandbassa*	**Habitat destruction**	CR
25	*Liberonautes lugbe*	**Habitat destruction**	CR

over the years and they have not shown up in other localities. Any development of the Upper and Lower Guinea forest zones could thus potentially impact a number of species. Ten of the restricted range species were assessed as threatened, with the remaining species being Least Concern, despite its relatively narrow distribution. 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 eleven (44%) of the region's 25 crab species are known from distribution ranges of less than 2,000 km^2 (two of which have an estimated range of less than 500 km^2, Table 6.2). Despite the danger of population fragmentation, the current population levels of those stenotopic species (able to tolerate a narrow range of environmental conditions) 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 specialised (marginal) habitat, rather than their being the remnant populations of formerly widespread species now in decline.

6.3.4 Data Deficient species

The five species of freshwater crabs from the western African region assessed as Data Deficient are all from the Upper and Lower Guinea forests, except for *P. senegalensis* from the Senegal River, in the savanna zone of Senegal (Figure 6.5). This status is due to insufficient information, either on their taxonomic distinction (for example, *A. gerhildae* and *A. afzelii*), or because they are known from only one or a few localities (*A. leonensisi* and *P. senegalensis* and *S. nigeria*), thought to be a possible product of under-sampling. Further research is needed on all of these species, which may prove to be restricted range endemics that are vulnerable to habitat loss.

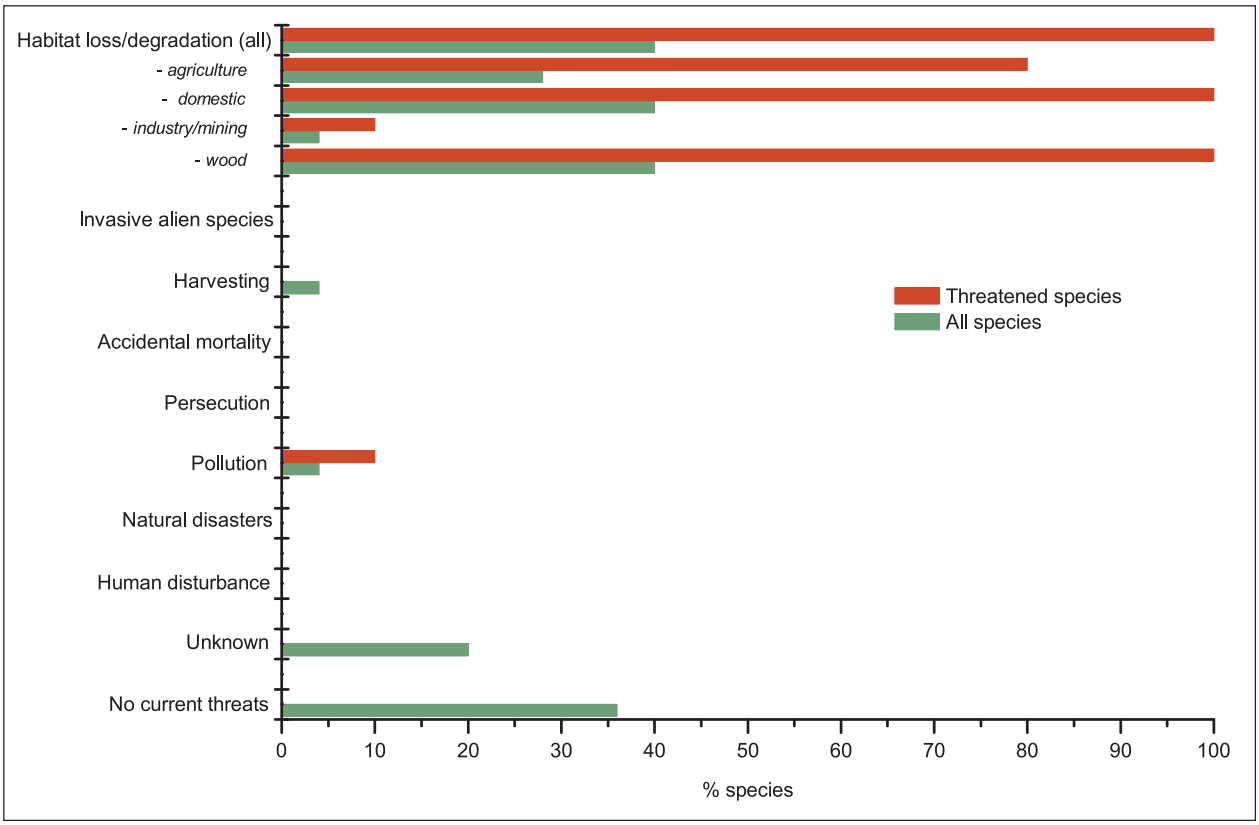
6.4 Major threats to freshwater crabs

The main current threats to the freshwater crabs of western Africa are habitat loss due to population and agricultural expansion and deforestation (see Figure 6.6). The main threats to individual species are listed in Table 6.3.

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

Figure 6.6 Percentage of freshwater crab species affected by each major current threat. Note that many species have more than one threat listed.



the food chain in the river systems of western 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 yellow-necked otter, the water mongoose, and the African civet, as well as for kites, egrets, herons, and the giant kingfisher. Other animals that prey on crabs include monitor lizards and crocodiles. In many rural parts of western Africa freshwater crabs form an important part of the diet of humans. It is clear that freshwater crabs are important members of freshwater communities in the aquatic ecosystems of western Africa, and it is vital to the health of these ecosystems that fishery managers consider measures that specifically include the conservation and sustainable use of local populations of river crabs.

6.4.2 Pollution

Pollutants from mining activities (such as bauxite, iron, and gold) in Guinea and Liberia and from organic wastes from leaking sewage systems in urban areas can accumulate in rivers and other freshwater bodies and affect crab populations. These pollutants impact freshwater crabs because they are benthic feeders, ingesting invertebrates and detritus that have high levels of contaminants. 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 the health of people who may eat them.

6.4.3 Threats in the Upper Guinea and Lower Guinea forests

Threats to the endemic species in the Upper Guinea and Lower Guinea forests include habitat destruction in the form of deforestation, 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. Other threats that result in deforestation and habitat destruction include political unrest. 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 rivers associated with cities and towns include pollution by sewage and industrial and general waste. Agricultural pesticides used by farmers may prove to be lethal to freshwater crabs, but more research needs to be carried out. All of the above combine to increase the overall level of threat to range-restricted endemic species of freshwater crabs, and the careful management of water resources in the future will have the biggest impact on their survival.

6.4.4 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

Plantain (*Musa sp*.) planted in a freshly deforested area near the village of Kamaso and the town of Asankrangwa in the region of the Upper Guinean Rainforest in Western Ghana. Photo: © Johannes Förster.

be complexes of several distinct cryptic taxa, each with specific ecologies and distributions requiring direct conservation action. One such possibility is *S. granulatus*, currently assessed as Least Concern primarily on account of its wide distributional range. However, this range consists of many relatively isolated subpopulations that show a great deal of morphological and genetic variation, and further investigations may show *S. granulatus* to be a species complex, as is probably the case for *P. perlatus* in South Africa (Daniels *et al*. 2002).

6.5 Conservation recommendations

As the biology and distribution patterns of the freshwater crabs of western Africa become better known, so are the potential threats to their long-term survival. With 12 of the 29 species of freshwater crabs from the western African region currently assessed as being at risk of global extinction, the region's largely endemic freshwater crab fauna appears to be in immediate trouble. 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 products 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, some forest and vegetation cover is maintained, and protected areas are respected.

Common species of western African freshwater crabs assessed as Least Concern 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 there 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 specialised 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 one that is assessed as Endangered. The numerous development projects in place or in planning could have a dramatic impact on species of freshwater crabs with 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 five species of freshwater crabs from western Africa is primarily a product of insufficient field survey. The scarcity of available specimens is in a large part due to the long-term poor security situation in that area, and little is known of the habitat needs, population trends, or threats to these species. For example, *A. leonensis* came to light only recently during examination of unidentified museum specimens. When more information has been gathered, all five DD species will probably prove to have a relatively restricted distribution and all will likely prove to be endemic to the river basin where they are found.

The conservation assessment of freshwater crabs in western 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 freshwater crabs from western 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.

Western Africa's freshwater crabs have a high degree of endemism, with many species living in specialised habitats such as highland streams and lowland marshes. Although many species live in protected areas and may not be under immediate threat, their inherent fragility and specific habitat requirements support the need to establish reserves specifically aimed at the inclusion and protection of freshwater 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 in 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 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 further surveys to discover new species, refine species distributions, define specific habitat requirements, describe population levels and trends, and identify specific threats to western Africa's important and unique freshwater crab fauna.

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Chapter 7. Aquatic plants of western Africa

Niang-Diop, F.[1] and Ouedraogo, L.R.[2]

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7.1 Overview of western Africa flora

The region possesses a hugely varied climate and a variety of wetland types, including large rivers such as the Senegal and Niger, smaller permanent and/or temporary rivers and streams, lakes, ponds and marshes and flood plains with their seasonally inundated habitats. It is because of the varied habitat types and high levels of precipitation in parts of the region that there is a large diversity of aquatic and semi-aquatic plant species in western Africa. In fact, south-eastern Nigeria and the Upper Guinea region in western Africa possess some of the highest levels of plant diversity and endemism in Africa (Linder 2001, Davis *et al.* 1994).

Airview of reeds in Diawling National Park, Mauritania. Photo: © Hellio -Van Ingen.

However, due to the vast number of species it has not been possible to assess the status of all of the freshwater aquatic plants in the region. Therefore, the assessments have focused on hydrophytes and helophytes of a selection plant families (definitions of hydrophytes and helophytes follow Cook 1996). The families were chosen at a pan-Africa scale to be applicable to western Africa and to the other regions of Africa (see Darwall *et al.* 2009 for the southern Africa assessment report). See chapter 2 (2.1.5 Aquatic plants) for the aquatic plant families assessed and the criteria used to identify them.

The aquatic flora of the region (only the species in the families assessed) are discussed in accordance with the freshwater ecoregions of western Africa as defined by Thieme *et al.* (2005). However, these regions (see Figure 1.1) are delineated predominantly on faunal distributions and therefore may not be the most suitable units, as aquatic plants are often just as well correlated to terrestrial ecoregions (Sieben 2008).

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Nymphaea micrantha. Photo: © Assane Goudiaby.

7.1.1 Xeric systems

Dry Sahel: Precipitation is very low and evaporation high in this ecoregion, but rainwater does sometimes form ponds along the brooks in mountainous areas. In these ponds the species *Nymphaea lotus, Aeschynomene crassicaulis, Aponogeton subconjugatus, Centrostachys aquatica, Ipomoea aquatica, Limnophyton obtusifolium, Nymphoides indica, Vossia cuspidata* and *Utricularia inflexa* can be found. In the semi-permanent pools, commonly called gueltas, species such as *Phragmites australis, Typha domingensis*, and *Potamogeton spp*. are present. Small tributaries of the Senegal and Niger rivers also cross the region and can sometimes overflow, allowing large meadows to form, which are dominated by *Vetivera spp.* and *Echinochhoa spp.,* with woody species also present, notably *Acacia nilotica, Mimosa pigra* and *Mitragyna inermis* (Claude *et al.* 1991). In some places the flora is almost monospecific, and is dominated by *Acacia nilotica*.

7.1.2 Savanna dry forest rivers

Senegal-Gambia catchments: This ecoregion, in addition to the coastal wetlands, includes continental wetlands characterised by the large alluvial plain of the Senegal River, the Gambia and Casamance valley, and numerous lakes, pools and ponds.

The floodplains contain a wide diversity of species. Along rivers, seasonal aquatic meadows are dominated by *Echinochloa pyramidalis, Typha domingensis, Phragmites australis*, *Panicum anabaptisum, Rotula aquatica* and *Sphenoclea zeylanica*. In the ponds, species such as *Nymphaea lotus, Pistia stratiotes, Ipomoea aquatica, Oryza barthii, Vossia cuspidata*, *Ceratophyllum demersum, Utricularia spp.* and *Potamogeton spp.* are found. In the seasonally flooded areas, woody species such as *Acacia nilotica* are found along with *Mitragyna inermis* and *Mimosa pigra* (Hughes and Hughes 1992, Thiam 1998, Ouedraogo and Guinko1998, Ouedraogo *et al.* 2003, Emms and Barnet 2006).

Volta: This ecoregion supports extensive floodplains containing relatively diverse levels of aquatic and semi-aquatic flora. Typical species include *Nymphaea lotus, Vossia cuspidata, Aeschynomene nilotica, A. indica, Oryza barthii, O. longistaminata, Nymphoides ezannoi, Cyperus digitatus, Panicum subalbidum, Cynodon dactylon* and *Acacia nilotica* (Hughes and Hughes 1992, Guyot *et al.* 1994, Sally *et al.* 1994). On hydromorphic soils and marshy meadows, *Vetivera fulvibarbis* dominates and is associated with *Cassia mimosoides.* In ponds, species such as *Echinochloa stagnina, Oryza barthii, O. longistamina, Vetivera nigritana* are found (Claude *et al* 1991). Flooded meadows are dominated by *Echinochloa spp., Oryza barthii* and *Vossia cuspidata,* whereas *Pistia stratiotes, Ceratophyllum demersum, Nymphaea spp.* and *Ludwigia spp.* are common on the edges of Lake Volta (Davies and Walker 1986).

Lower Niger-Benue: This ecoregion contains large floodplains including lakes and temporary ponds. Species such as *Oryza barthii, Echinochloa pyramidalis* and *Vetivera nigritana* are present and the shrubs and trees are dominated by *Mitragyna inermis, Phyllanthus reticulates, Mimosa pigra, Acacia nilotica* and *A. seyal.* In the rainy season *Acroceras amplectens, Brachiaria mutica, Echinochloa stagnina* and *Panicum anabaptisum* are abundant.

Bight coastal: This ecoregion consists of a range of inter-connected wetlands (rivers, lakes, lagoons, etc.) that connect to the Gulf of Guinea. *Cyperus papyrus, Typha domingensis* and *Phragmites australis* are common in the region, and *Ceratophyllum demersum, Nymphaea spp., Pistia stratiotes, Potamogeton schweinfurthii,* and *Utricularia spp.* are often present at the edges of lakes. In Lake Aheme and the Couffo river (Benin) *Echinochloa spp.* and *Vetivera nigritana* are abundant, and *Cyperus papyrus* and *Phragmites karka* border the rivers and lakes of the Oueme delta (Hughes and Hughes 1992).

7.1.3 Highland and mountain systems

Fouta Djalon: Many freshwater plants are endemic to this ecoregion. According to the Ministère des Travaux Publics et de l'Environnement, Guinea (MTPE 1997), most of the 69 endemic plants of Guinea are found in this region (many of these species are, however, not assessed here as they do not belong to the families selected for this assessment). The area contains a relatively dense hydrographic network with a diversity of freshwater habitats, including waterfalls, lakes, marshes and ponds. The freshwater flora is dominated by

Wetland with typha, an invasive grass (on left), in Komadugu Yobe river basin, North East Nigeria. Photo: © Danièle Perrot-Maître.

Gramineae (grasses) but other species such as *Potamogeton schweinfurthii* and *Vallisneria spp.* are also present, and there are many aquatic algae rooted on the rocks. *Raphia sudanica* can be found in the permanent marshy forests.

Mount Nimba: Mount Nimba rises to over 1,700 metres and lies between the savannah belt in the north and tropical forest at the coast. High altitude grasslands are found at between 550 and 600 m altitude, leading to gallery forest (1,000 m and 1,600 m), and primary forest in the foothills (600 m and 1,000 m) all of which possess a high diversity of plants (UNEP-WCMC 2008). Permanent marshy forest is the main aquatic vegetation type and *Raphia spp*. (palms) are one of the dominant species. Rheophytes dominate in the steep running water streams (Thieme *et al.* 2005). Stagnant water is not common in this ecoregion, so Nymphaea species are rare, however *Nymphaea heudelotii* is found in the Northern part of Nimba (Schnell, 1952).

7.1.4 Moist forest rivers

Northern Upper Guinea: This ecoregion contains floodplains with lakes surrounded by marshy forest and meadows. Species such as *Nymphaea lotus, Polygonum senegalense, Utricularia spp*. are found in the lakes, and the marshes are dominated by *Raphia spp.*
Southern Upper Guinea: In this ecoregion, floodplains are rare and the major habitat types for aquatic plants are the steep and partly torrential moist forest rivers with mangroves and swamps at their mouths. In these marsh forest areas species such as *Raphia spp*. are found.

Eburneo: Lakes, lagoons and floodplains are abundant throughout this ecoregion. The freshwater flora is dominated by species such as *Pistia stratiotes, Ceratophyllum demersum, Nymphaea lotus, Cyrtosperma senegalense* and *Nymphoides indica*. In the seasonally flooded zones, other species such as *Echinochloa pyramidalis, Oryza barthii,* and *Vossia cuspidata* are present.

Ashanti: This ecoregion is characterised by more gently descending rivers that flow into lagoons and swamps, including the Aby Lagoon complex in Côte D'Ivoire where the vegetation is dominated by mangrove and marsh forests, characterised by *Raphia spp*.

Upper Niger: The tributaries of the upper Niger River have created large floodplains containing ponds, pools, lagoons and

marshy zones with gallery forests. The aquatic flora is dominated by species such as *Echinochloa pyramidalis*, *E. colona, E. stagnina*, *Vetiveria nigritana, Oryza barthii* and *Panicum spp.* (Hughes and Hughes 1992). The permanent pools support species such as *Nymphaea lotus, Phragmites australis, Eichhornia crassipes* and *Ceratophyllum demersum.* Shrubby, arborescent, semi-aquatic species, notably *Mimosa pigra, Acacia nilotica* and *Mitragyna inermis*, are also present. In the seasonally flooded ponds *Brachiaria mutica, Acroceras amplectens, Echinochloa stagnina, E. colona, Panicum anabaptisum, P. laetum, P. subalbidum* and *Sorghum arundinaceum* are common.

7.1.5 Floodplains, swamps, and lakes

Inner Niger Delta: This important wetlands network is characterised by floodplains, ponds, pools and lakes. The floodplains are dominated by species such as *Echinochloa pyramidalis, Echinochloa stagnina, Acroceras amplectens, Oryza barthii, Panicum anabaptisum, Andropogon gayanus, Vetivera nigritana, Eragriostis atrovirens.* The floating *Nymphaea lotus* and the submerged macrophyte *Ceratophyllum demersum* are well represented in the pools, and in the dry season *Echinochloa stagnina* and *Polygonum senegalense* form meadows (Brunet-Moret *et al.* 1986a, Hughes and Hughes 1992, Swartz *et al.* 2005). The southern part of the Inner Niger Delta has many lakes, such as Lake Debo, where *Echinochloa stagnina* is so abundant that it forms dense grasslands in the dry season, termed '*bourgoutiere',* which are important grazing areas for pastoralists (Brink and Belay 2006).

Lake Chad Catchment: The aquatic flora of the Lake Chad Catchment is dominated by *Cyperus papyrus* (introduced to the region), *Phragmites australis, Typha australis* and *Vossia cuspidata* (Hughes and Hughes 1992). In the lake itself, submerged species such as *Ceratophyllum demersum, Potamogeton schweinfurthii, Vallisneria spiralis* and *Nymphaea spp.* are common. Along the edges of Lake Chad *Cyperus papyrus*, *Cyperus articulatus*, *Pycreus mundtii*, *Phragmites australis, Echinochloa stagnina, E. colona, Oryza barthii, Vossia cuspidata*, *Leersia hexandra* and *Typha australis* are all common.

7.1.6 Large river deltas

Niger Delta: Permanent and seasonal swamp forests dominated by shrub species such as *Mitragyna inermis*, *Raphia vinifera, Anthocleista vogelii* and *Carapa procera* make up the main wetland habitats of the delta.

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

The 495 aquatic plant taxa from the selected families have been assessed for their risk of extinction within the western Africa region using the IUCN Red List Categories and Criteria, and Regional Guidelines (IUCN 2001, 2003). The regional Red List

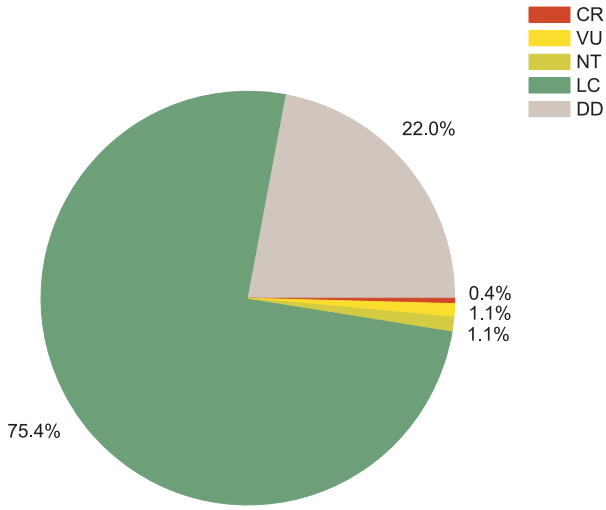
Cyperus lateriticus (VU) Photo: © Assane Goudiaby.

Table 7.1 The number of wetland species in each regional Red List Category in the western Africa region.

	Regional Red List Category	Number of species	Number of regional endemics
	Extinct	0	0
	Regionally Extinct	0	-
	Extinct in the Wild	0	0
Threatened categories	Critically Endangered	2	2
	Endangered	0	0
	Vulnerable	5	2
	Near Threatened	5	2
	Least Concern	356	11
	Data Deficient	104	25
	Not Applicable	23	-
	Total	472	42

Note: The total figure does not include NA (Not Applicable) species. All species assessed as regionally threatened that 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 western African region. CR: Critically Endangered, VU: Vulnerable, NT: Near Threatened, LC: Least Concern, DD: Data Deficient.



status of any species endemic to western Africa will be equivalent to its global Red List status.

Twenty three species are assessed as Not Applicable. Six of these have ranges marginal to the region (<5% of their global range) and the rest are non-native species, so they have been removed from the analysis in this chapter. Of the species that have been assessed the majority (356 species, 75.4%) fall into the Least Concern category and only seven species (1.5%) are classified as threatened (Table 7.1 and Figure 7.1). This is a relatively low level of threat when compared, for example, with southern Africa where 5.5% of the aquatic flora is threatened (Sieben 2008). However, 104 species (22%) have been classified as Data Deficient, many being known from only a few records, and could be threatened. In comparison Data Deficient freshwater plants account for only 6.6% of the species in southern Africa.

The threatened species are:
Podostemaceae (riverweeds):

- *Ledermanniella keayi* (CR, endemic – assessed in 2000), found in fast-flowing streams in Mount Oku and the Ijim Ridge area in Cameroon, is potentially impacted by irrigation and upstream agricultural development.
- *Saxicolella marginalis* (CR, endemic – assessed in 2000), recorded from fast-flowing streams in Cameroon and Nigeria, is potentially impacted by water pollution.

Cyperaceae (sedges):

- *Bolboschoenus grandispicus* (VU^{RG}), found in flooded depressions in the littoral sand dunes in western Senegal, is threatened by drought (leading to salinisation) and agricultural expansion.
- *Cyperus lateriticus* (VU, endemic), found in the margins of temporary water bodies of the Fouta Djalon area in Senegal, is threatened by increasing frequency of drought.

Gramineae/Poaceae (true grasses):

- *Echinochloa stagnina* (VU^{RG}), widespread in western Africa, and found in all major lakes and river system, is believed likely to decline in the near future due to drought, over-harvesting, agricultural expansion and invasive species.
- *Rhytachne furtiva* (VU, endemic), known from two sites in Burkina Faso and Ghana, is impacted by increasing drought and fires.
- *Sacciolepis rigens* (VU^{RG}), known from the Oti River system (a branch of the Volta River) in Ghana and Togo, is threatened by increasing drought and fires.

7.3 Species richness patterns

Some 494 species of aquatic plants have been mapped using GIS. However, due to a lack of digitised point localities and high resolution distribution data, the majority could only be mapped to a country level. Only 54 species could be mapped more accurately to river sub-basins.

The distribution of aquatic wetland plants in western Africa, mapped at the country level in most cases (Figure 7.2) shows the countries with the highest level of species richness (between 299 and 365 species per grid cell) are Senegal and Nigeria. The relatively low number of species in the southern Upper Guinea is unusual, as the wider region has high rainfall and overall plant species richness. This could be an artefact due to high numbers of Data Deficient species which could not be mapped accurately.

Guinea contains the highest levels of endemic species (between 21-26 species per grid cell), with Senegal, Mali, Guinea-Bissau, Sierra Leone and Nigeria all containing high levels of

Figure 7.2 Wetland plants species richness in the western Africa region, based mostly on country distribution information. Species richness = species per hexagonal grid cell (289 km²).

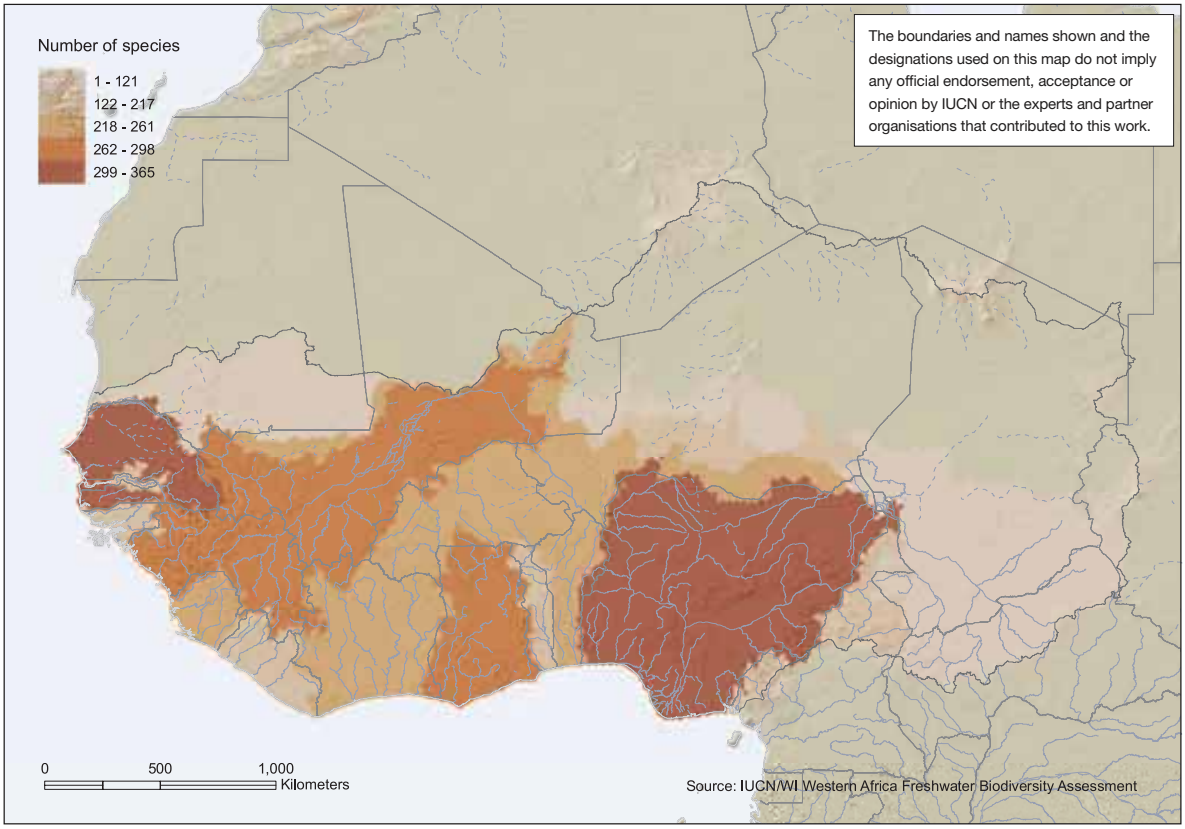


Figure 7.3 Endemic wetland plants species richness in the western Africa region, based mostly on country distribution information. Species richness = species per hexagonal grid cell (289 km²).

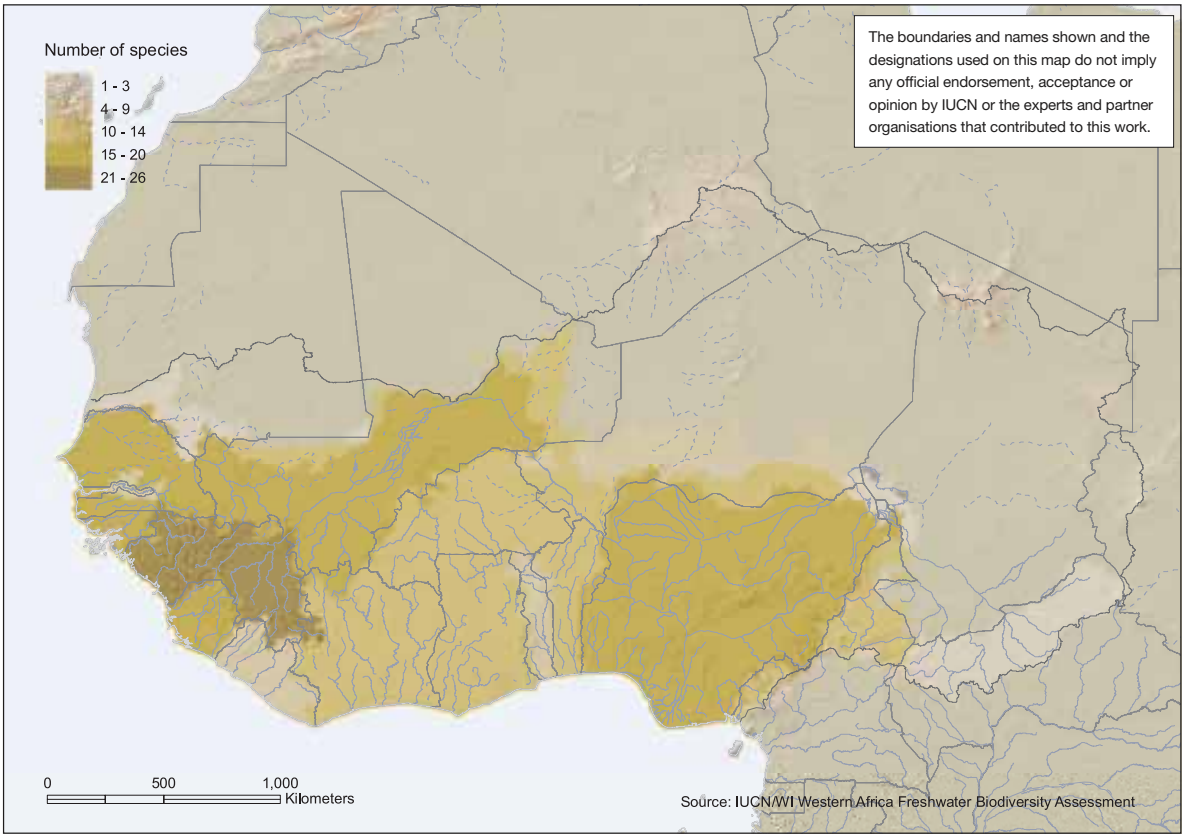
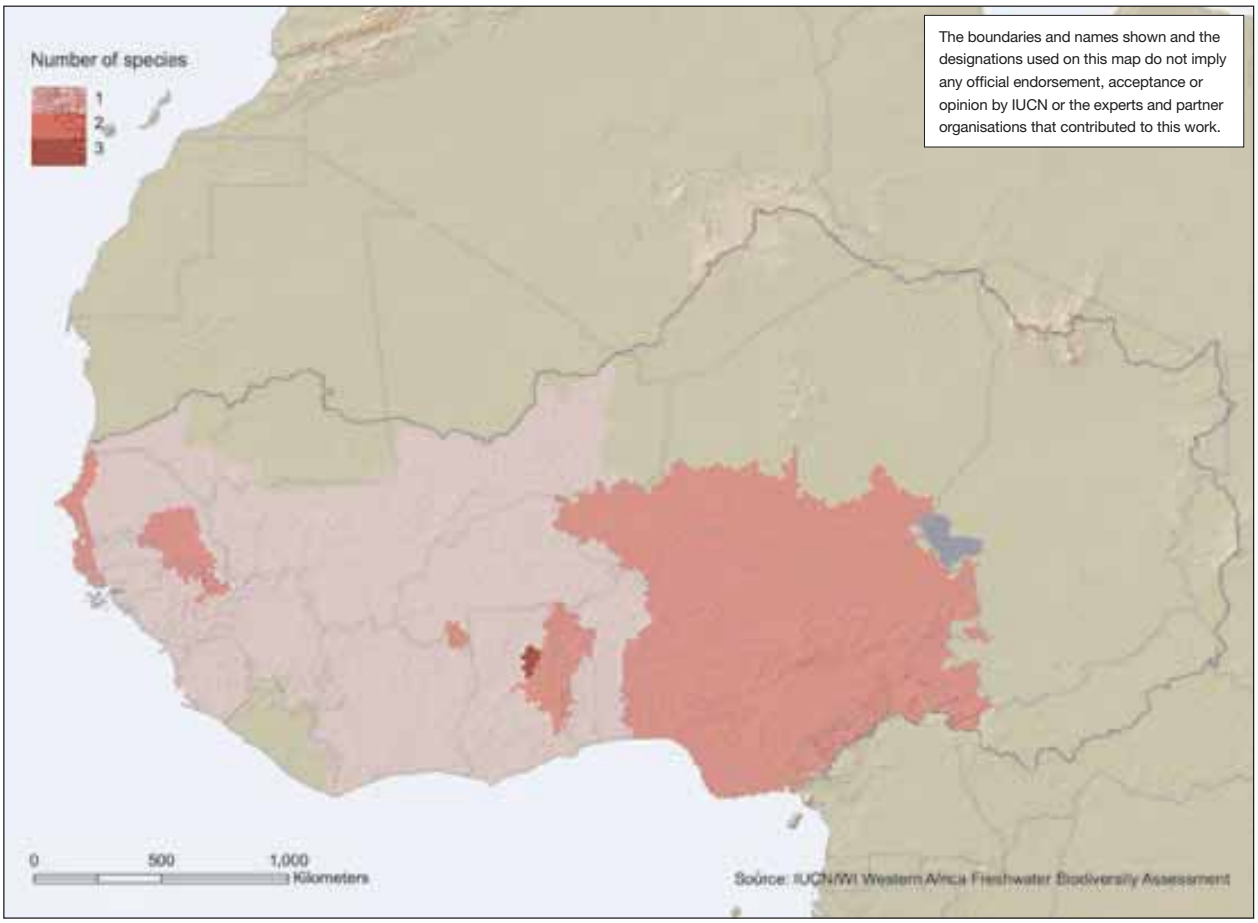


Figure 7.4 Threatened wetland plants species richness in the western Africa region, based mostly on country distribution information. Species richness = species per hexagonal grid cell (289 km²).



endemicity, with between 14-20 species per grid cell (Figure 7.3). This generally supports the view that the two areas (Upper Guinea and south east Nigeria) have high levels of endemism (Linder 2001, Davis *et al.* 1994).

The highest number of threatened species (three) is in a tributary to northern end of Lake Volta in Ghana (see Figure 7.4). Nigeria, Cameroon and Niger each have two threatened species. However, due to the high levels of DD species, there are likely to be more threatened species as more information becomes available.

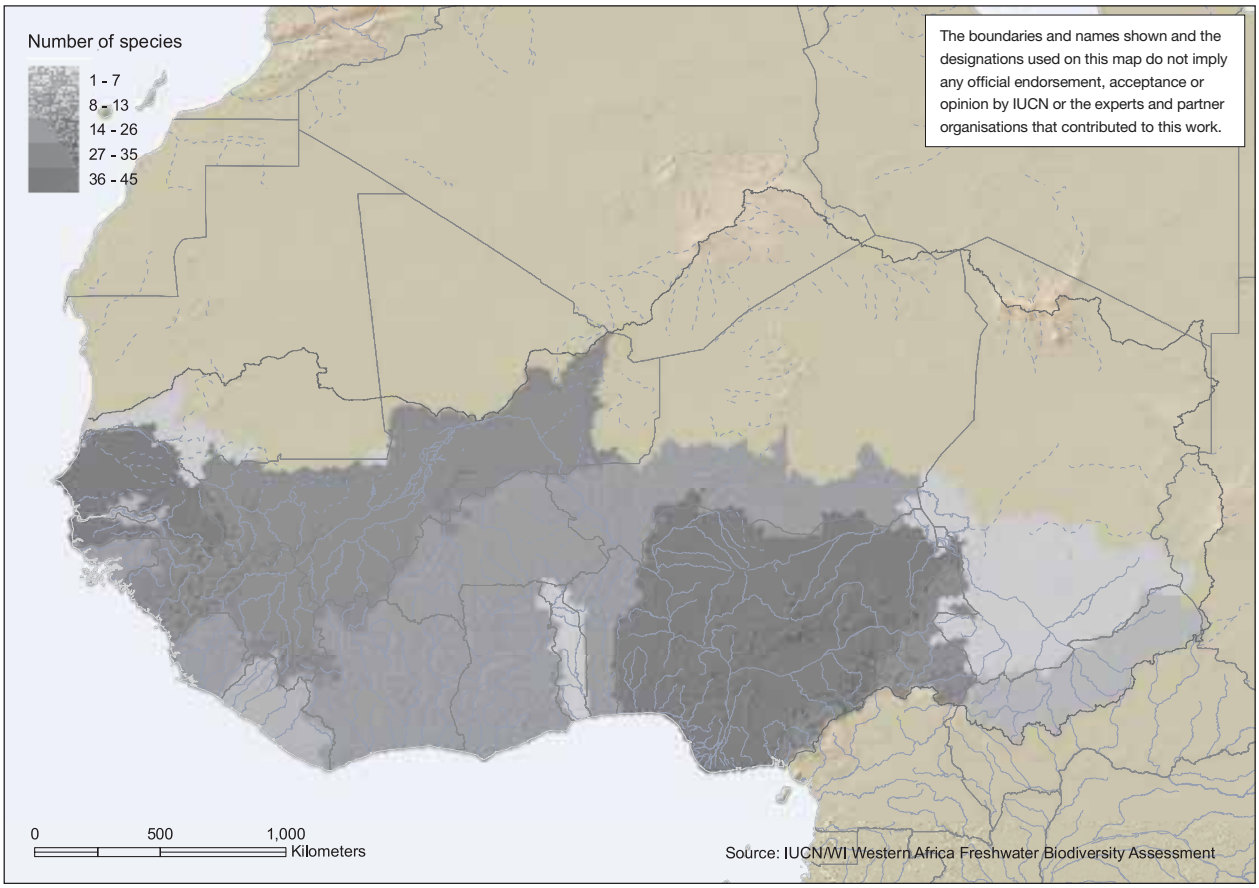
Senegal and Nigeria have the highest numbers of Data Deficient species, with between 36 and 45 species in each grid cell. Mali and Guinea also have high levels (between 27-35) (Figure 7.5).

7.4 Threats to aquatic plants

This assessment process has helped to identify many of the major threats to western Africa's aquatic plants. Drought, and habitat loss due to expanding agriculture, are the greatest threats, impacting 44% and 38% of species, respectively (Figure 7.6). Invasive species, water pollution, and habitat loss due to changes in native species dynamics and invasive species, when combined impact just under 20% of all species. Over-harvesting is identified as impacting just over 10% of species. As there are so few species assessed as threatened (seven) the proportion of species impacted by each threat is similar, with the noticeable exception being drought, which impacts 86% of the threatened species. For a large proportion of species (29%) the threats remain unknown, thus reflecting the very high number of Data Deficient species. Only 7% of species were recorded as having no known threats.

Freshwater plants are of high value, providing food for humans and their livestock as well as the supply of many ecosystem services such as water filtration, flood control, and critical habitats for many animal species. Although not many plants are listed as threatened they do face many threats, including drought, agricultural development, pollution, invasive alien species, overexploitation and the creation of dams. It is therefore important that we continue to monitor the overall loss of vegetation, even if few species are currently threatened.

Figure 7.5 Data Deficient wetland plants species richness in the western Africa region, based mostly on country distribution information. Species richness = species per hexagonal grid cell (289 km²).



7.4.1 Water abstraction and drought

The growing need for food to support an increasing human population has led to rising levels of water extraction for crop irrigation. This increased level of water extraction, coupled with severe droughts across the region since the 1960s, has contributed to the loss and degradation of many wetlands across the region.

7.4.2 Alien invasive species

Alien invasive species are a major threat to western African freshwater plants. Many wetlands have been invaded by alien species such as *Pistia stratiotes*, *Eichhornia crassipes*, *Typha australis* and *Salvinia molesta*. The main factor allowing species to become invasive is modification of the ecosystem through human activities, such as the use of fertilizers in agriculture and dam construction. For example, in the Senegal River, the proliferation of *Typha domingensis*, *Azolla pinnata*, *Ludwigia stolonifera* and *Potamogeton spp.* is largely due to construction of the Manantali and Diam dams, which created new hydrological conditions (increase of water level, low variation of water salinity, etc.) favouring the rapid growth and proliferation of these species (Kuiseu *et al.* 2001). These species form extensive meadows covering entire water surfaces, preventing oxygen and light penetration, thus severely impacting native species, particularly in the submerged zones.

7.4.3 Pollution

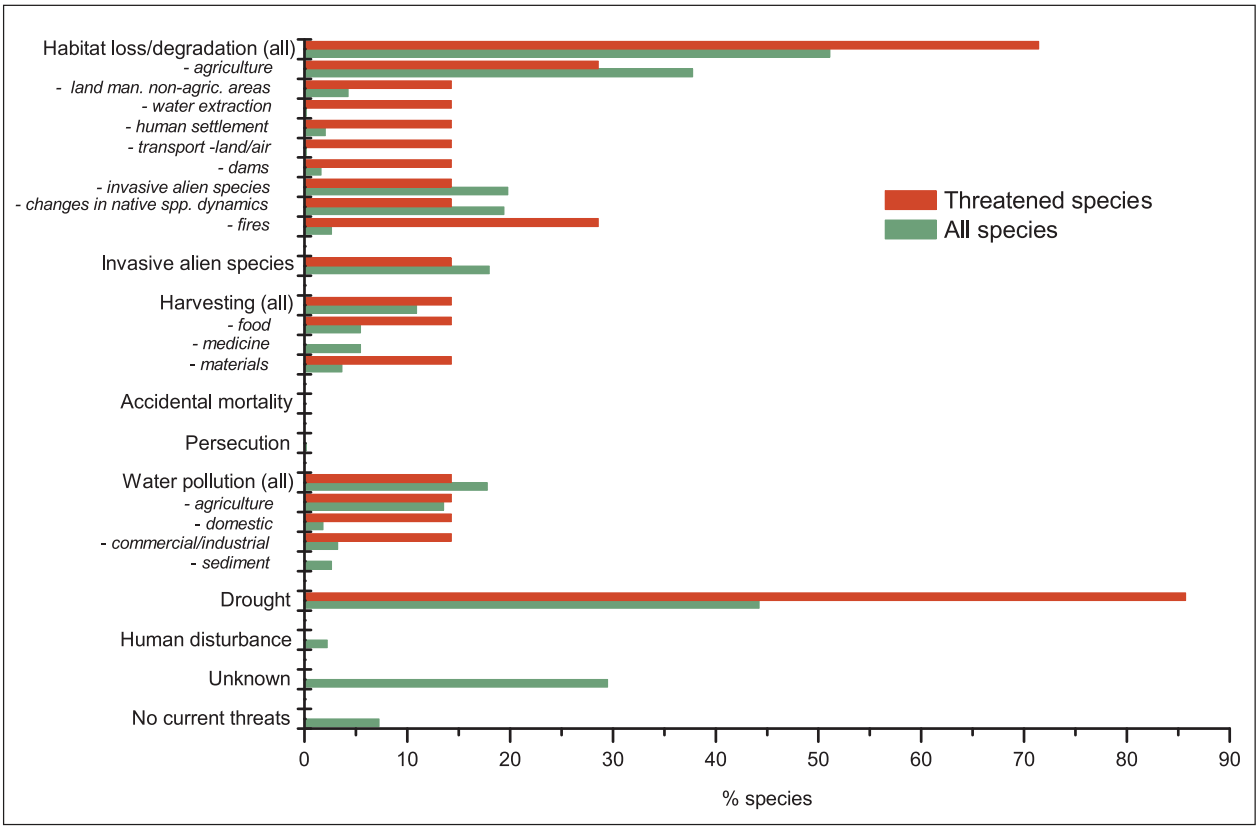
The use of pesticides and fertilizers in agriculture is the major source of water pollution in the region, although industrial development and domestic pollution also present a growing threat. In both cases, their impacts on wetland flora are significant.

7.5 Conservation recommendations

The management of freshwater wetlands requires a strategy which takes full account of the ecological functions of the wetland and the services the wetland provides. Such a strategy requires an improvement in the level of available scientific information. The data provided through this assessment needs to be maintained and improved upon, it also needs to be used by the development planning community to help inform their decisions.

The control of invasive alien species is identified as an urgent requirement for the protection of western Africa's aquatic plant species, and additional research and resources are needed

Figure 7.6 Percentages of species affected by each threat. Note that many species have more than one threat listed.



to tackle this problem. Currently there are three available methods that might be employed to remove alien invasive species; mechanical, chemical and biological. For example, in the Senegal River, mowing has been used to control *Typha australis*, and the weevil *Cyrtobagous salviniae* has been used to control the spread of *Salvinia molesta* (Pieterse *et al.* 2003).

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Chapter 8. Regional synthesis for all taxa

Smith, K.G. and Darwall, W.R.T.[1]

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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 western 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 wetland 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.

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

Taxon	Number of described species	Number of species in western Africa	% of global total found in western Africa
Fish	~15,000	542	3.6%
Molluscs	~5,000	90	1.8%
Odonata	5,680	287	5.1%
Crabs	1,446	35	2.4%
Amphibians	4,231	150	3.5%
Mammals	145	16	11 %
Waterbirds	1989	380	19.1%
Turtles	260	3	1.2%
Plants	~2,614	472	18.1%

Data sources: Balian *et al.* (2008); IUCN Red List (2008).

8.1 Patterns of species richness

The western 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 5% of total global land mass (excluding Antarctica), it is apparent that many groups, waterbirds, plants and mammals in particular, are well represented within the region.

Of the 1,395 species assessed here at the regional scale, just over 14% are regionally threatened (Table 8.2). When compared with the global level of threat to some of those taxonomic groups that have been comprehensively assessed (e.g. amphibians, 30% threatened; birds, 12% threatened; mammals, 21% threatened (IUCN 2008)) this figure may seem relatively low. This can largely be attributed to the relatively low levels of past development and subsequent impacts to western Africa's environment as compared to some other regions of the world. The Mean Species Abundance (MSA - an index of the mean abundance of original species), in sub-Saharan Africa in 2000 was calculated to be 73%, whereas Europe (MSA of 45%) and South and East Asia (MSA of 55%) are much lower (CBD and MNP 2007). There are, however, a number of serious current and looming threats to the region's inland water ecosystems (see *Situation Analysis* in chapter 1) with massive levels of population growth and development. This, combined with the predicted impacts of climate change, sets the stage for a potential major loss of freshwater biodiversity. The MSA predictions for 2050 are that sub-Saharan Africa will have the greatest decline in MSA of any region on Earth with a decline

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

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	521	0	0	0	16	44	77	56	273	55	16
Odonates	287	0	0	0	7	6	14	3	217	40	24
Molluscs	90	0	0	0	5	5	5	2	59	14	4
Crabs	25	0	0	0	2	4	4	0	10	5	0
Aquatic Plants	472	0	0	0	2	0	5	5	356	104	23
Total	1395	0	0	0	32	59	105	66	915	218	67

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, introduced species), NE – Not Evaluated.
* Excludes those species classified as Not Applicable (NA).

of 11.7%, compared to a global decline of 7.6% (CBD and MNP 2007).

A comparison can also be made with other comprehensive regional freshwater biodiversity assessments. Eastern Africa, an area very rich in freshwater dependent species and very high levels of endemism, has just under 23% of species assessed as regionally threatened (note: this doesn't include plants) (Darwall *et al.* 2005) – a level of threat significantly higher than that observed in western Africa, though when plants are excluded for western Africa the level of threat jumps to 20%. The eastern Africa situation was largely attributed to alien invasive species impacting on the many range restricted endemic fish species of the large lakes, and high levels of wetland degradation. For southern Africa, just over 7% of the species are assessed as regionally threatened (Darwall *et al.* 2009). This relative low level of threat is most likely a reflection of the current low levels of development throughout much of the region, with the exception being South Africa, where development levels are much higher, and where the majority of the threatened species in the region are currently found.

Many species (33%) are endemic to western Africa, so their regional Red List assessments are equivalent to *global* assessments and therefore represent the risk of global extinction for the species. Of the 460 regionally endemic species assessed here (fishes, molluscs, odonates, crabs and plants), 155 species (33.7%) are globally threatened (Table 8.3).

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 in western Africa is 1,009 of which 197 species (19.5% of those assessed) are assessed as globally threatened (Table 8.3), which is 50% greater than in southern Africa which has a threat level of 12% when the same taxonomic groups are included (Darwall *et al.* 2009).

The Red List status for each species assessed for this project is listed in Appendix 1 on the accompanying DVD for both the global and regional scales.

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	300	0	0	15	39	59	45	109	33
Odonates	61	0	0	7	3	5	3	24	19
Molluscs	36	0	0	5	3	5	2	11	10
Crabs	21	0	0	2	4	4	0	6	5
Aquatic Plants	42	0	0	2	0	2	2	11	25
Amphibians	150	0	0	2	13	12	18	88	17
Water Birds	380	0	0	0	2	8	13	356	1
Turtles	3	0	0	0	0	0	2	1	0
Mammals	16	0	0	0	2	3	0	11	0
Total	1009	0	0	33	66	98	85	617	110

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 or introduced species).
Data sources: IUCN Red List (2008) (incl. www.iucnredlist.org/amphibians; www.iucnredlist.org/mammals), BirdLife International (2009)

8.1.1 Centres of species richness

When the species distributions from the four animal species groups assessed through this project (e.g. fishes, odonates, molluscs, and crabs – plants were excluded as they are mostly mapped to country boundaries) are overlaid, areas with the highest numbers of species are identified. Figure 8.1 shows that the Niger Delta and the Ebrie Lagoon (Côte D'Ivoire) contain the greatest number of species in the region (between 268 and 338 species per grid cell). Other areas of high species richness (222–267 species) include the coastal basins of the Upper Guinea ecoregion (Sierra Leone and Liberia), the lower courses of rivers in Côte D'Ivoire (Eburneo ecoregion) and western Ghana (Ashanti ecoregion), lower Volta and Oueme rivers, the Ogun drainage in western Nigeria, the lower Niger river between the delta and the confluence with the Benue river and the upper Cross river and Bamenda Highlands in south-west Cameroon. Species richness then declines northwards with the exception being the upper Niger river and inland Niger Delta.

This mapping presentation is, however, biased towards highlighting areas rich in the most speciose groups such as the fishes and odonates. In order to therefore highlight areas rich in representation from all taxonomic groups the distribution maps for fishes, molluscs and odonates were overlaid. Crabs were not included in the analysis due to the relatively low number of species (25) found in the western Africa region, and plants were excluded as they were mostly mapped to country boundaries rather than sub-basins. 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 taxonomic groups (Figure 8.2). Five areas have been identified as meeting this threshold for all three species groups. Moving from west to east the areas are: i) the southern coastal area of Guinea; ii) the lower river Jong in Sierra Leone; iii) Ebrié Lagoon in Côte d'Ivoire; iv) lower Ogun and Oueme rivers and their coastal lagoons in Benin, and; v) western Nigeria and the Niger Delta to the lower Cross river in southern Nigeria.

8.1.2 Distribution of threatened species

The upper Cross river (west Cameroon highlands) and the Niger Delta contain the highest number of regionally threatened fishes, odonates, molluscs and crabs (20–29 species per grid cell) in western Africa (Figure 8.3). Other areas that contain high numbers of threatened species (13 – 19 species per grid cell) are the wider Niger Delta and the lower Cross river, and the lower Oshun and Ogun basins (western Nigeria), Pra and, Tano (Ghana), upper Cavally (Liberia/Côte d'Ivoire), St. Paul

Figure 8.1 Western Africa species richness for all four animal taxonomic groups. Species richness = species per hexagonal grid cell (289 km²).

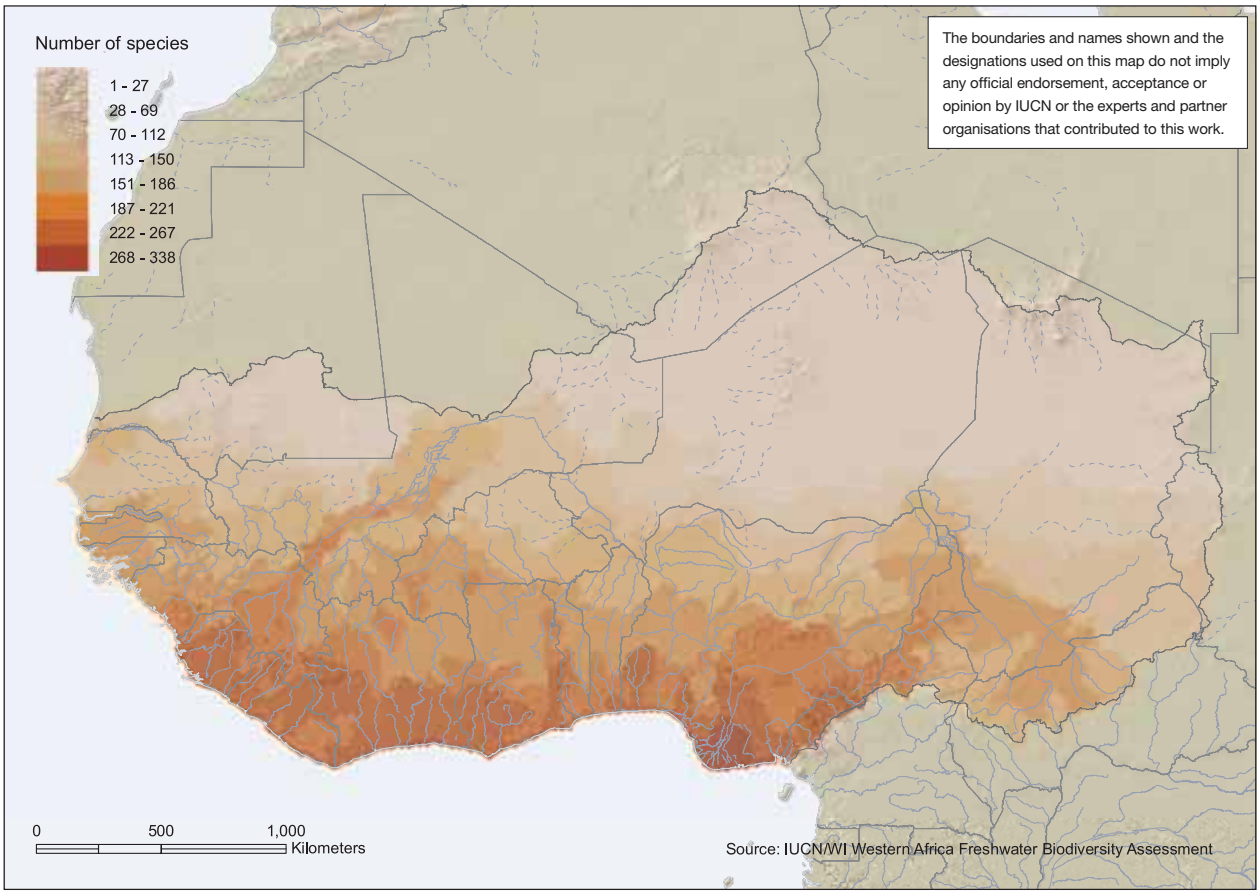


Figure 8.2 Areas containing exceptionally high numbers of species from all taxonomic groups. The map represents those hexagonal grid cells that hold at least 20% of the total species complement for each of the fishes, molluscs and odonates. The sub-basins that contain the grid cells with >20% of total species complement for all three taxonomic groups are highlighted.

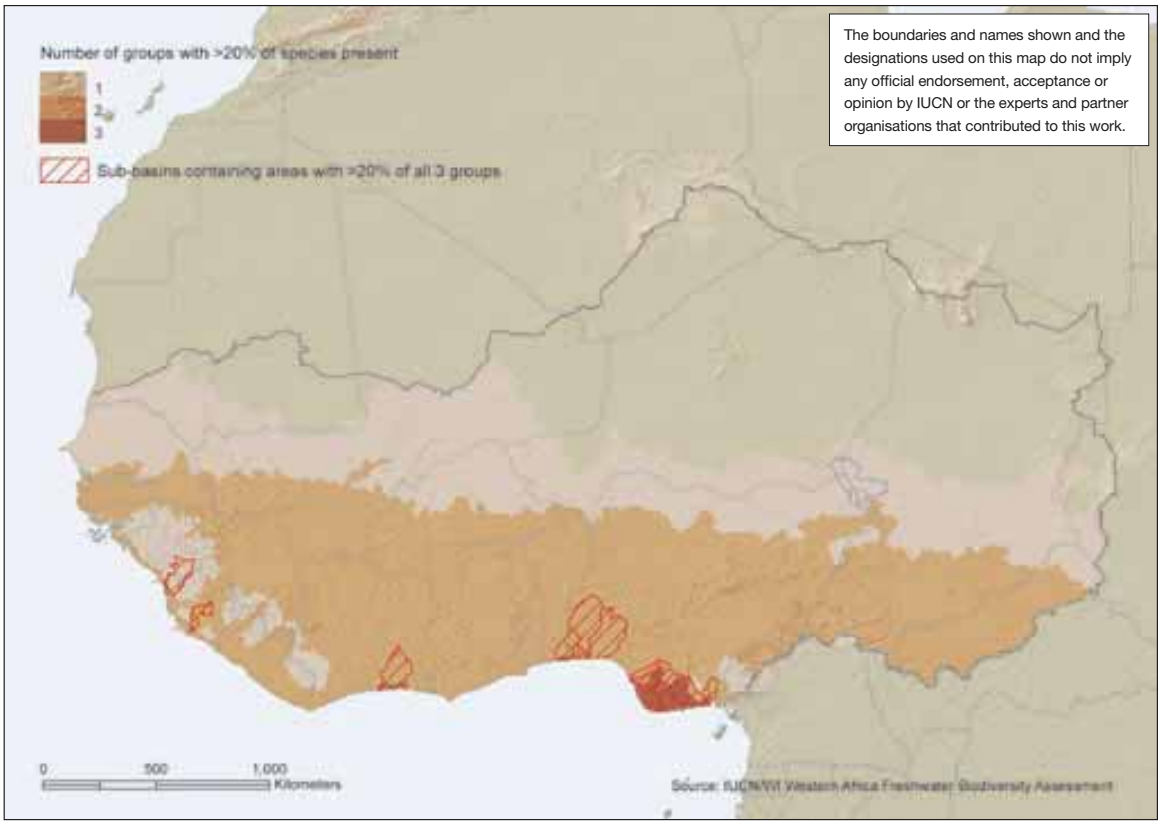


Figure 8.3 Threatened fishes, molluscs, odonates and crabs in the western Africa region. Species richness = species per hexagonal grid cell (289 km²).

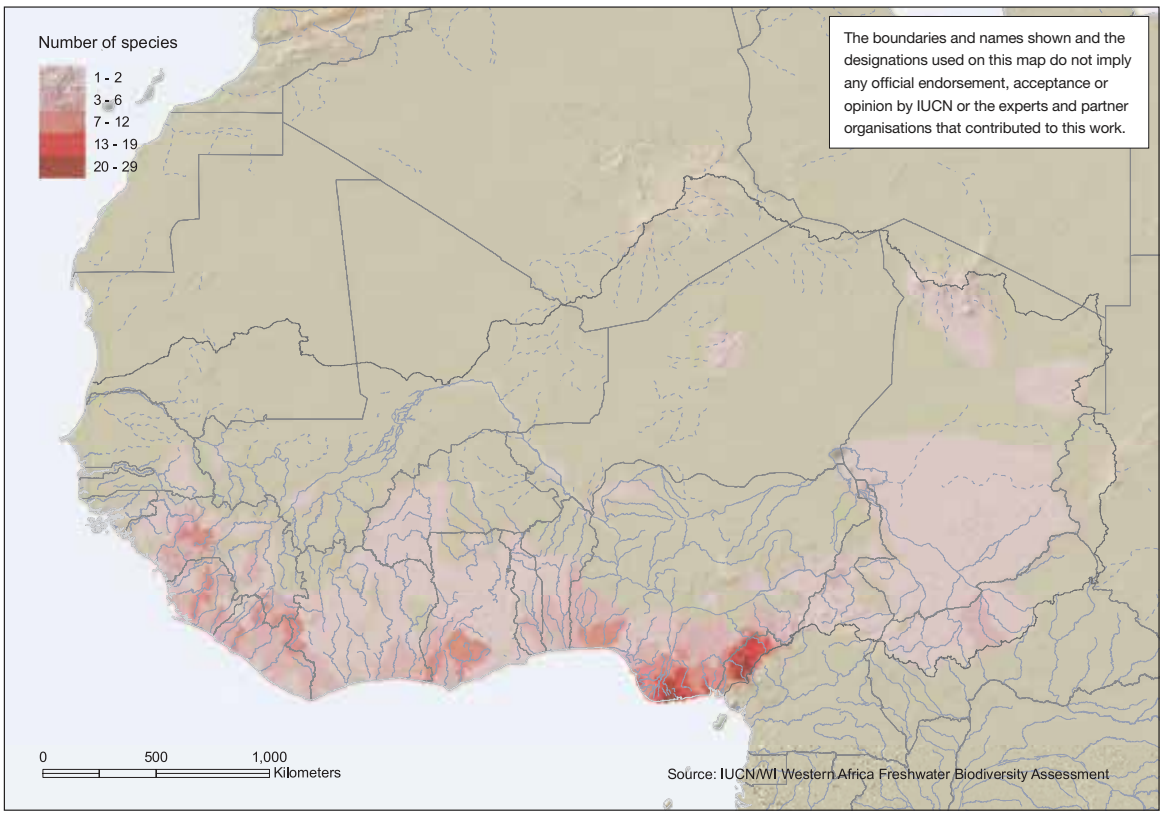
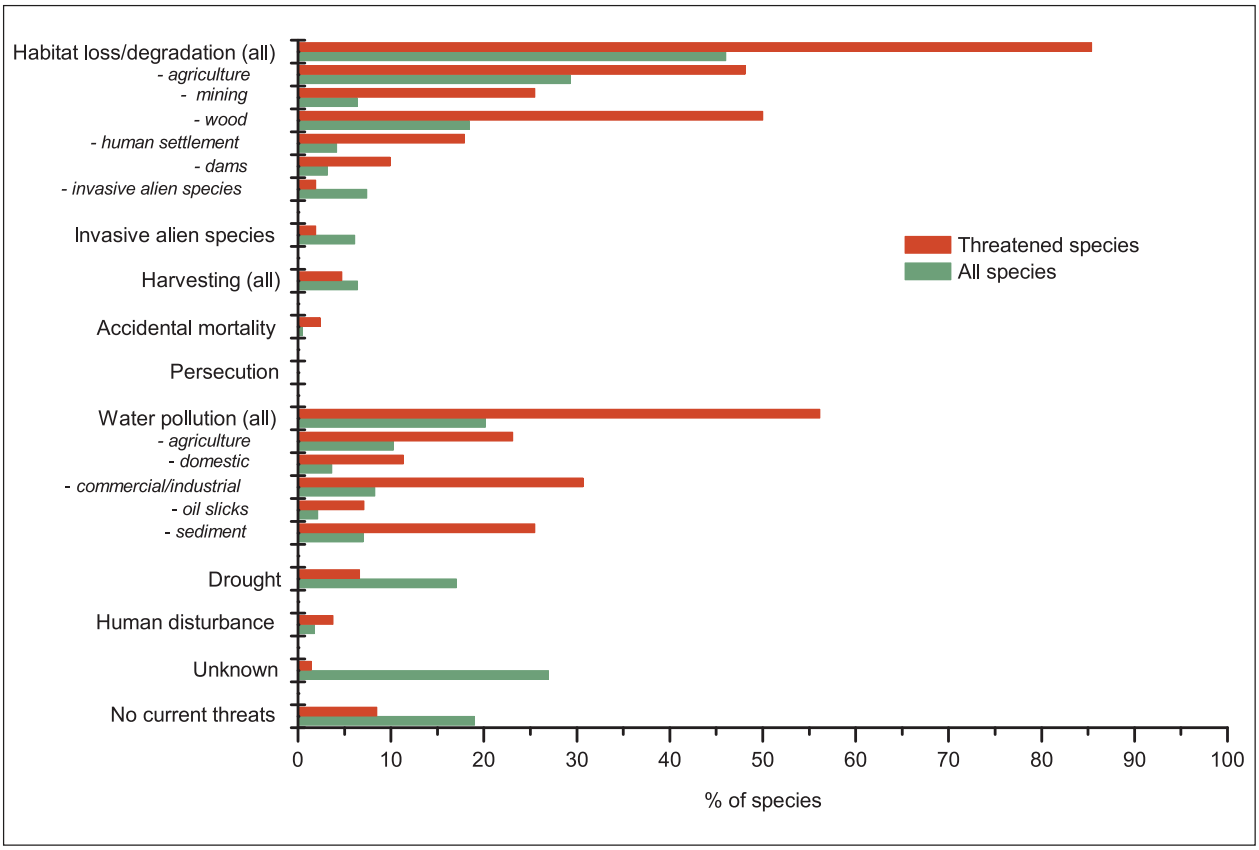


Figure 8.4. Major current threats to freshwater species in western Africa.



basin in Liberia, the Moa, Jong and Rockel rivers in Sierra Leone and the upper Konkoure and upper Baffing in Guinea all contain between 7-12 threatened species per grid cell.

Figure 8.4 shows the major current threats to freshwater biodiversity in western Africa. Habitat loss primarily due to deforestation, agriculture, and to a lesser extent mining, impacts over 85% of the regionally threatened species and nearly half of all species in the region. Water pollution impacts over 55% of threatened species, with agriculture and the resulting sedimentation identified as the main causes along with commercial/industrial activities (including mining). Only 19% of species from these taxonomic groups have no current threat identified, and 8% of the threatened species also have no current threat identified. However, these species will be listed as threatened due to future threats – for example, a dam may be planned to be constructed upstream of the rapids in which a species survives. For 27% of the species threats are potentially present but there is insufficient information available to be sure (classified as "unknown").

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 sub-basin as defined in the Hydro1K data layer. Most restricted range species are found in the Upper Guinea region of western Africa. In particular, 74 species are only known from the level 3 basin that covers Liberia and most of Sierra Leone, and 19 species are endemic to the sub-basin covering western Guinea to south Senegal (Figure 8.5). It is important to note that the sizes of the level 3 basins vary quite drastically, from 200,000 km² to less than 1,000 km² (average, approximately 31,500 km²), with some representing sub-basins within a catchment while others include multiple river basins. However, similar patterns are evident in Figure 8.6 which shows the richness of species endemic to the western Africa region. It shows that the upper Guinea region and the basins in western Ghana and eastern Côte d'Ivoire, with between 49 and 75 species per grid cell, contain the highest levels of regionally endemic species.

8.2 Conservation priorities for the region

The results show that western Africa supports a high diversity of freshwater species, of which a significant proportion is threatened. As development increases across the region the status of western Africa's freshwater biodiversity will worsen unless successful conservation measures can be undertaken.

An immediate priority is to implement conservation actions in the basins that have been identified to contain exceptional levels of species diversity (see section 8.1.1) and those containing high levels of threatened species (section 8.1.2). These actions need

Figure 8.5 Number 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.

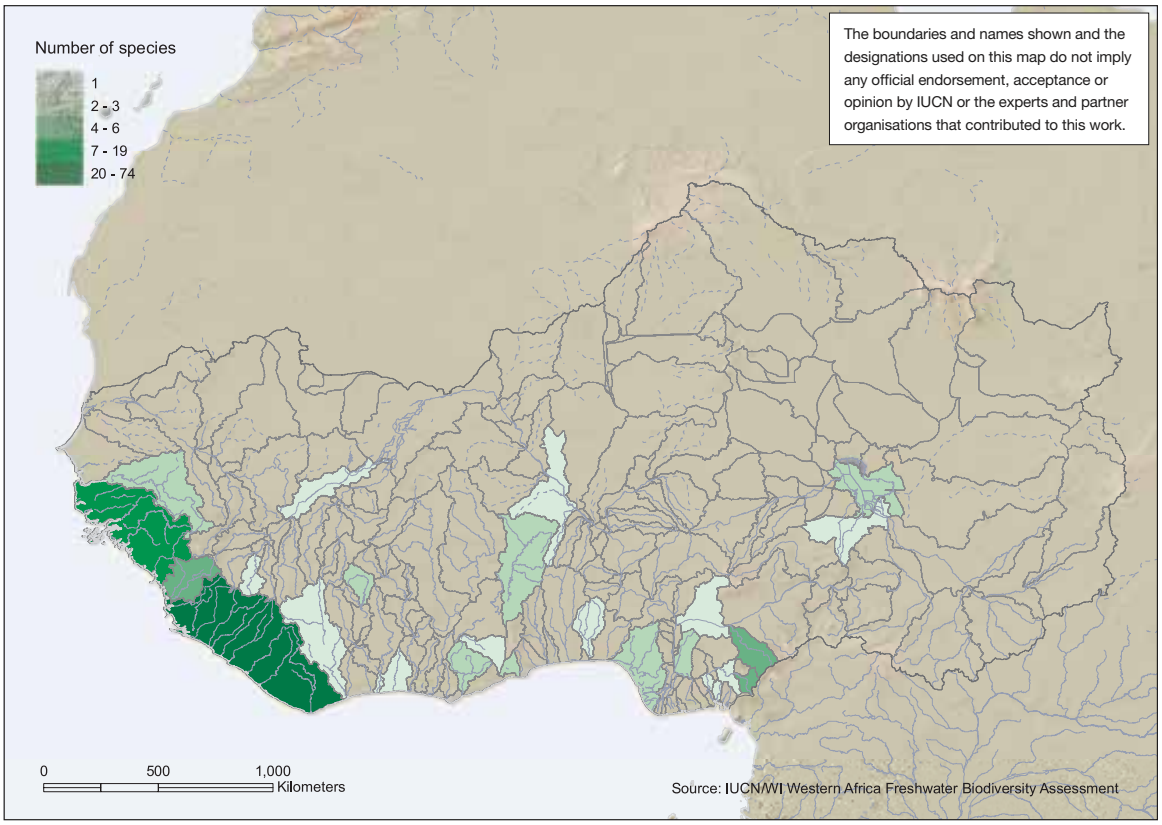
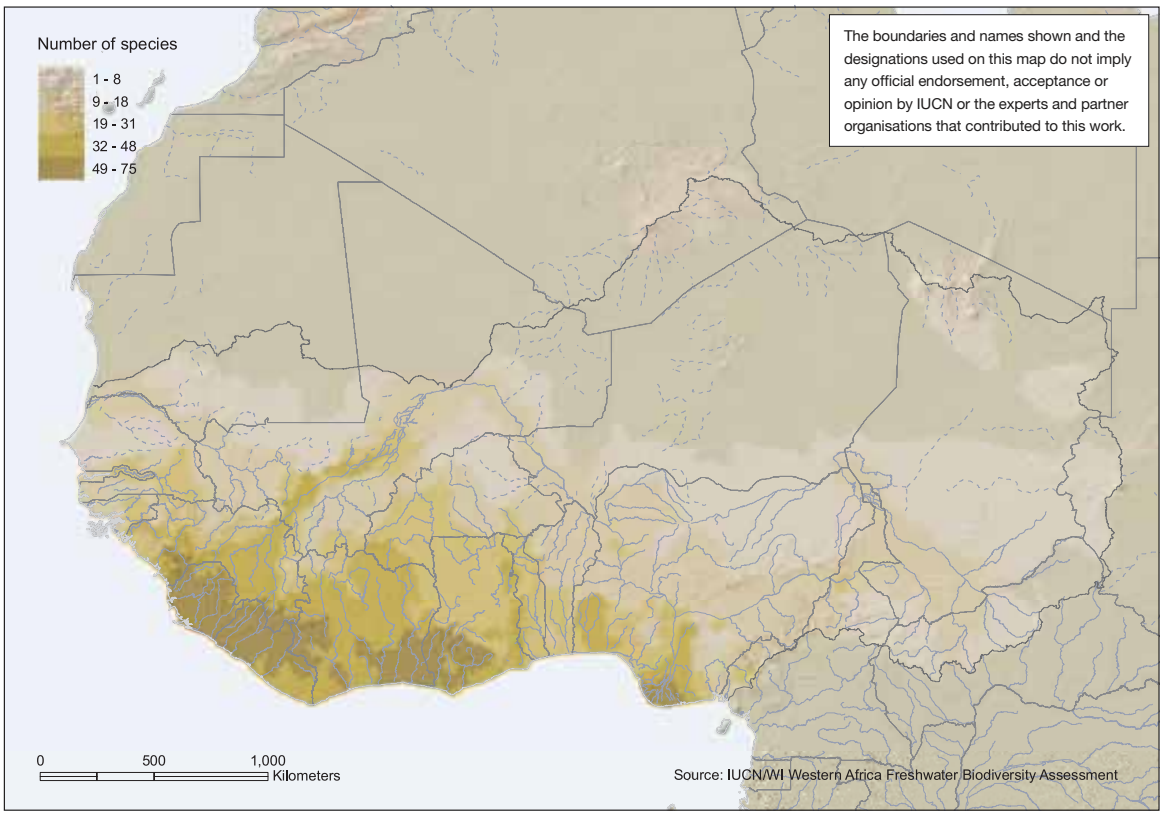


Figure 8.6 Western African endemic fishes, molluscs, odonates and crabs in the western Africa region. Species richness = species per hexagonal grid cell (289 km²).



to address the downstream impacts of the key threats, such as agricultural and mining pollution and deforestation often leading to increased sedimentation. If this situation continues along current trends some species will become extirpated from catchments and may become extinct altogether. Ecosystem level consequences of the loss of such species are poorly understood, as are the knock on effects to the services they provide to human populations. It is often the poorest communities that rely most heavily upon freshwater resources, for example, as a protein source, for building materials, and for income when subsistence harvest surpluses are sold. Consequently, this poorest section of the community, which has few alternative livelihood options, suffers the most when species are lost or ecosystems are degraded.

8.2.1 Environmental Impact Assessments (EIA)

EIAs, when correctly undertaken, are a valuable tool for informing the development planning process, particularly where threatened or restricted range species are expected to be found. This report (and the IUCN Red List website) provides data useful to the initial planning stages of EIAs, as the expected species composition of every sub-catchment in the region can be identified, along with information on species ecology, Red List status, threats and utilisation. It should be noted, however, that the spatial data presented are of too low resolution to replace the need for additional field surveys as required for a fully comprehensive EIA.

8.2.2 Protected Areas

Protected Areas need to be specifically designed for the protection of freshwater species, particularly those that have restricted ranges or limited numbers of congregation, migration or breeding sites. Design must take good account of the high connectivity within freshwater systems if the Protected Areas are to be effective. For example, the success of a protected area established for freshwater species conservation may be greatly reduced if upstream activities some distance outside the Protected Area boundaries, such as excessive water withdrawal or regulation, may significantly alter the downstream flow regime within the protected area to the detriment of those species being protected. A good understanding of the threats and ecology of the target species, as provided here, is often essential for optimising the design of the Protected Area. Protected Areas can also be used to help maintain water quality through the protection of upper catchment forests and vegetation.

8.2.3 Integrated Water Resource Management (IWRM) and Environmental Flows

In western Africa there are many transboundary rivers (the Niger river basin alone passes through nine countries), and as the region continues to develop and populations grow the demand for water in neighbouring countries is going to increase. There is therefore a need for IWRM to be adopted, along with other similar management approaches, such as Environmental Flows. IWRM aims to manage entire river catchments (both water and land) so that the economic and social benefits are maximised while maintaining ecosystem functions (see the Global Water Partnership Toolbox for more information on IWRM and case studies (www.gwptoolbox.org)). Environmental Flows, a component part of IWRM, is a concept based on the understanding that a river's flow regime is critical to the maintenance of a functioning wetland ecosystem. The approach aims to find a balance between the quantity, quality and timing of water flows required to sustain freshwater and estuarine ecosystems, and the water needs of the associated human population (SWH 2009). For example, using this approach, the natural flow regime of a river may be maintained or restored (such as through the controlled opening and closing of dams) to allow target species reliant on seasonal fluctuations to be maintained.

8.2.4 Filling the information gaps

There are a large number of Data Deficient species in the region, with between 10% (fishes) and 22% (crabs) of species falling into this category. Further research and survey work are desperately needed to gather more information on these species' distributions, taxonomy, ecology and their utilisation and threats. Findings from future field surveys will undoubtedly uncover more threatened species, and will likely add to the growing body of evidence that freshwater biodiversity has great value to local livelihoods.

8.2.5 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 DVD. Policy briefs will be forthcoming. All species global assessments and distribution maps 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 organizations 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 at: www.unep-wcmc.org/freshwater_biodiversity/Africa/survey/
In conclusion, we hope that the information provided through

this assessment will be taken up by the key stakeholders in freshwater ecosystems throughout western 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.

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Appendix 1. Example species summary and distribution map

Elattoneura dorsalis

VU

Taxonomic Authority: Kimmins, 1938

☐ Global Assessment ☑ Regional Assessment Region: Western Africa ☑ Endemic to region

No synonyms available

Common names

YELLOW-FRONTED THR English

Upper Level Taxonomy

Kingdom: ANIMALIA Phylum: ARTHROPODA

Class: INSECTA Order: ODONATA

Family: PROTONEURIDAE

Lower Level Taxonomy

Rank: Infra- rank name: ☐ Plant Hybrid

Subpopulation: Authority:

General Information

Distribution

Known only from Sierra Leone: recording from the following locations (villages) Yana, Kamakoni (Kimmins 1938), Newton, Kasewe (Marconi & Terzani unpubl.), all lie relatively north-west in the country.

Range Size

Area of Occupancy:

Extent of Occurrence:

Map Status:

Elevation

Upper limit:

Lower limit:

Depth

Upper limit:

Lower limit:

Depth Zones

☐ Shallow photic ☐ Bathyl ☐ Hadal

☐ Photic ☐ Abyssal

Biogeographic Realm

☑ Afrotropical

☐ Antarctic

☐ Australasian

☐ Neotropical

☐ Oceanian

☐ Palearctic

☐ Indomalayan

☐ Nearctic

Population

No information available.

Total Population Size

Minimum Population Size: Maximum Population Size:

Habitat and Ecology

Based on the ecology of other species of the genus, it can be assumed to be a forest stream species.

System

☐ Terrestrial ☑ Freshwater ☐ Marine

Movement pattern

☐ Nomadic ☐ Congregatory/Dispersive ☐ Migratory ☐ Altitudinally migrant

Crop Wild Relative

☐ Is the species a wild relative of a crop?

Threats

No specific threats are known for the species. However deforestation for agriculture, which is occuring in this densely populated region, is believed to be a potential threat.

	Past	Present	Future
1 Habitat Loss/Degradation (human induced)	☑	☑	☑
1.1 Agriculture	☑	☑	☑
1.1.1 Crops	☑	☑	☑

Conservation Measures

No information available.

	In Place	Needed
3 Research actions	☐	☑
3.2 Population numbers and range	☐	☑
3.3 Biology and Ecology	☐	☑
3.4 Habitat status	☐	☑
3.5 Threats	☐	☑
3.9 Trends/Monitoring	☐	☑

Countries of Occurrence

	PRESENCE							ORIGIN				
	Year Round	Breeding Season only	Non-breeding season only	Passage migrant	Possibly extinct	Extinct	Presence uncertain	Native	Introduced	Re-Introduced	Vagrant	Origin uncertain
Sierra Leone	☑	☐	☐	☐	☐	☐	☐	☑	☐	☐	☐	☐

General Habitats	Score	Description	Major Importance
1 Forest	9	Possible	Not applicable
1.6 Forest - Subtropical/Tropical Moist Lowland	9	Possible	Not applicable
5 Wetlands (inland)	9	Possible	Not applicable
5.1 Wetlands (inland) - Permanent Rivers/Streams/Creeks (includes waterfalls)	9	Possible	Not applicable

IUCN Red Listing

Red List Assessment: (using 2001 IUCN system) Vulnerable (VU)

Red List Criteria: B1ab(ii,iii)

Date Last Seen (only for EX, EW or Possibly EX species):

Is the species Possibly Extinct? ☐ Possibly Extinct Candidate? ☐

Rationale for the Red List Assessment

Short-listed by Dijkstra & Vick (2004) as western African odonate requiring special attention. Known from four sites in Sierra Leone within a 20,000 km2 area of lowland forest habitat, which is expected to deteriorate in the future due to agricultural expansion and therefore listed as Vulnerable.

Reason(s) for Change in Red List Category from the Previous Assessment:

☐ Genuine Change
- ☐ Genuine (recent)
- ☐ Genuine (since first assessment)

☐ Nongenuine Change
- ☐ New information
- ☐ Knowledge of Criteria
- ☐ Incorrect data used previously

☐ Taxonomy
☐ Criteria Revisio
☐ Other

☐ No Change
- ☐ Same category and criteria
- ☐ Same category but change in criteria

Current Population Trend: Unknown

Date of Assessment: 05/06/2006

Name(s) of the Assessor(s): Dijkstra, K.-D.B.

Evaluator(s): Amakye, J.S., Ogbogu, S.S., Tchibozo, S. & Smith, K.

Notes:

% population decline in the past:

Time period over which the past decline has been measured for applying Criterion A or C1 (in years or generations):

% population decline in the future:

Time period over which the future decline has been measured for applying Criterion A or C1 (in years or generations):

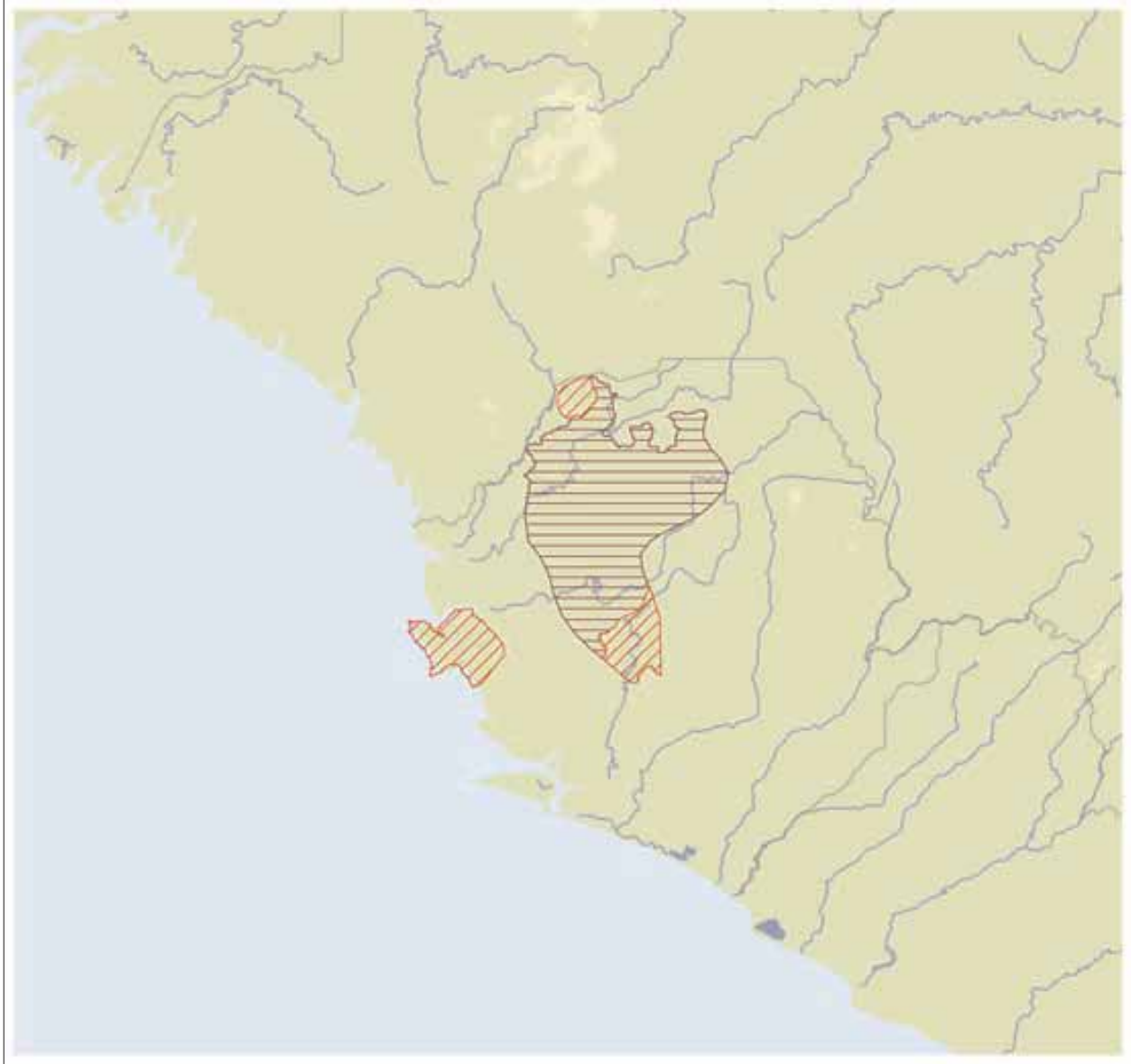
Number of Locations: 4

Severely Fragmented:

Number of Mature Individuals:

Bibliography

Kimmins, D.E., , 1938, New African species of Elattoneura (Odonata). , Annals and Magazine of Natural History 1, 294-302., ,


Elattoneura dorsalis
Range type
Present (native)
Possibly present (native)
national boundaries
n/a
subnational boundaries
lakes, rivers, canals
salt pans, intermittent rivers
elevation meters
5000
4000
3000
2000
1000
0
32 km

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

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European Red List of Amphibians. Compiled by Helen J. Temple and Neil Cox, 2009

European Red List of Reptiles. Compiled by Neil Cox and Helen J. Temple, 2009

The Status and Distribution of Dragonflies of the Mediterranean Basin. Compiled by Elisa Riservato, Jean-Pierre Boudot, Sonia Ferreira, Milos Jovic, Vincent J. Kalkman, Wolfgang Schneider and Boudjéma Samraoui, 2009

The Status and Distribution of Mediterranean Mammals. Compiled by Helen J. Temple and Annabelle Cuttelod, 2009

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