CONGO RIVER ENVIRONMENT AND DEVELOPMENT PROJECT (CREDP)

BIODIVERSITY SURVEY: SYSTEMATICS, ECOLOGY, AND CONSERVATION ALONG THE CONGO RIVER SEPTEMBER-OCTOBER, 2002

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CREDP is financed by USAID and implemented by Innovative Resources Management

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1. SUMMARY

The Congo River is the second most important site in the world for freshwater biodiversity, specifically fishes. Yet it is also one of the poorest known. Some areas have not been surveyed since Max Poll's expedition in 1953 (Poll, 1959); others, since the late 1970's (e.g., lower Congo rapids: Stewart and Roberts, 1976). Covering an estimated 1,500,000 miles^2, it is the second largest river basin after the Amazon.

This rapid biodiversity survey was made at the request of Innovative Resources Management, the nongovernmental organization implementing the USAID-funded Congo River Environment and Development Project (CREDP). The following taxonomic groups were qualitatively sampled, to obtain an estimate of the number of species: fishes, birds, amphibians, reptiles, mammals, aquatic invertebrates, terrestrial and aquatic plants. In addition, ecological parameters of the river water were assessed at each site.

The survey was conducted by Dr. Caroly A. Shumway of the New England Aquarium, in collaboration with Dr. John Sullivan (Cornell University), Mr. Robert Schelly (American Museum of Natural History) and a team of researchers from the Kinshasa- based nongovernmental organization, Environmental Resources Management and Global Security, with the focal point coordinator being Dr. Dieudonné Musibono. Other team members included Dr. Séraphin Ifuta, Dr. Julien Punga, Dr. Jean-Claude Palata, and Mr. Victor Puema. Plants were brought back to the University to be identified by the Herbarium of the University. At each site, a local CREDP facilitator was present: either Germain Mankoto or Aimé Kamamba.

At each site, we actively involved local partners, including fishermen, in the work. Using a participatory approach, we showed our partners how and why we identified fish and other species, and how and why we were collecting water quality parameters. In Bas-Congo, the fishermen themselves conducted part of the water quality analyses. We also worked with the fishermen to create a field guide for fishes in the local languages, Lingala and Kikongo.

The survey was conducted in three provinces: Bandundu, Bas-Congo, and Equateur, with very different ecological characteristics. In Bandundu, the survey was conducted at several sites in Mushie, between Mushie and Bokoni, and around Bokoni. In Bas-Congo, the survey was conducted at 5 study sites in Inga: Inga #1 (aka Tank), Point 50, Nziya, Songa, and Fwomalo. In Equateur, the survey was conducted at Bodjia, Gombe, the confluence of the Ubangi and Congo Rivers, Irebu, midway between Gombe and Mbandaka, and Mbandaka.

For fish, nets used included cast nets, seine nets, gill nets, and dip nets. We also purchased samples directly from fishermen, both in their fishing grounds or at the market. For birds, a mist net was used. For amphibians, dip net sampling and tape recording of frog calls were used. For macroinvertebrates, dip net sampling, kick net, drop net (left in position) and Hester-Dendy sampling methods were used.

Overall, at least 121 species of fish were recorded: 83 species of fish in Bandundu; 47 in Bas-Congo, and 54 in Equateur. The numbers per province don't sum up to 121, because a number of species were found in all 3 sites. We collected fish from 23 families, representing 92% of the

families known for the Congo basin. Some of the undetermined material likely represents species new to science.

We also identified 60 species of birds, 17 species of amphibians, 8 species of reptiles, 9 species of mammals, 38 species of aquatic invertebrates, and 39 species of plants. One-fourth of the plant species are invasive, while 1/3 have medicinal value. Almost all of the mammal species recorded were bushmeat, a worrisome fact for all provinces. We recorded one hippopotamus killed for bushmeat, and one alive, upstream from Bokoni on the Kasai River.

Important reference collection material of fish species were, under a federal permit, deposited with the American Museum of Natural History (AMNH), New York, U.S.A and Cornell University. A scientific reference collection of select preserved fish specimens is being made for the University of Kinshasa. The AMNH is pursuing a complete identification of species now.

2. TERMS OF REFERENCE

This biological field survey of the animals and plants living in and along the Congo River (including terrestrial and aquatic plants, fishes, birds, mammals, amphibians, reptiles, and macroinvertebrates) was conducted for IRM, by the New England Aquarium (NEAq) as External Technical Assistance Provider. IRM is the implementing agency for the USAID-funded CREDP project. The NEAq organized the survey, in collaboration with researchers from the Kinshasa-based nongovernmental organization, Environmental Resources Management and Global Security, with the focal point coordinator being Dr. Dieudonné Musibono. Other scientists with ERGS included Dr. Séraphin Ifuta, Dr. Julien Punga, Dr. Jean-Claude Palata, and Mr. Victor Puema. Additional members of the team were Dr. John Sullivan and Mr. Robert Schelly, two ichthyologists from Cornell University and the American Museum of Natural History, respectively.

The terms of reference were:

1. To conduct a rapid biodiversity survey of the animals and plants living in and along the Congo River, in three provinces. The aim of the survey was to establish baseline data on the living aquatic resources of the river, and along the river: on their systematics, ecology, their use, and their conservation. As wide an ecological range of aquatic habitats as possible would be visited, focusing in particular on sites heavily utilized by the local residents. Terrestrial ecological integrity would be assessed. In addition, ecological parameters of the river water would be assessed at each site.

2. The survey would be conducted during Sept. and Oct., 2002, with the agreement and support of local people, the Governors of the Provinces, local partners, and the relevant authorities.

3. The opportunity would be taken during the course of the study to train local partners, local residents, and, where possible, students in essential techniques of biodiversity surveying and water quality analysis, including the collection, sorting, scientific determination of species using published keys for identification, and preservation of said species; and the analysis of various water quality parameters.

4. The results of the survey would be used to provide recommendations for monitoring by the local partners and communities. Specifically, the NEAq will provide a list of possible options for communities to begin tracking abundance, resource use, and ecosystem integrity. Our local partners will determine which of these options works best for them.

5. Partial scientific sponsorship (in exchange for export of museum reference specimens) would be provided by The New England Aquarium, Cornell University, and the American Museum of Natural History.

6. Additional necessary equipment, laboratory consumables, and literature would be purchased for the project by the NEAq, and (with receipts provided), reimbursed by IRM. Unused items would be left with IRM or with one of the project's partners.

Dr. Caroly A. Shumway, New England Aquarium, Boston, MA

3. ACKNOWLEDGEMENTS

This work has been supported by the U.S. Agency for International Development, and we thank them for their assistance. Many thanks to Innovative Resources Management for requesting our involvement. We are grateful to the DRC government for granting the U.S. members of the team visas to allow us to travel to the DRC; and to the Governors of the Provinces of Bandundu (Prof. Kidinda Shandingo), Bas-Congo, and Equateur for permitting us to conduct fieldwork on the living aquatic resources of the Congo River and for their enthusiastic support of the CREDP project. At the conclusion of this survey, the Honorable Directeur Chef de Service, Kadekya Muandumusa in the Ministère des Affaires Foncières, Environnement et Tourisme, kindly granted us a permit to export samples of preserved specimens of the fishes from this survey for scientific purposes. Thanks to the Dean of the Science Faculty at the University of Kinshasa for facilitating the export permit. Thanks to our local partners on site, who assisted us with this survey. Bandundu: Thanks to the chief of Bokoni village (Mundele) and the chief of the fishers, Bino, and the two fishermen who worked with us, Lepetit, Abrahim and Zephyrin (driver). Bas-Congo: Dr. Ditseki di Mabiala (Inspecteur Provincial de l'Agriculture, Peche et Elevage), Mr. Gabriel Lazayadio (Administrator de Territoire, Mr. Kabuiku Cesar August, President (Comite National des Voluntaires Au Travail, CNVT), and Mr. Floribert Tshipele, Directeur, CNVT. Thanks to the Societé Nationale d'Electricité (SNEL) for granting us permission to survey the various sites at Inga. Thanks to the President and Vice-President of the Fishing Association, Manua Tsakala and Makumba Baku, respectively, and to all of the fishermen who worked with us: Kitoko Likoto, Elumba Gi, Frank Vwanga, Maneu Tza, Mundele Luwuata, and Entretien. Thanks to the missions, priests, and nuns for providing accomodations in Mushi and Mbandaka. Equateur: Thanks to the mayor of Gombe, Mboyo Bakobo, for graciously providing the use of his home and yard for accomodation and meetings. Thanks for Fulgence Ndombe, chief of pecheurs at Bodjia, and Mr. Dikanza, president of the Gombe Fishing Association for their support of our survey in their villages.

We are grateful to the local facilitators, Germain Mankoto and Aimé Kamamba for their assistance in the field, and to Eve Gillian of MONUC and Evelyn Samu, CARPE focal point for DRC, for their assistance.

Thank you to the supporting institutions, which provided materials and time: the New England Aquarium, Cornell University, and the American Museum of Natural History. In particular, thanks to Greg Stone (V.P. of Global Marine Programs) for lending the depth meters, and Suky Padawar (Education) for lending the refractometere. Many thanks to Aaron Dunning and Cristina Santiestevan for their efforts in preparing for the trip and the report. Thanks to ERGS-UNIKIN for the laboratory facilities used for chemical analysis of water samples.

Most importantly, many thanks to the citizens who patiently assisted us in our enquiries.

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5. ORGANIZATIONAL PROFILES

The American Museum of Natural History
The American Museum of Natural History was founded in 1869 in the heart of New York City, New York, USA, and has since become one of the world's foremost scientific and educational institutions. Today, in addition to educating the public via exhibits, the AMNH conducts research in areas spanning the fields of vertebrate and invertebrate zoology, systematics, anthropologyogy, paleontology, and the physical sciences and publishes the magazine *Natural History*.

Cornell University
Founded in 1865, Cornell is a privately chartered Ivy League Institution that is also the land grant university for the state of New York, USA. Cornell's mission is to serve society not only by educating, but also by extending the frontiers of knowledge. Cornell has approximately 20,000 undergraduate and graduate students, and is home to 100 interdisciplinary centers, institutes, laboratories, and programs. The rich tradition of research at Cornell continues in fields as diverse as the environment, space research, international issues, and communications.

Environmental Resources Management and Global Security
Environmental Resources Management and Global Security (ERGS) is a university-based private initiative in Kinshasa, DRC, that promotes the rational management of environmental resources for global security. Founded by Professor Diedonné Musibono in 1998, ERGS' expertise comes from science, social science, and engineering. ERGS's services have been used in ecotoxicology, enviromental audits, environmental restoration/water quality management, biodiversity surveys, management and conservation.

Innovative Resources Management
Innovative Resources Management (IRM) is a non-governmental organization based in Washington, D.C., USA, committed to meeting the complex challenges of sustainable development with proven solutions that facilitate the building of effective teams and coalitions, promote effective natural resources management and economic development, and strengthen the technical and institutional capacity of all stakeholders. For the past 10 years, IRM staff has worked at the cutting edge of developing coalition-building methodologies to combat global desertification and tropical forest degradation, catalyzed the emergence or growth of national and local NGO coalitions involving successful partnerships across government institutions, research centers, donors, and resource user groups, and taken the lead in the development of methodologies that provide local resource users both the incentive and capacities to manage natural resources sustainably. Many of IRM's projects are in African nations.

New England Aquarium
The New England Aquarium (NEAq) is a non-governmental organization based in Boston, MA, USA, whose mission is to present, promote and protect the world of water. Conservationists at the NEAq (in the Department of Global Marine Programs) work to resolve aquatic conservation problems worldwide by creating and linking community efforts with science-based policy development and public education. The Aquatic Biodiversity Program, a division of the

department, underscores the value of science in addressing pressing questions in aquatic biodiversity, the interdependence of humans with other species and ecosystems, and the importance of changing human behavior. Our efforts are varied, spanning grassroots and non-profit organizations, community groups, scientific research, and public education and outreach in the U.S., Africa, and the South Pacific. Our goal is to establish the necessary long-term relationships and ongoing projects which encourage people to integrate environmental values into their daily lives.

6. INTRODUCTION

6.1 The importance of the Congo River to biodiversity

The Congo River is one of the world's biological treasures. It is the second largest river basin in the world, after the Amazon. The river is of global biodiversity importance, particularly with regard to freshwater fish, due to its species richness, high endemicity, evolutionary importance (being the site of origin for the evolution of 7 out of 10 Lake Tanganyikan families), and complexity of habitats, ranging from rapids, seasonal and permanent swamps, river, riverbanks, floodplains and flooded forest, and streams (wcmc.org). Teugels and Guegan consider that the climatic stability, environmental stability, and complexity of habitats have favored such high speciation. According to FishBase (www.fishbase.org), the Congo River contains at least 686 species of fish, from 25 families, 80% of which are endemic (cited in Teugels and Guegan, 1994, Muzigwa, 1992). In comparison, a similar sized temperate river, the Mississippi, contains only 250 species. The Congo river is a national symbol for the Congolese, provides needed animal protein (20% of daily requirements, as of 1991), and is the most important means of transport in the country.

6.2. Map of the three axes under study

We rapidly surveyed three project sites in three provinces (Bandundu, Bas-Congo, and Equateur) (see arrows on map below). These sites are included in the following ecoregions, denoted by WWF (Thieme et al., 2003, in prep.): Bandundu: *Kasai*; Bas-Congo: *Lower Congo Rapids*; and Equateur: *Sudanic Congo (Oubangi)*, *Cuvette Centrale*, *Sangha*, and *Lake Tumba*.

Zoogeographically, our survey covered two ichthyofaunic zones: 1) Matadi to Malebo Pool (rapids); and 2) Central Basin (Malebo Pool to Kisangani falls) (Poll, cited by Lowe-McConnell, 1986). Hyrodographically, the project also covered two zones: Bas-Congo, being in the Lower Congo zone (Kinshasa to Matadi); the other two sites in the Kinshasa to Kisangani zone (Teugels and Guegan, 1994). Note that Lake Tumba and Mai-Ndombe are important evolutionary sites for African freshwater fish.

7. METHODS

7.1. Field personnel

The team was comprised of the following scientists:

Water team

1. Scientific coordinator/Ichthyologist – Dr. Caroly Shumway (NEAq, US)
2. Scientific coordinator/water quality expert - Dr. Dieudonné Musibono (ERGS, DRC)
3. Ichthyologist/Electric fish expert – Dr. John Sullivan (Cornell, US)
4. Ichthyologist/Cichlid expert – Robert Schelly (AMNH, US)
5. Ichthyologist - Mr. Victor Puemba. (ERGS, DRC)
6. Macroinvertebrate expert – Dr. Julien Punga (ERGS, DRC)

Land team

7. Bird expert – Dr. Séraphin Ifuta (ERGS, DRC)
8. Amphibian/Reptile/Mammal expert - Dr. Jean-Claude Palata (ERGS, DRC)
9. Plants were brought back to the University to be identified by the Herbarium of the University.

Community facilitator

10. CREDP team member – Germain Mankoto or Aimé Kamamba (IRM)

7.2. Participatory approach

At each site, we actively involved those interested local partners, including fishermen, in the work. Using a participatory approach at the different field stations, we showed our partners how and why we identified fish and other species. For those partners with us on pirogues, we showed how and why we were collecting water quality parameters. Where possible, we enlisted the help of the local fishermen to conduct water quality analyses, including depth measurements and chemical analyses. In Bas-Congo, the fishermen themselves routinely conducted much of the water quality analyses, while we recorded (and confirmed) their observations. For all provinces, we also worked with the fishermen to create a field guide for fishes in the local languages, Lingala and Kikongo.

7.3. Sampling stations

Raw data for each station was noted on two separate sheets, one for the water team and one for the land team (for example, see Appendix). This data has been summarized in tables for all of the stations within a given province. For each province, Tables 1-7a,b, or c summarize species information for all of the animal groups and plants studied; Table 8a, b, or c summarizes water quality data. For Bandundu and Bas-Congo only, an additional table (table 9) summarizes heavy metal analyses of the water. Following the tables, individual sampling station reports are provided. These are prepared in a standard format, indicating name of geographical locality, location, date of visit, procedures, and ecological notes. Photographic records were made at each station (Appendix).

7.4.Water quality analysis

Water quality was analyzed during this biodiversity survey, since the health and survival of aquatic biota depend on clean water. We were interested in two different categories in water

quality analysis: 1) those elements that influence productivity; and 2) those elements which are potentially harmful to the fauna. We selected the measures below for a baseline determination, based on recommendations from AAAS (1983), EPA (1994), and Wooton (1992). For a general overview of water quality parameters in fish ecology, see Lowe-McConnell (1991).

AAAS (1983) recommends that the following always or often be tested: temperature, turbidity, dissolved gases, inorganic nutrients, organic nutrients, pH, conductivity, benthic organisms, and fish. These measures are useful for understanding impacts of mining, agriculture, forestry, sewage, fertilizer, and pesticides (Table 1). A study of 204 volunteer monitoring programs in the United States (EPA, 1994) found that the top 9 parameters measured were, in order: temperature, macroinvertebrates, pH, dissolved oxygen, debris cleanup, flow, habitat assessments, and nitrogen. The most common water quality concern for rivers is point sources of organic, oxygen-consuming waste. Dissolved oxygen, temperature, flow, and nitrogen are usually used in monitoring programs where these problems occur.

Note that seasonal variations in water quality affect the abundance and distribution of organisms.

Table 1. Recommendations for baseline studies (AAAS, 1983).

TABLE 3.2 Recommendations for baseline studies for assessing impacts on water bodies.

Components of Aquatic Ecosystems	Generic & Specific Project Actions: Impoundments							Withdrawal/Return Water Uses						Dredging		Introduction of Chemicals				Biotic Resource Harvest			
	Irrigation	Hydroelectric	Flood control	Water supply	Industrial	Recreational	Fisheries	Agriculture/irrigation	Livestock	Municipal/domes	Industrial	Mining	Waste disposal treatment	Estuarine	Riverine	Fertilizer	Pesticides	Industrial emissions	Domestic emissions	Fish	Shellfish	Vegetation	Aquaculture
1. Physical properties																							
a. Climate		S	S	S																			
b. Precipitation	A	A	A	S	S	S	S	A	S	S	S	S	S			S	S	O	S	S	S	S	S
c. Surface water	A	A	A	A	A	A	A	A	O	O	O	O	O	S	S	A	A	A	A	A	A	O	A
d. Groundwater	S	O	O	O	O	O	O	A	S	O	O	A	A	S	S	A	A	A	O	S	S	S	S
e. Tides and wave action		S	S		S	S	O							A									
f. Currents and circulation	O	O	O	O	O	O	A	S	S	S	S	S	S	A	A	A	A	O	O	O	O	O	O
g. Temperature	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A
h. Salinity	A	S	S	A	O	O	A	A	A	A	A	S	S	A		S	S	S	S	A	A	S	A
i. Density and stratification																O	O	O	O	O	O	O	O
j. Light and transparency	S	S	S	S	S	S	S	A	A	O	O	O	O	A	A	A	A	O	O	O	O	O	O
2. Chemical properties																							
a. Dissolved gases	O	O	O	O	O	O	O	A	A	A	A	A	A	O	O	A	A	O	O	A	A	A	A
b. Dissolved solids																							
1) Inorganics nutrients/others	O	O	O	O	O	O	O	A	A	O	O	O	A	A	A	A	O	O	O	A	A	O	A
2) Organics	S	S	S	S	S	S	S	O	A	O	S	S	A	O	O	A	A	O	O	O	O	O	O
c. Particulates																							
1) Inorganic	O	O	O	O	O	O	O	A	A	A	A	A	A	A	A	S	O	S	S	S	O	S	S
2) Organic	S	S	S	S	S	S	S	A	A	O	S	S	A	O	O	S	S	S	S	S	S	S	S
d. pH	O	O	O	O	O	O	O	A	A	A	A	A	A	O	O	A	O	A	A	O	O	O	O
e. Conductivity	A	A	A	A	A	A	A	A	A	A	A	A	A	O	O	A	O	A	A	A	A	O	A
3. Biotic properties																							
a. Benthos	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	O	O
b. Plankton																							
1) Zooplankton								A	A	O	O	O	O			A	A	A	A	A	S	S	O
2) Phytoplankton								A	A	A	A	A	A			A	A	A	A	A	O	O	O
c. Fish and fisheries	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	O	A	A
d. Littoral vegetation	O	O	O	O	O	O	O	O	O	O	O	O	O	A	A	A	O	O	O	A	O	A	O
e. Wetland vegetation	A	O	A			O	A	A	O	O	O	O	O	A	A	A	O			A	A	A	A
f. Periphyton	O	O	O	O	O	O	O	A	A	O	A	A	A	O	O	A	A	O	O	S	S	S	S
g. Microbiota, pathogens other	A	O	O	A	O	A	O	A	O	A	O	S	A	S	S	S	S	S	S	S	A	S	O
4. Functional properties																							
a. Nutrient cycling	A	A	A	A	A	A	A	A	A	O	O	O	A	A	A	A	S	O	O	A	A	A	A
b. Primary productivity	O	O	O	O	O	O	O	A	A	O	O	O	A	O	O	A	S	O	O	O	O	A	A
c. Secondary productivity	O	O	O	O	O	O	O	O	O	O	O	O	O	S	S	A	O	O	O	A	A	S	S
d. Eutrophication								A	A	O	O	O	A			A	S	S	O	O	O	O	S
e. Ecosystem indices	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	A	A	A	S	A	A		A
f. Water balance	A	A	O	O	S	S	S	A	S	S	S	S	S							S	S	O	S

Water quality was analysed on site for the following parameters, using a Hagen test kit: alkalinity, total hardness, phosphates, nitrates, and calcium. A digital pH meter (Orion) was used to determine pH. A conductivity meter was used to determine conductivity. Dissolved oxygen was measured with a YSI Dissolved Oxygen Meter. Transparency and turbidity were assessed on site with a Secchi disk. True colour, turbidity, iron, manganese, cadmium, lead and copper were analysed in the laboratory by spectrophotometry, using the HACH DR/2000 (Hach, 1991). True color was determined by spectrophotometry, as described by Hach (1991) for DR/2000 analysis. Color was determined after filtration through Watman 0.45 ìm paper.

Note that several water quality samples were collected for laboratory analysis of turbidity, true color, and heavy metals at a given site. Empty cells in the water quality tables indicate the columns of additional samples.

An explanation of the importance of these measures is provided below.

Clarity/turbidity. Measures of light transmission are useful in assessing the level of primary productivity in the river as well as the presence of dissolved organic matter. Secchi Disk readings can vary seasonally due to changes in primary productivity and amount of sediment entering the water during flooding. Turbidity is a measure of the cloudiness of the water. Light is extinguished by three factors: 1) absorption by the water itself; 2) absorption by dissolved or suspended particles in the water; and 3) scattering by particles in the water. Suspended materials decrease the productivity of the system. The most important inorganic particles that impact clarity are suspended clays and silt, which increase in amount with mining and forestry activity. Dissolved organics that impact clarity result from decomposition, secretions, fecal waste, and input from terrestrial sources.

Colour/true color. Water colour may differ greatly between waters with different chemical and biological properties. A brown or black tinge indicates a high level of humic substances which would render the water acidic, with low biological productivity.

Water temperature. Biotically, water temperature is an important measurement, because temperature affects the growth rate, development, metabolic rate, and distribution of aquatic species. Some species spawn more in warmer waters. Temperatures can also affect the spread of disease. Temperature affects the nutrient cycle, because increasing temperatures increase the rate of synthesis and decomposition of organic matter. Where water is slow-moving or stagnant, a change in water temperatures can influence the mixing of water layers. Thermal stratification is the most common means of creating density layers.

pH. This measure tells one about the concentration of hydrogen ions in the water. A pH less than 7 is acidic; that greater than 7 is basic. Being a logarithmic scale (pH is the log of the reciprocal of the hydrogen ion concentration), a one-unit change in pH indicates a 10-fold change in hydrogen ion concentration.
Changes in pH can be the result of both physical inputs to the water as well as biological inputs.

Carbonate Hardness (kH) – Carbonate hardness, also known as alkalinity, is a measure of the carbonate (CO_3) and bicarbonate ($H_2CO_{3)}$ ion concentrations dissolved in water. The lower the

carbonate hardness, the lower the buffering capacity of the water, and the more likely the water is to suffer pH swings.

General Hardness (gH) – General Hardness is a measure of the concentration of Calcium and Magnesium ions. These salts are important in regulating the cellular functions of aquatic organisms, and in buffering the water.

Phosphate – Phosphorus is critical for metabolic processes involving the transfer of energy. Phosphate is generally the limiting nutrient in freshwater. A low concentration indicates that the water is not productive, and the animals in the water column must obtain their primary production from elsewhere. An overabundance would indicate eutrophication, which could lead to oxygen depletion. Note that tropical waters are typically nutrient-poor

Nitrate – Nitrogen's primary role in organisms is protein synthesis; plants also use nitrogen for photosynthesis.

Calcium – Calcium was measured as another nutrient needed for organisms. It is not limiting in most freshwaters.

Dissolved oxygen – Dissolved oxygen is critical for the survival of most aquatic life. This measure tells one how saturated the water is with oxygen. It is a measure of the metabolic activity in the water. The oxygen enters and leaves the water via the photosynthetic and respiratory activities of the biota, and by surface diffusion. The warmer the water temperature, the less oxygen it can hold. Most animals and plants grow fine when DO levels are highrer than 5 mg/L. They become stressed between 3-5 mg/L. At 3 mg/L, the water is hypoxic, and mobile species will move elsewhere; nonmobile ones may die. In tropical waters, the reserve of oxygen above the critical minimum concentration (3 mg/l) is much less than that of temperate waters.

Conductivity – Conductivity provides information about the water's ability to conduct an electrical current. Conductivity is useful for estimating ionic content, and therefore, the fertility of the water. This parameter is critical for electric fish, one of the key groups of fishes in the Congo river, as the conductivity of the water is an important cue in their reproductive cycle.

Current flow – Current flow is important as a key determinant of habitat preferences, due to its influence on substrate, dissolved oxygen levels, and flora. Slower currents permit greater development of both planktonic and benthic flora and fauna. Unfortunately, due to cost constraints, we were only able to estimate current qualitatively.

Macroinvertebrates – Macroinvertebrates provide a simple method for monitoring the ecological integrity of a river. For example, 75% of the U.S. programs that monitor rivers monitor macroinvertebrates (EPA, 1994).

Heavy Metals – Heavy metals give an indication of the level of pollution in the water from agriculture, mining or industry. Metals were analysed on samples from Bas-Congo (Inga) and Bandundu (Bokoni, on the Kasai River) trips because of upstream activities related to mining or industries. However samples from Gombe (Equateur) were also analysed for comparison.

Attention was paid to lead (Pb), cadmium (Cd), copper (Cu), manganese (Mn), iron (Fe) and hexavalent chromium (CrVI) because of their effects on aquatic ecosystems (Musibono, 1999; Musibono, 1992; Dégrémont,1989).

7.5. Fish sampling and identification

For fish, we used cast nets (epervier), seine nets, experimental gill nets (with four panels varying in size), and dip nets. Net choice depended on the site. We also purchased samples directly from fishermen, both in their fishing grounds and at the market. We mainly sampled along river banks. We had hoped to sample in the middle of the river with a shrimp trawl, since the fish species would have been different in these areas, but could not do so given the small size of our research boats.We primarily used the 1994 Max Poll and Jean-Pierre Gosse book (General des poisson d'eaus douce de l'Afrique) as the reference guide. A copy of this book has been left with the University of Kinshasa and with the IRM field office in Kinshasa. We also had a list of the freshwater fishes of the DRC from FISHBASE (www.fishbase.org). Another useful general list is the Checklist of the freshwater fishes of Africa (CLOFFA 1,2,3,4 – Daget et al., 1984, 1986a, b, 1991).

7.6. Other vertebrate sampling and identification

For birds, a mist net was used. The net was checked every few hours. For amphibians, dip net sampling and tape recording of frog calls were used. Tape recordings of species serve as valid records of a species (Davies, 2002). Amphibian surveys were primarily conducted during the crepuscular period (dusk). Note that our amphibian counts in the dry season are less than would be found in the rainy season, as amphibians are much more active during the latter period. We used Borrow and Demey (2001) and Serle and Morel (1979) as reference guides.

7.7. Macroinvertebrate sampling and identification

For macroinvertebrates, dip net sampling, kick net, drop net (left in position for as many days as feasible) and Hester-Dendy sampling methods were used. We used Bland (1978); Dartevelle; Grisse (1972); Holthus (1951); and Tachet et al. (1996) as reference guides.

7.8. Museum specimens

In the field, numerous fish species, in particular, were identified only to genus. Collections of museum specimens (small representatives of the species) and tissue samples were transported back to the American Museum of Natural History to ensure accurate identification to the species level. After verification of species identification, a representative collection of fish specimens was sent back to the University of Kinshasa.

Tape recordings of bird and amphibian species will be deposited at the Macauley Library of Natural Sounds, Cornell University, Ithaca, NY, to be available for other researchers. Representative plant specimens were deposited at the University of Kinshasa herbarium. Representative invertebrate specimens were deposited at the University of Kinshasa.

7.9. Specimen preservation

All of the fish specimens collected were fixed in the field in 10% formalin solution. Large samples were slit on the ventral surface to allow the fix to enter internal organs. In Bandundu, the solution was made up in the field with H20, paraformaldehyde powder, and a handful of

KOH pellets (4 pellets) used to get the paraformaldehyde into solution. A teaspoon of marble chips were used to buffer the solution. At the other two sites, formalin was used directly. Once fixed in formalin for one week, specimens were removed from the solution, provisionally identified, labelled, rinsed, damp-packed with H_20 in cheesecloth, triple sealed in heavy-duty polythene bags, and placed in approved liquipak drums for shipment to the American Museum of Natural History (AMNH). Those specimens registered at the AMNH were transferred to an alcohol preservative for long-term storage.

Tissue samples of select specimens were also prepared for molecular analysis to assist in species identification. Tissue samples (several mm) were obtained from a piece of muscle below the dorsal fin, and placed in 1.8 ml of ethanol in Eppendorf tubes. Some tissue samples were placed in a lysis buffer. A lighter was used to sterilize the forceps between specimens.

7.10. Taxonomic conventions

The following taxonomic conventions have been used throughout the report.
Order name is printed in upper case bold, e.g., **CRUSTACEA**
Family name printed in upper case, e.g., LIBELLULIDAE
Genus and species printed in italics, e.g., *Petrocephalus microphthalmus*
sp. = species undetermined

8. RESULTS

8.1 SUMMARY OF SPECIES REPRESENTED IN SURVEY

A summary of all species observed during this survey is presented in the following tables: Table 1a (Fish), 2a (birds), 3a (amphibians), 4a (reptiles), 5a (mammals), 6a (invertebrates), and 7a (plants).

Fish: 54% of the Congo's fishes (including characins, catfishes, electric (knife) fishes, carps and loaches) are part of the higher teleostean lineage named Otophysi (Ostariophysi in older literature).Graph 1 shows the percentage of species in each of the 11 orders that we recorded. The most abundant orders (with more than 5% of the species represented) are the same top 5 orders as reported by Teugals and Guegan for the Congo River (1994): Osteoglossiformes, Siluriformes, Characiformes, Perciformes, and Cypriniformes. Graph 2 shows the percentage of species among each of the 23 families recorded. These families represent 92% of the known families for the Congo River. This graph shows that the dominant family is the electric fish family, Mormyridae (order Osteoglossiformes), representing 25% of the species identified, and 27% of the mormyrids known for the Congo River. The second most dominant is Characidae (12%), followed by the fin-eating family Distichodontidae, two catfish families (Mochokidae and Bagridae) and Cichlidae, all at 8%. Graph 3 shows that Mormyridae significantly dominate in all provinces, representing over 20% of the sample. Other prominent families (representing over 5% of the sample) in all provinces include: Characidae, Mochokidae, Bagridae, Distichotidae, and Cyprinidae. Cichlidae are prominent in both Bandundu and Bas-Congo. Cyprinidae and Claridae are among the dominant families only in Equateur.

Table 1a shows the species found in the three provinces. Overall, at least 121 species of fish were recorded: 83 species of fish in Bandundu; 47 in Bas-Congo, and 54 in Equateur. None of the species are considered threatened or endangered by WCMC or Cites. The numbers per

province don't sum up to 121, because a number of species were found in all 3 sites. Three of the species observed are exotic: *Heterotis niloticus* (found in all 3 provinces), *Tilapia nilotica*, and *Lates niloticus*. Guy Teugels of the Africa Museum in Belgium estimates the following number of fish species for each ecoregion: *Kasai* (which includes Bandundu sites): 203, with an estimated 49 endemics: *Lower Congo Rapids* (which includes Bas-Congo sites): 59, with an estimated 17 endemics; and *Central Congo* (which includes some Equateur sites): 206, with an estimated 11 endemics.

To aid in understanding, the following is an overview of some fish families, listed by common name:

1. Lungfishes – Protopterus is an air-breathing fish. It can live in anoxic or hypoxic water.
2. Bichirs - Polypterus is characteristic of ancient fishes, with lobed fins and a hard coating on its scales.
3. Herrings – Odaxothrissa is a common freshwater species of a largely marine herring family (Clupeidae).
4. Elephant fishes – Mormyrids are weakly electric fish, with an electric organ in their tail, used for location and communication. They are primarily active at night.
5. Characins – Characids can be identified by their small dorsal adipose fin.

6. Killifishes (Cyprinodonts). These top minnows are small insectivorous species that are an important prey item for other fish. They feed on insect larvae, such as mosquitoes, and may be important for disease control.
7. Cichlids are recognized by a single pair of nostrils.

Other groups: We also recorded 60 species of birds, 17 species of amphibians, 9 species of reptiles, 9 species of mammals, 38 species of aquatic invertebrates, and 35 species of plants. All of the mammal species recorded were bushmeat, a worrisome fact for all provinces. The largest mammal seen was one hippopotamus killed for bushmeat.

Birds. The DRC is known to have 929 bird species, of which 24 are endemic, and 26 threatened. With our rapid investigation, using only one mist net, we recorded 60 species of birds, belonging to 15 families. The most abundant order was the Passeriformes, followed by Coraciiformes and Ciconiiformes. We observed the following 5 threatened bird species (on the CITES list):*Treron calva* (African green pigeon; Bandundu), *Turtur afer* (Blue-spotted wood dove; Equateur), *Streptopelia semitorquata* (Bas-Congo and Equateur), *Corythaeola cristata* (Great blue turaco; Bandundu), and *Pycnonotus spp* (bulbuls; Bandundu and Equateur).

Plants. The DRC is known to have 11,007 higher plant species, of which 1,100 are endemic, and 69 are threatened. While our survey focused on animal groups, we identified the dominant plants in each habitat. We recorded 39 species of plants. Over 25% of these species are invasive.Thirty-three percent of the plants have medicinal value.

Abundant aquatic plants at our station sites included *Oryza barthii* (wild rice*), Echinocloa pyramidalis* (antelope grass), and *Echinochloa stagnina*. We also found *Hyparrhenia diplandra, Panicum maximum*, and the invasive *Imperata cylindrica (*cogon grass), mainly at Gombe, Bokoni and Inga stations. Associated aquatic plants included *Cyperus sp*. and *Pistia stratiotes*

(water lettuce), and the invasive species of *Panicum repens*, *Ipomea aquatica* (water spinach), *Eichornia crassipes* (water hyacinth), *Salvinia nymphellula,* and *Mimosa pigra* (sensitive plant). The littoral vegetation provides spawning and nursery grounds for both fish and macroinvertebrates, and a substrate for periphyton (a microscopic community of algae, protozoa, bacteria, snails, and insect larvae).

Secondary and degraded forest plants characterized were the shrub (*Alchornea cordifolia),Ficus spp*. (fig tree), *Chromolaena odorata* (an invasive shrub),and *Vossia cuspidata* (hippo grass).

Amphibians. The DRC is known to have 80 amphibian species, of which 53 are endemic (Earthtrends, 2001). We recorded 17 species in the families Bufonidae and Ranidae. None of these species are known to be threatened or endangered. Of these, 14 were Ranids, which represents 38% of all Ranids known for the DRC. Eighteen species are estimated for the Central Congo.

Reptiles. The DRC is known to have 377 reptile species, of which 35 are endemic, and 3 threatened. 77 reptile species are estimated for the Central Congo. We recorded 9 species, including the threatened dwarf crocodile, *Osteolaemus tetraspis*, on sale at the Mushi market.

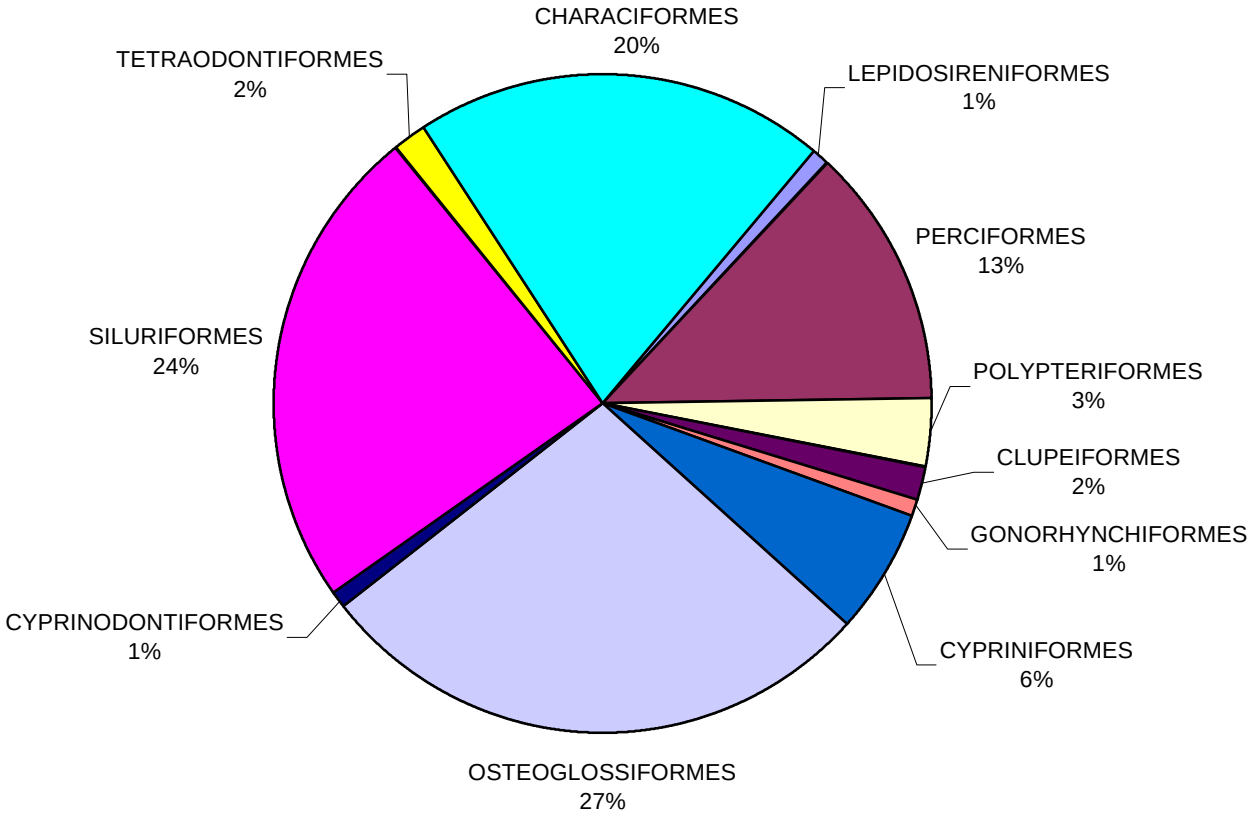
Mammals. The DRC is known to have 450 mammal species, of which 28 are endemic, and 38 threatened. 123 mammal species are estimated for the Central Congo. We recorded 9 species, of which The sitatunga (*Tragelaphus spekei*) is a truly aquatic mammal, found only in swamp grasses. Its hooves are specially adapted to walk on marshy soil.

Macroinvertebrates. The most dominant classes reported in the literature are Crustaceans and Insects, followed by Molluscs. These were also the 3 most dominant classes found in our survey. The Decapopa, Odonata, Caenogastropoda, and Hemiptera were the most abundant orders in our survey, with the Atyidae and Assimineidae the most abundant families represented.

Phylum	**Order**	**Species number**	**% represented**
Mollusca	Caenogastropoda	5	13
	Stylommatophora	1	2.7
	Sigmurethra	3	8
Arachnida	Araneae	1	2.7
	Labidognatha (suborder)	1	2.6
Crustacea	Decapoda	11	29
Insects	Odonata	6	16
	Hemiptera	6	16
	Coleoptera	2	5
	Heteroptera	2	5
Total	**10**	**38**	**100**

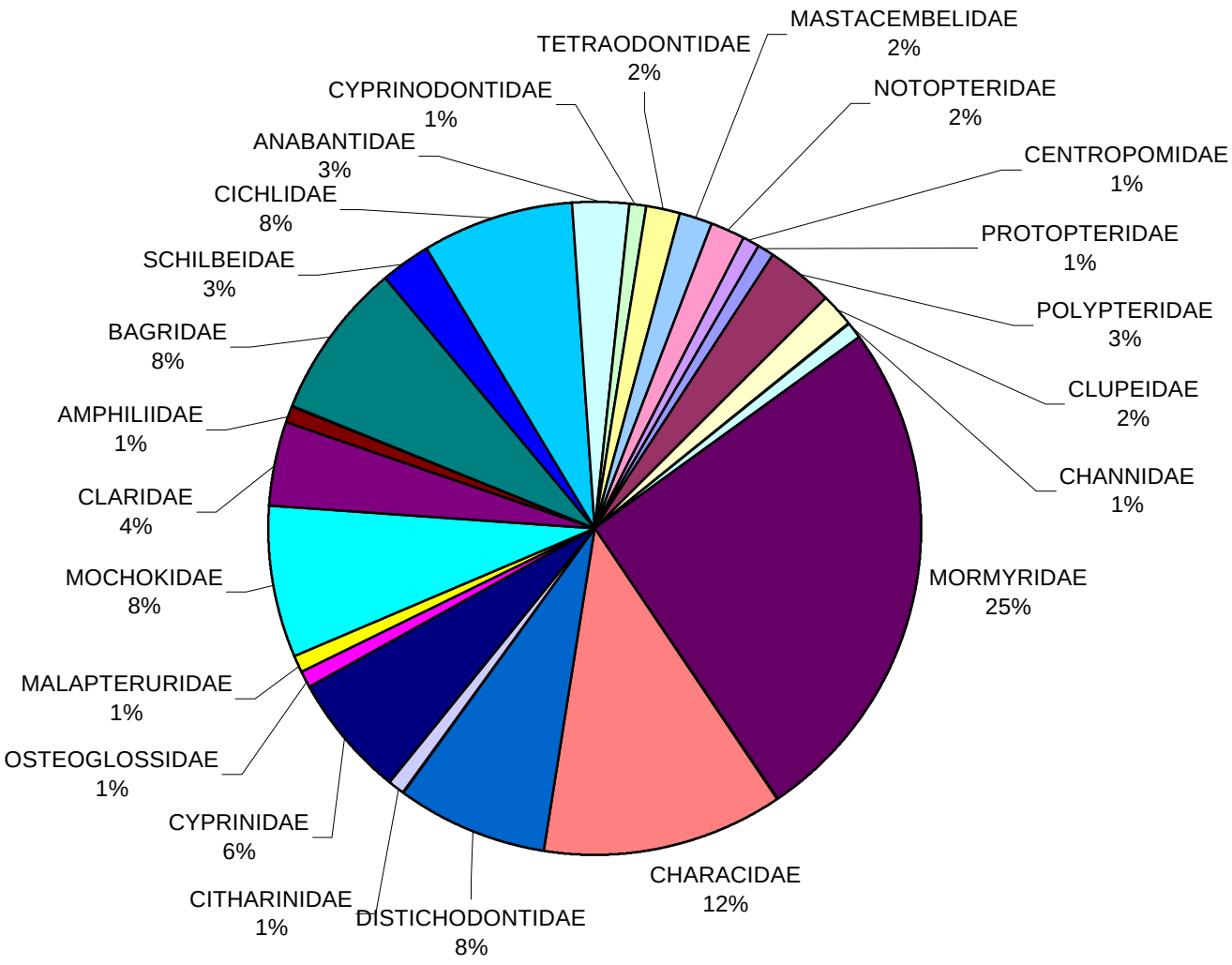
GRAPH 1. FISH ORDERS REPRESENTED

Percentages indicate the proportional representation of species in each order.



GRAPH 2. FISH FAMILIES REPRESENTED

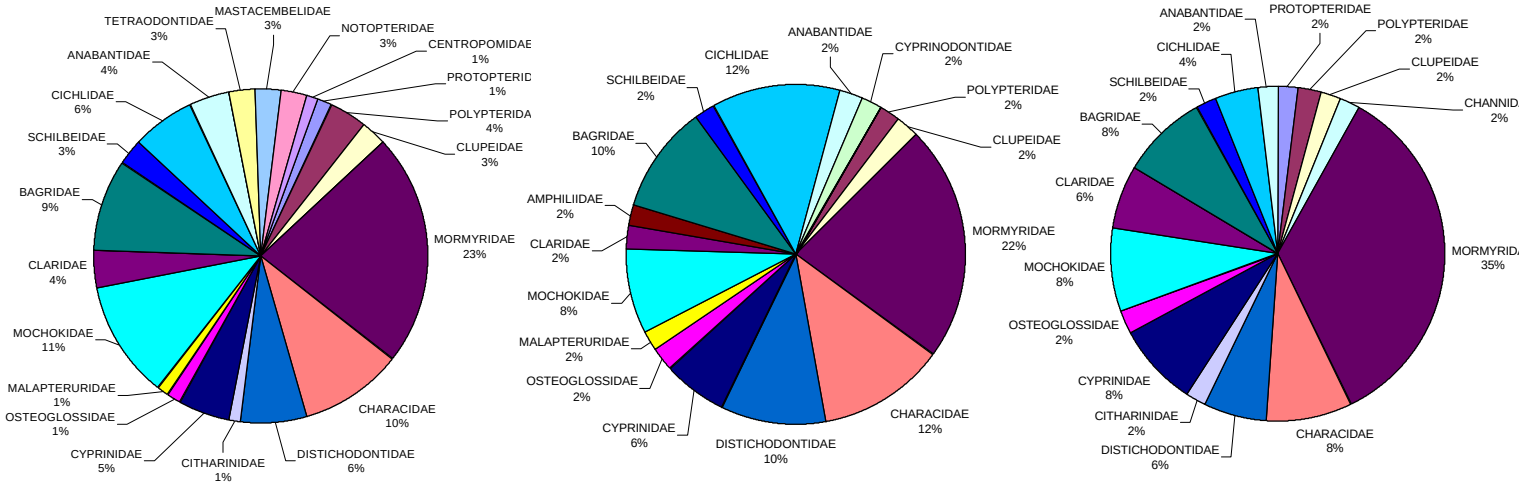
Percentages indicate the proportional representation of species in each family.



GRAPH 3. FISH FAMILIES REPRESENTED IN EACH PROVINCE.

Percentages indicate the proportional representation of species in each family.

BANDUNDU **BAS-CONGO** **EQUATEUR**



8.2. Summary tables of species for all provinces.

TABLE 1A. SUMMARY OF FISH SPECIES RECORDED PER PROVINCE
+ = recorded ; sp. = unidentified, may not be the same across provinces.

ORDER	FAMILY (common name)	SPECIES	BANDUNDU	BAS-CONGO	EQUATEUR
LEPIDOSIRENIFORMES	PROTOPTERIDAE (lungfishes_	*1. Protopterus dolloi*	+		+
POLYPTERIFORMES	POLYPTERIDAE (bichir)	*2. Polypterus sp. 1 (black)*	+		
		3. Polypterus sp. 2 (bande)	+	+ sp.	
		4. Polypterus sp. 3 (Bdd)	+		
		5. Polypterus sp. 4			+ sp.
		6. Polypterus ornatus	+		
CLUPEIFORMES	CLUPEIDAE (herrings/sardines)	*7. Odaxothrissa spp.*	+		
		8. Clupeidae spp.	+	+ sp.	+ sp.
GONORHYNCHIFORMES	CHANNIDAE (snakeheads)	*9. Parachanna obscura*			+
OSTEOGLOSSIFORMES	MORMYRIDAE (elephantfishes)	*10. Petrocephalus sp. 1*		+ sp.	+
		11. Petrocephalus sp. 2			+
		12. Petrocephalus sauvagii	+		+
		13. Petrocephalus sp. (simus?)	+		
		14. Petrocephalus microphthalmus	+		
		15. Gnathonemus petersii	+		
		16. Gnathonemus sp.		+	+
		17. Genyomyrus donnyi	+		
		18. Hippopotamyrus discorhynchus	+	+	+
		19. Hippopotamyrus plagiostoma			+
		20. Hippopotamyrus pictus	+		
		21. Hippopotamyrus sp.			+
		22. Mormyrops anguilloides	+	+	+
		23. Mormyrops mariae	+		
		24. Mormyrops nigricans			+
		25. Marcusenius greshoffi	+		+
		26. Marcusenius sp. 1	+	+ sp.	+ sp.
		27. Marcusenius sp. 2	+		+ sp.
		28. Marcusenius sp. 3	+		
		29. Marcusenius monteiri		+	+
		30. Stomatorhinus sp. 1 (little, black)	+		
		31. Pollimyrus adspersus	+		
		32. Pollimyrus sp.	+		
		33. Mormyrus proboscirostris	+		+
		34. Mormyrus caballus bombanus	+	+	+
		35. Mormyrus ovis			+
		36. Campylomormyrus mivris		+	

		37. Campylomormyrus urirrostrus		+	
		38. Campylomormyrus tamandua	+		+
		39. Campylomormyrus elephas	+		
		40. Campylomormyrus sp. 1		+ sp.	+ sp.
		41. Campylomormyrus sp. 2		+ sp.	
	OSTEOGLOSSIDAE (bony tongues)	*42. Heterotis niloticus (Cuvier)*	+	+	+
	NOTOPTERIDAE (featherbacks)	*43. Xenomystus nigri (Gthr.)*	+		
		44. Papyrocranus afer (Gthr.)	+		
CHARACIFORMES	CHARACIDAE (characins)	*45. Bryconaethiops sp.*	+		
		46. Brycinus sp.			
		47. Hydrocynus goliath	+	+	+
		48. Hydrocynus vittatus?	+		
		49. Alestes sp.	+		+
		50. Brycinus sp. 1	+		+ sp.
		51. Brycinus sp. 2	+		
		52. Bryconaethiops sp.			+
		53. Micralestes sp.	+		
		54. Small characid sp. 1		+	+ sp.
		55. Small characid sp. 2		+	
		56. Small characid sp. 3		+	
		57. Small characid sp. 4		+	
		58. Small characid sp. 5	+ sp.	+	
	DISTICHODONTIDAE	*59. Ichthyborus ornatus*	+		
		60. Ichthyborus afer		+	+
		61. Phago sp.	+	+	+
		62. Distichodus sp.			+
		63. Distichodus lusosso		+	+
		64. Distichodus sexfasciatus		+	
		65. Eugnathichthys sp.	+		
		66. Xenocharax spilurus	+		
		67. Nannocharax sp.	+		
	CITHARINIDAE	*68. Citharinus gibbosus (Blgr.)*	+		+
CYPRINIFORMES	CYPRINIDAE (minnows/carps)	*69. Barbus sp.*	+		
		70. Labeo vellifer		+	
		71. Labeo coubie		+	
		72. Labeo sp. 1	+	+ sp.	+ sp.
		73. Labeo sp. 2	+		+ sp.
		74. Labeo sp. 3	+		+ sp.
		75. Leptocyprus sp.			+
TETRAODONTIFORMES	TETRAODONTIDAE (puffers)	*76. Tetraodon mbu (Blgr.)*	+		

		77. Tetraodon miurus (Blgr.)	+		
SILURIFORMES	MALAPTERURIDAE (electric catfishes)	*78. Malapterurus electricus*	+	+	
	MOCHOKIDAE (squeakers)	*79. Synodontis acanthomias*	+		+
		80. Synodontis sp. 1	+	+ sp.	+ sp.
		81. Synodontis sp. 2	+	+ sp.	+ sp.
		82. Synodontis sp. 3	+	+ sp.	+ sp.
		83. Synodontis sp. 4	+	+ sp.	
		84. Synodontis sp. 5	+		
		85. Synodontis sp. 6	+		
		86. Synodontis sp. 7	+		
		87. Synodontis sp. 8	+		
	CLARIIDAE (airbreathers)	*88. Heterobranchus longifilis (Val.)*	+		+
		89. Channallabes apus (Gthr.)	+		
		90. Chariallobes sp.		+	
		91. Clarias sp. 1	+		+ sp.
		92. Clarias sp. 2			+ sp.
	AMPHILIIDAE (loach catfishes)	*93. Belonoglanis sp.*		+	
	BAGRIDAE (bagrids)	*94. Bagrus sp.*	+	+ sp.	
		95. Bagrus ubangensis			+
		96. Auchenoglanis occidentalis	+		+
		97. Chrysichthys sp. 1	+	+ sp.	+ sp.
		98. Chrysichthys sp. 2	+	+ sp.	+ sp.
		99. Chrysichthys sp. 3	+	+ sp.	
		100. Chrysichthys sp. 4	+		
		101. Rheoglanis dendrophorus		+	
		102. Parailia sp.	+		
	SCHILBEIDAE (schilbeids)	*103. Schilbe sp. 1*	+		
		104. Schilbe sp. 2	+		
		105. Schilbe mystis		+	+
PERCIFORMES	CICHLIDAE (cichlids)	*106. Tylochromis sp.*	+	+ sp.	+ sp.
		107. Lamprologus sp.	+	+ sp.	
		108. Hemichromis sp.	+	+ sp.	+ sp.
		109. Nannochromis sp.	+		
		110. Steatocranus sp. 1		+	
		111. Steatocranus sp. 2		+	
		112. Tilapia (Oreochromis) sp? = marichal	+		
		113. Tilapia sp.		+	
		114. Tilapia nilotica			+
	ANABANTIDAE (climbing gouramies)	*115. Ctenopoma sp. 1*	+	+ sp.	+ sp.
		116.Ctenopoma sp. 2	+		

		117. Ctenopoma sp. 3	+		
	MASTACEMBELIDAE (spiny eels)	*118. Mastacembelus sp. 1*	+		
		119. Mastacembelus sp. 2	+		
	CENTROPOMIDAE (snooks)	*120. Lates niloticus (L.)*	+		
CYPRINODONTIFORMES	CYPRINODONTIDAE (killifishes)	*121. Cyprinodintidae sp.*		+	
		TOTAL SPECIES/AXIS	**83**	**47**	**54**

TABLE 2a. SUMMARY OF BIRD SPECIES RECORDED PER PROVINCE

ORDER	FAMILY (common name)	SPECIES (common name, where available)	Bandundu	Bas-Congo	Equateur
CICONIIFORMES	ARDEIDAE (herons)	1.*Bubulcus ibis* (cattle egret)	+		+
		2.*Egretta alba* (Great white egret)	+		+
		3.*Egretta ardesiaca* (black heron)	+	+	+
		4.*Egretta garzella* (little egret)	+		
		5.*Egretta gularis* (Western reef heron)		+	
		6.*Ardea purpurea* (purple heron)	+		
	CICONIIDAE (storks)	7.*Ciconia episcopus* (woody-necked stork)	+ M		
CORACIIFORMES	MEROPIDAE (bee-eaters)	8.*Merops pusillus* (little bee-eater)	+	+	+
	BUCEROTIDAE (hornbills)	9. *Tockus sp*	+		
		10. *Tockus fasciatus* (African pied hornbill)			+
	ALCEDINIDAE (kingfishers)	11. *Alcedo cristata* (Malachite kingfisher)	+		
		12.*Ceryle rudis* (Pied kingfisher)	+	+	+
		13.*Halcyon senegalensis* (woodland kingfisher)	+		+
		14.*Halcyon leucocephala* (Gray-headed kinfisher)			+
		15.*Halcyon sp.*		+	
GRUIFORMES	RALLIDAE (rails)	16. *Porphyrio alleni* (Allen's gallinule)			+
PICIFORMES	CAPITONIDAE (barbets)	17. *Pogoniulus bilineatus* (yellow-rumped tinkerbird)	+	+	
		18. *Pogoniulus sp.*		+	
PELECANIFORMES	ANHINGIDAE (anhinga)	19. *Anhinga rufa* (African darter)	+		+
	PHALACROCORACIDAE (cormorants)	20.*Phalacrocorax africanus* (long-tailed cormorant)	+	+	
PSITTACIFORMES	PSITTACIDAE (parrots)	21. *Psittacus erythacus* (grey parrot)			+
FALCONIFORMES	ACCIPITRIDAE (hawks/eagles)	22. *Gypohierax angolensis* (palm-nut vulture)	+	+	+
		23.*Milvus migrans* (black kite)	+		+
GALLIFORMES	PHASIANIDAE (pheasants and partridges)	24. *Francolinus sp.*		+	

COLUMBIFORMES	COLUMBIDAE (pigeons and doves)	25. *Treron calva* (African green pigeon)	+ M		
		26. *Turtur afer* (blue-spotted wood dove)	+		+
		27. *Streptopelia semitorquata*		+	+
CHARADRIIFORMES	JACANIDAE (jacanas)	28. *Actophilornis africanus* (African jacana)	+		+
	CHADRIIDAE (plovers)	29. *Vanellus albiceps*	+		
	SCOLOPACIDAE (sandpipers and snipes)	30.*Tringa sp.*	+		
MUSOPHAGIFORMES	MUSOPHAGIDAE (turacos and allies)	31. *Corythaeola cristata*	+		
CUCULIFORMES	CUCULIDAE (cuckoos, coucals, and anis)	32. *Centropus senegalensis* (Senegal coucal)	+	+	+
CAPRIMULGIFORMES	CAPRIMULGIDAE (nightjars and allies)	33. *Macrodipteryx vexillarius* (Pennant-winged nightjar)			+
APODIFORMES	APODIDAE (swifts)	34. *Rhaphidura sabini* *(Sabine's spinetail)*			+
PASSERIFORMES	PASSERIDAE (Old-world sparrows)	35. *Passer griseus* (Gray-headed sparrow)	+	+	+
	PLOCEIDAE (weavers)	36. *Ploceus melanocephalus* (black-headed weaver)			+
		37. *Ploceus nigerrimus* (Veillot's black weaver)	+		
		38. *Ploceus pelzelni* (slender-billed weaver)			+
		39. *Ploceus aurantius* (orange weaver)	+		
		40. *Ploceus cucullatus* (village weaver)	+		+
		41.*Quelea quelea* (red-billed Quelea)			+
		42. *Brachycope anomala* (bob-tailed weaver)			+
	ESTRILDIDAE (waxbills)	43. *Estrilda sp.*			+
		44. *Lonchura cucullata* (bronze mannikin)	+	+	
		45. *Uraeginthus angolensis* (blue-breasted cordonblue)		+	
	PYCNONOTIDAE (bulbuls)	46. *Pycnonotus barbatus* (common bulbul)		+	+
		47. *Pycnonotus spp*	+		+
	CORVIDAE (crows, jays, and allies)	48. *Corvus albus* (pied crow)	+	+	+
	HIRUNDINIDAE (swallows and martins)	49. *Hirundo abyssinica* (lesser-striped swallow)		+	

		50. *Hirundo senegalensis* (mosque swallow)		+	
		51. *Hirundo rustica* (barn swallow)		+	
		52. *Delichon urbica* (house martin)		+	
	NECTARINIDAE (sunbirds and spiderhunters)	53. *Nectarinia sp.*	+		
		54. *Nectarinia chnloropygia*	+		
		55. *Anthrepes collaris* (collared sunbird)			+
	VIDUIDAE (Indigo birds)	56. *Vidua macruora* (pintailed whydah)	+		+
	MOTACILLIDAE (pipits and wagtails)	57. *Motacilla agwimp* (African pied wagtail)		+	
		58. *Motacilla flava* (yellow wagtail)	+		
	SYLVIIDAE (Old-world warblers)	59. *Cisticola natalensis* (croaking cisticola)		+	
	TURDIDAE (thrushes)	60. *Saxicola torquata* (South African stonechat)			+
	TOTAL SPECIES BY AXIS		**34**	**23**	**32**

Table 3a. SUMMARY OF AMPHIBIAN SPECIES RECORDED PER PROVINCE

FAMILY	SPECIES	Bandundu	Bas-Congo	Equateur
BUFONIDAE	1. *Bufo funereus*		+	+
	2. *Bufo maculatus*	+		
	3. *Bufo regularis*	+		+
RANIDAE	4. *Discroglossus occipitalis*			+
	5. *Hemisus marmoratum*	+		
	6. *Hymenochirus curteines*		+	
	7. *Rana mascariensis*	+	+	+
	8. *Phrynobatrachus natalensis*	+		
	9. *Phrynobatrachus sp.*	+		
	10. *Rana fuscigula angolensis*			+
	11. *Rana fuscigula nutti*			+
	12. *Rana fuscigula*	+	+	
	13.*Rana regularis*	+		
	14. *Rana sp.* 1			+
	15. *Rana sp. 2*		+	
	16. *Rana sp. 3*		+	
	17. *Rana sp. 4*	+		
	Many larvae		+	
	TOTAL SPECIES/AXIS	**9**	**6**	**7**

Table 4a. SUMMARY OF REPTILE SPECIES RECORDED PER PROVINCE

FAMILY	SPECIES (common name)	Bandundu	Bas-Congo	Equateur
TESTUDINIDAE	1. *Kinixys sp.* (a tortoise genus)	+		
COLUBRIDAE	2. *Colubridae sp.* (a snake genus)	+		
SCINCIDAE	3. *Mabuya maculilabris* (speckle-lipped skink)	+	+	
	4. *Mabuya sp.*			+
CROCODYLIDAE	5. *Osteolaemus tetraspis* (dwarf crocodile)	+		
AGAMIDAE	6. *Agama agama* (common agama)		+	
TRIONYCHIDAE	7. *Trionyx triunguis* (African soft-shelled turtle)			+
	8. *Cycloderma aubryi* (Aubrey's flapshell turtle)			+
	TOTAL SPECIES /AXIS	**4**	**2**	**3**

Table 5a. SUMMARY OF MAMMAL SPECIES RECORDED PER PROVINCE

FAMILY	**SPECIES** (common name)	**Bandundu**	**Bas-Congo**	**Equateur**
PTEROPODIDAE	1. *Myonycteris torquata* (little collared fruit bat)		+	
	2. *Eidelon helvum* (straw-colored bat)		+	
CERCOPITHECIDAE	3. *Papio anubis* (anubis or olive baboon)			+
	4. *Cercopithecus ascanius* (red-tailed monkey)	+		+
	5. *Cercopithecus mitis* (blue monkey)			+
POTAMOGALIDAE	6. *Potamogale velox* (giant otter shrew)		+	
BOVIDAE	7. *Cephalophus monticola* (blue duiker)	+	+	
	8. *Tragelaphus spekei* (sitatunga)	+	+	
HIPPOPOTAMIDAE	9. *Hippopotamus amphibius* (hippopotamus)	+		
	TOTAL SPECIES/AXIS	**4**	**5**	**3**

Table 6a. SUMMARY OF MACRO-INVERTEBRATE SPECIES RECORDED PER PROVINCE

ORDER	**FAMILY** (common name)	**SPECIES**	**Bandundu**	**Bas-Congo**	**Equateur**
ARANAE	ARACHNIDAE (spiders)	1. *Unknown sp.*	+		+
LABIDOGNATHA (sub-order)	(spider)	2. *Unknown sp.*			
COLEOPTERA	DYSTICIDAE (predaceous diving beetles)	3. *Cybister tripunctatus*	+	+	+
		4. *Hydraticus dregei*	+		
DECAPODA	ATYIDAE (freshwater shrimp)	5. *Caridina africana*	+	+	+
		6. *Caridina sp. 1 (brown/black)*	+	+ sp.	
		7. *Caridina sp. 2 (green)*	+		

		8. *Caridina sp. 3 (yellow, long)*	+		
		9. *Caridina sp. 4*		+	+ sp.
		10. *Caridina sp. 5*		+	
	PALAEMONIDAE (freshwater shrimp)	11. *Palaemon dux congoensis*	+		
	POTAMONIDAE (freshwater crab)	12. *Potamonautes dybowkin*		+	
		13. *Potamonautes africanus*	+		
	ATEMNIDAE	14. Unknown species	+		
	THERIDIIDAE	15. *Theridiid sp.*			
HEMIPTERA	BELOSTOMATIDAE (giant water bugs)	16. *Belostoma niloticum*	+	+	+
		17. *Belostoma sp.*			+
	HYDROMETRIDAE (watermeasurers)	18. *Hydrometra sp.*	+		+
	NEPIDAE (water scorpions)	19. *Ranatra grandicollis*	+	+	+
		20. *Ranatrea fusca*	+		
	NOTONECTIDAE (back swimmers)	21. *Anisops varia*	+		+
HETEROPTERA	GERRIDAE (water striders)	22. *Gerris sp.*	+	+	+
		23. *Gerris sp.*		+	
CAENOGASTROPODA	ASSIMINEIDAE (small aquatic prosobranch snails)	24. *Assimi oreidae;*		+	
		25. *Pseudogibula duponti*		+	
		26. *Pseudogibula pallidior*		+	
	HYDROBIIDAE (small aquatic prosobranch snails)	27. *Hydrobia plena*		+	
	AMPULARIIDAE (apple snails)	28. *Aetheria elliptica*	+	+	+

STYLOMMATOPHORA	SIBULINIDAE	29. *Pseudoglossoria bessei*		+	
SIGMURETHRA	ACHATINIDAE (achatine snails)	30. *Achatina zebriolata*			+
		31. *Achatina schweintfurthi*			+
		32. *Achatina greyi*			+
ODONATA	COEANAGRIONIDAE (pond damselflies)	33. *Megaloprepus caerulatus*	+	+	+
	LIBELLULIDAE (skimmer dragonflies)	34. *Libellula quadrimaculata*	+	+	+
		35. *Palpopleura lucia*	+	+	+
	GRYLLIDAE	36. *Gryllid sp.*	+		
	AESHNIDAE (hawker dragonflies)	37. *Aeshnid sp.*		+	
	TRIGONIDIIDAE	38. *Trigonidiid sp.*			
	TOTAL SPECIES/AXIS		**22**	**20**	**19**

Table 7a. SUMMARY OF PLANT SPECIES RECORDED PER PROVINCE

FAMILY	Species (common name, where available)	Bandundu	Bas-Congo	Equateur	Comments
POACEAE	1.*Panicum repens L.* (Australia torpedo grass)	+	+	+	Invasive grass
	2.*Panicum maximum* (guinea grass; colonial grass)	+	+	+	Medicinal value
	3.*Oryza barthii* (species of wild rice)	+	+	+	Valuable for agricultural diversity
	4.*Echinochloa pyramidalis* (antelope grass)	+	+		Provides valuable dry-season grazing after coarse rainy-season growth has been burned off.
	5. *Echinochloa stagnina*				Aquatic perennial; good fodder
	6.*Imperata cylindrica* (cogon grass or speargrass)	+	+	+	Invasive, one of the ten worst weeds in the world
	7. *Hyparrhenia diplandra*		+	+	Dominant grass species of flooded wood savannah regions
	8. *Vossia cuspidata* (hippo grass)				Found in marshes
SALVINIEACEAE	9.*Salvinia molesta* (giant salvinia)	+			Invasive, free-floating water fern
	10. *Salvinia nymphellula*		+		Floating plant
ARACEAE	11. *Pistia stratiotes* (water lettuce)				
PONTEDERIACEAE	12. *Eichornia crassipes*	+	+	+	Invasive floating plant
CYPERACEAE	13.*Cyperus papyrus* (papyrus)	+			Grass
	14.*Cyperus sp.*		+		Grass
FABACEAE	15. *Mimosa pigra* (catclaw mimosa; aka giant sensitive plant)		+		Invasive, highly destructive; forms dense monocultures and suppresses other vegetation as well as impacts on fish life.
	16. *Mimosa pudica* (sensitive plant)	+			Invasive
SOLANACAE	17. *Physalis angulata L.* (Cape gooseberry; aka cutleaf ground cherry)	+			Considerable medicinal value; Bush
CONVOLVULACAE	18. *Ipomoea aquatica* Forsk (water spinach; aka swamp cabbage)	+	+		Invasive species; floating vine; Medicinal value
MORACEAE	19. *Ficus mucosa (fig tree)*		+	+	Medicinal value; documented to be used by chimps for same reason; timber species
	20. Ficus sp.			+	
RUBIACAE	21. *Nauclea latifolia* Smith (Pin cushion tree; aka African peach)	+	+		Small tree; medicinal value
EUPHORBIACAE	22. *Ricinodendron heudelotii* (Baill)	+			Tree
	23. *Bridelia ferruginea* Benth	+			Tree; medicinal value
	24..*Alchornea cordifolia L.*	+		+	Shrub; medicinal value

	25. *Hymenocardia acida*		+		Medicinal value
VERBENACAE	26. *Vitex doniana* Sw.	+			Tree found in flooded forests
IRVINGIACAE	27. *Irvingia smithii* Hook. F.	+	+		Tree in gallery forest
STERCULIACAE	28. *Melochia melissifolia* Benth	+			Invasive shrub
ASTERACEAE	29. *Chromolaena odorata*	+	+		Invasive perennial shrub
THELIPTERIDACAE	30. *Cyclosorus dentatus* (Forsk) (lynyolo)		+		Medicinal value
MYRTACAE	31. *Eugenia congolensis* DeWild and Th. Dur.		+		Tree found in flooded forests
PALMAE	32. *Elaeis guinensis* (African oil palm)			+	
ARECACEAE	33. Raphia sp. *(palm)*			+	
POLYGONACAE	34. *Polygonum acuminatum* H.B. and K. (knotweed)		+		Freshwater plant; medicinal value
ANACARDIACAE	35. *Lannea antiscorbutica* (Hiern) Engl.(pink lannea)		+		Found in riverine forests with sandy soil
CAESALPINIACAE	36.*Griffonia tessmannii* (De Wild) Compere			+	Shrub; medicinal value
BOMBACEAE	37. *Ceiba pentandra (kapok tree)*		+		Invasive tree
	38. *Andansonia digitata (African baobob)*		+		Native tree; medicinal value; pollinated by bats
FLACOURTIACAE	39.*Coloncoba glauca (P.Beauv.) Gilg.*			+	Tree; seeds used to destroy rats; oil used to treat leprosy
	TOTAL SPECIES/AXIS	**19**	**22**	**13**	

8.3. Water quality analysis. The following table shows the average concentration of heavy metals (µg/L) in the river in each province. These results show that the Bas-Congo site (Inga) is the most polluted site and the Equateur site (Gombe) the least polluted. However, all values might not be harmful to ecosystems due to the high percentage of organic material. The high percentage of organic material at Inga might be due to the death of water hyancinth *Eichornia crassipes* and algae. Data are still needed.

METAL	BANDUNDU	BAS-CONGO	EQUATEUR
Iron (Fe)	74	92	55
Cadmium (Cd)	4	18	1
Lead (Pb)	7	162	2
Manganese (Mn)	17	9	78
Copper (Cu)	7	47	2
Chromium (Cr VI)	0.6	4	0.2
% of organic material from suspended matter	8	31	13

TRIP # 1: BANDUNDU PROVINCE: MUSHIE TO BOKONI

8.4. Summary

8.4.1. Map of Station Sites in Bandundu

Stars mark the four sampling sites; bold numbers indicate water quality stations. All species and water quality were sampled at Mushi and Bokoni. Only fish were sampled at Bandundu.

8.4.2. Background

Our sampling sites are within the *Kasai ecoregion* (ecoregion # 21, Thieme et al., 2003, in prep.) in the Bandundu Province. WWF considers this region, particularly along the Fimi River to be among the highest priority areas for freshwater conservation, but notes that the region has been little studied ichthyologically. The region is thought to show high species richness for invertebrates. Sixty species of frogs are known for the ecoregion.The area is characterized by savannah-covered plateaus, cut by streams and rivers. The area has been little studied to date. Along the rivers, one finds 100 m to 10 km strips of tall seasonally and permanently indundated swamp forest and lowland (gallery) forest. The Kasai river starts on the Lunda Plateau of Angola. Major tributaries of the Kasai are the Kwango, Kwilu, Loange, Lulua, Sankuru and Wamba rivers. The peak of the rainy season is December and March. Flooding can raise the water level to 3 meters.

To the north of our sampling sites is Lake Mai-Ndombe. Its black waters are visible where the Fimi River converges with the Kisai. During high flooding, Lake Mai-Ndombe connects to Lake Tumba, making it one of the largest blocks of shallow blackwater and flooded forest in the Congo basin (WWF, 2003).

8.5. Results

Aquatic habitats: Aquatic habitats included sand, papyrus swamps, grassy shores, islands (grass or sand), and lowland tree roots. Several invasive species are present. We sampled primarily near grass or sand islands. The islands and

floating grasses provide important habitat for attached algae, invertebrates and fishes. They also store substantial amounts of nutrients, and are a source of dissolved organic compounds.

Terrestrial habitats: Terrestrial habitats included shrub savanna, flooded wood savannah, primary and secondary lowland gallery forest, and croplands. Invasive species are present.

Species: We found 83 fish species, comprising 21 families. Dominant families are Mormyridae (representing 23% of the sample), Mochokidae (11%), Characidae (10%), Bagridae (9%), Distichodontidae and Cichlidae (6%). While some of these species may possibly be new, this awaits confirmation from the AMNH. Some of the species are also valuable, or promising, for the aquarium trade (e.g., the beautifully colored *Synodontus* sp., *Polypterus ornatus, Nannochromis sp.*, *Campylomormyrus tamandua*, 'hammerhead' *Synodontus* (Appendix). A transparent shrimp (*Polyaemon dux congolese*) would also be a possibility for the pet trade. A particular species of Distichodus sells for as much as $50 in the pet trade (Sullivan, personal communication). With the help of an older experienced fishermen in the fishing village of Bokoni, we made considerable progress on a field guide to fishes in the local languages, Lingala and Kikonga.

We found 34 bird species; 9 species of amphibians, 4 species of reptiles, and 4 species of mammals, the latter, all found as bushmeat. The lack of live mammals is of concern, particularly the lack of large mammals such as hippopotamus. In the past, hippopotami were abundant along the river banks (WWF, 2003, in prep., Mankoto, 2002). Hippopotami are critical for maintaining the integrity of riverine systems, and their disappearance affects the species composition of riverine plants and animals alike (Naiman and Rogers, 1997; for further details, see Discussion, section 6.6. and Conclusions, section 8). For example, they maintain the health of fish stocks by stirring up rich water sediments and increasing water fertility with their feces (Meine and Archibald, 1996). Hippos are the main animals responsible for modifying the physical environment in this part of Africa, creating pools in the water which serve as habitats for crocodiles and larger fish, and channels to/from the river as they migrate nightly to their land feeding grounds (Naiman and Rogers, 1997). The distribution of some flooplain tree species depends on animals such as hippos to eat the seeds, which enhances germination and aids dispersion (Feely, 1965).

We found 22 species of macroinvertebrates, primarily rheophilic. They were captured under the vegetation composed of the wild rice, *Oryza barthii*, and the invasive species water hyacinth, *Eichornia crassipes*. The most abundant macroinvertebrate group included larvae of skimmer dragonflies (in the family Libellulidae) and freshwater shrimp of the genus Caridina. These invertebrates likely are a key food item for vertebrate fauna, including fishes.

We identified 19 plant species. Several native species are noted for their medicinal value, especially the Cape gooseberry, *Physalis angulata*. Seven plant species are invasive; this is 37% of the plants observed.

8.5.1. Systematic account of all species for Bandundu province.

Table 1b. Provisional list of fishes recorded. Note: identification to species will take 6 months-1 year.

			STATION	
FAMILY	**SPECIES**	**Mushi**	**Bokoni**	**Bandundu**
PROTOPTERIDAE	*1. Protopterus dolloi*			+ M
POLYPTERIDAE	*2.Polypterus sp. 1 (black)*	+		
	3. Polypterus sp. 2 (banded)			+ sp. M
	4. Polypterus ornatus		+	+ M
	5.Polypterus sp. 3 (Bdd)			+ M
CLUPEIDAE	*8.Odaxothrissa spp.*	+		
	7. Clupeidae spp.	+		
MORMYRIDAE	*8.Petrocephalus microphthalmus*	+ M		
	9.Petrocephalus sauvagii		+	
	10.Petrocephalus sp. (simus?)		+	
	11.Gnathonemus petersii		+	
	12.Genyomyrus donnyi		+	+ M
	13. Hippopotamyrus pictus	+		
	14. Hippopotamyrus discorhynchus	+	+	
	15.Mormyrops anguilloides	+	+	+ M
	16.Mormyrops mariae		+	
	17.Marcusenius greshoffii	+ M		
	18.Marcusenius sp. 1	+	+	
	19.Marcusenius sp. 2	+	+	
	20.Marcusenius sp. 3		+	
	21.Stomatorhinus sp. 1 (little, black)	+	+	
	22.Pollimyrus adspersus		+	
	23.Pollimyrus sp.	+M	+	
	24.Mormyrus proboscirostris		+	
	25.Mormyrus caballus bombanus			+ M
	26.Campylomormyrus tamandua		+	+
	27.Campylomormyrus elephas		+	
CHARACIDAE	*28.Bryconaethiops sp.*		+	
	29.Hydrocynus goliath	+	+	+ M
	30.Hydrocynus vittatus?	+	+	
	31.Alestes sp.	+	+	+ M
	32.Brycinus sp. 1	+	+	+ M
	33.Brycinus sp. 2	+	+	
	34.Micralestes sp.		+	
	35.Other small characids		+	
DISTICHODONTIDAE	*36.Ichthyborus ornatus*		+	+ spp. M
	37.Phago sp.		+	+ M
	38.Eugnatichthys sp.		+	
	39.Xenocharax spilurus		+	
	40.Nannocharax sp.		+	
CITHARINIDAE	*41.Citharinus gibbosus (Blgr.)*	+	+	+ M
CYPRINIDAE	*42.Barbus sp.*	+	+	
	43.Labeo sp. 1	+	+	+ spp. M
	44.Labeo sp. 2	+	+	
	45.Labeo sp. 3	+	+	
BAGRIDAE	*46.Bagrus sp.*		+	
	47.Auchenoglanis occidentalis		+	+ M
	48. Chrysichthys sp. 1		+	+ sp. M
CHANNIDAE	*49. Parachanna obscura*		+	+ M
	50.Chrysichthys sp. 2		+	

	51.Chrysichthys sp. 3		+	
	52.Chrysichthys sp. 4		+	+ M
SCHILBEIDAE	*53.Parailia sp.*	+		
	54.Schilbe sp. 1	+	+	
	55.Schilbe sp. 2	+	+	
NOTOPTERIDAE	*56.Xenomystus nigri (Gthr.)*		+	
	57. Papyrocranus afer (Gthr.)		+	
ANABANTIDAE	*58. Ctenopoma sp. 1*		+	
	59. Ctenopoma sp. 2		+	
	60. Ctenopoma sp. 3		+	
CENTROPOMIDAE	*61. Lates niloticus (L.)*	+	+	
OSTEOGLOSSIDAE	*62. Heterotis niloticus (Cuvier)*		+	+ M
TETRAODONTIDAE	*63. Tetraodon mbu (Blgr.)*		+	
	64. Tetraodon miurus (Blgr.)		+	
MASTACEMBELIDAE	*65. Mastacembelus sp. 1*	+		
	66. Mastacembelus sp. 2		+	
MALAPTERURIDAE	*67. Malapterurus electricus*			+ M
MOCHOKIDAE	*68. Synodontis sp. 1*	+		+ sp.
	69. Synodontis sp. 2	+		
	70. Synodontis sp. 3	+		
	71. Synodontis sp. 4	+		
	72. Synodontis sp. 5	+		
	73. Synodontis sp. 6		+	
	74. Synodontis sp. 7		+	
	75. Synodontis sp. 8		+	
CLARIIDAE	*76.Heterobranchus longifilis (Val.)*	+		
	77. Channallabes apus (Gthr.)			+ M
	78. Clarias spp.		+	+ M
CICHLIDAE	*79. Tylochromis*		+	
	80. Lamprologus sp.		+	
	81. Hemichromis sp.		+	
	82. Nannochromis sp.		+	+
	83. Tilapia (Oreochromis) sp? = marechal		+	+ M

Table 2b. Birds recorded. For common names, see Table 2a.

		STATION			
FAMILY	**SPECIES**	**Bandundu-Bokoni**	**Mushi**	**Mushi-Bokoni**	**Bokoni**
ACCIPITRIDAE	*1. Gypohierax angolensis*	+			+
	2. Milvus migrans	+	+	+	+
ALCEDINIDAE	*3. Alcedo cristata*				+
	4. Ceryle rudis			+	+
	5.Halcyon senegalensis			+	
ANHINGIDAE	*6. Anhinga rufa*	+		+	+
ARDEIDAE	*7. Ardea purpurea*			+	
	8. Bubulus ibis	+			
	9. Egretta alba	+	+	+	
	10. Egretta garzella	+		+	+
	11. Egretta ardesiaca		+		+
BUCEROTIDAE	*12. Tockus fasciatus*				+
CAPITONIDAE	*13. Pogoniulus bilineatus*				+
CHARADRIIDAE	*14. Tringa sp*			+	
	15.Vanillus albiceps			+	
CICONIIDAE	*16. Ciconia episcopus*		+ M		
COLUMBIDAE	*17. Treron calva*	+ M			
	18. Turtur afer				+
CORVIDAE	*19.Corvus albus*	+	+	+	+
CUCULIDAE	*20. Centropus sp*				+
ESTRILDIDAE	*21.Lonchura cucullata*		+		
JACANIDAE	*22. Actophilornis africanus*			+	
MEROPIDAE	*23. Merops pusillus*		+	+	+
MOTACILLIDAE	*24. Motacilla flava*		+		
MUSOPHAGIDAE	*25. Corythaeola cristata*				+
NECTARINIDAE	*26. Nectarinia chloropygia*				+
	27. Nectarinia sp.				+
PASSERIDAE	*28. Passer griseus*		+		
PHALACROCORACIDAE	*29.Phalacrocorax africanus*				+
PLOCEIDAE	*30. Ploceus cucullatus*				+
	31. Ploceus nigerrimus				+
	32. Ploceus aurantius				+
PYCNONOTIDAE	*33. Pycnonotus sp.*				+
VIDUIDAE	*34. Vidua macroura*				+

Table 3b. Amphibians.

		STATION	
FAMILY	**SPECIES**	Mushi	Bokoni
BUFONIDAE	*1. Bufo regularis*	+	
	2. Bufo maculatus	+	
RANIDAE	*3. Rana fuscigula*	+	+
	4. Rana regularis		+
	5. Rana mascareniensis	+	+
	6. Rana sp.		+
	7. Phrynobatrachus natalensis	+	
	8. Phrynobatrachus sp.	+	
	9. Hemisus marmoratum	+	

Table 4b. Reptiles.

		STATION	
FAMILY	**SPECIES**	**Mushi**	**Bokoni**
PELOMEDUSIDAE	*1. Kinixys sp.* *(a genus of tortoise)*	+	
CELUBRIDAE	*2. Celubridae sp.* *(a genus of snake)*	+	
SENCIDAE	*3. Mabuya maculilabris* *(speckle-lipped skink)*	+	+
CROCODYLIDAE	*4. Osteolaemus tetraspis* *(dwarf crocodile)*	+	

Table 5b. Mammals.

		STATION	
FAMILY	**SPECIES**	**Mushi**	**Bokoni**
HIPPOPOTAMIDAE	*1. Hippopotamus amphibius* (hippopotamus)	+	
CERCOPITHECIDAE	*2. Cercopithecus ascanius* (red-tailed monkey)	+	
BOVIDAE	*3. Cephalophus monticola* (blue duiker)	+	
	4. Tragelaphus spekei (sitatunga)		+

Note: all but *Cephalophus monticoloa* were found as bushmeat.

Table 6b. Macroinvertebrates

			STATION	
ORDER	**FAMILY**	**SPECIES**	**Mushi**	**Bandundu**
DECAPODA	ATYIDAE	1. *Caridina africana*		+
		2. *Caridina sp. 1* (brown/black)	+	
		3. *Caridina sp. 2* (green)	+	
		4. *Caridina sp. 3* (yellow, long)	+	
	POTAMONIDAE	5. *Potamonautes africanus*	+	
	PALAEMONIDAE	6. *Palaemon dux congoensis*		+
	ATEMNIDAE	7. *Unknown sp.*		
COLEOPTERA	DYSTICIDAE	8. *Cybister tripunctatus*		+
		9. *Hydraticus dregei*		
	NOTONECTIDAE	10. *Anisops varia*		+
HETEROPTERA	GERRIDAE	11. *Gerris sp.*		
HEMIPTERA	NEPIDAE	12. *Ranatrea fusca*		+
		13. *Ranatrea grandicollis*		+
	BELOSTOMATIDAE	14. *Belostoma niloticum*		+
	HYDROMETRIDAE	15. *Hydrometra sp.*		+
ODONATA	COEANAGRIONIDAE	16. *Megalopropus caerulatus*		
	LIBELLULIDAE	17. *Palpopleura lucia*		+
		18. *Libellula quadrimaculata*		+
	GRILLIDAE	19. *Unknown sp.*		
	TRIGONIDIIDAE	20. *Unknown sp.*		
ARANAE	ARANEIDAE	21. *Unknown sp.*		+
MESOGASTROPODA	AMPULLARIDAE	22. *Aetheria elliptica*		+

Table 7b. Plants.

FAMILY	Species (common name, where available)	Comments
POACEAE	1.*Panicum repens L.* (Australia torpedo grass)	Invasive grass
	2.*Panicum maximum* (guinea grass; colonial grass)	Medicinal value
	3.*Oryza barthii* (species of wild rice)	Valuable for agricultural diversity
	4.*Echinochloa pyramidalis* (antelope grass)	Nutritious fodder for dry-season grazing
	5. *Imperata sp.*	Grass
SALVINIEACEAE	6.*Salvinia molesta* (giant salvinia)	Invasive, free-floating water fern
PONTEDERIACEAE	7. *Eichornia crassipes* (water hyacinth)	Invasive floating plant
CYPERACEAE	*8. Cyperus papyrus* (papyrus)	Grass
SOLANACAE	9.*Physalis angulata L.* (Cape gooseberry; aka cutleaf ground cherry)	Considerable medicinal value; bush
CONVOLVULACAE	10. *Ipomoea aquatica* Forsk (water spinach; aka swamp cabbage)	Invasive species; floating vine; Medicinal value
FABACEAE	11. *Mimosa pudica* (sensitive plant)	Invasive; medicinal value
RUBIACAE	12.*Nauclea latifolia* Smith (Pin cushion tree; aka African peach)	Small tree; medicinal value
EUPHORBIACAE	13. *Ricinodendron heudelotii* (Baill)	Tree
	14. *Bridelia ferruginea* Benth	Tree; medicinal value
	15. *Alchornea cordifolia L.*	Shrub; medicinal value
VERBENACAE	16.*Vitex doniana* Sw.	Tree found in flooded forest
IRVINGIACAE	17. *Irvingia smithii* Hook. F.	Tree in gallery forest
STERCULIACAE	18. *Melochia melissifolia* Benth	Invasive shrub
ASTERACEAE	19. *Chromolaena odorata*	Invasive perennial shrub

8.5.2. Water Quality Analysis.

Productivity, as measured by PO_4 and NO_3, was very low. This is typical for tropical rivers. Therefore, the beginning of the food chain in the river originates from the land: specifically, terrestrial plant matter and insects. Transparency was greatest by Bokoni, intermediate for the black water areas, and lowest when the water became muddy (samples M_F-M_H). For turbidity and true color, from Mushi to Bokoni, eight samples were taken (4 in Mushi; 4 between the two villages.) For these eight samples, the mean turbidity was 32.1 FTU and the true color was 178 (Pt-Co units). At Bokoni, 7 samples were taken, and the mean turbidity was 23.3 and true color was 53.6. The pH generally was acidic, particularly at the confluence of the Fimi River and the Kasai. Black waters, such as found in Mushi and en route to Bokoni, have low pH and reducing properties, and are vulnerable to deoxygenation, when newly drowned vegetation rots. The pH became slightly basic by the gallery forest (7.6; sample M_H). Conductivity generally ranged from 20-30 ìS, with the exception of low conductivity of 10 ìS by Mushi, on the Kwa river. Dissolved oxygen levels were lower adjacent to Mushi (77%, or roughly 6 mg/L), presumably indicating increased inputs of biological waste from the village. However, the dissolved oxygen is within a level that is not stressful for aquatic animals (see methods section for details). Heavy metal analysis of all sites indicates the water is within safe water drinking standards, as defined by the U.S. EPA (www.epa.gov/safewater).

Table 8b. Summary of water quality data for Bandundu province.

STATION NUMBER

	1	2	3	4	5	6	7	8	9	10
Sample	M_A	M_B	M_c	M_D	M_E	M_F	M_G	M_H	B_A	B_{B-G}
Site Description	Mushi Wetland by village	Mushi Wetland Opposite Village	Mushi Grassy Wetland	Mushi Center of river	Betwn Mushi/ Bokoni Center of channel, Fimi River	Betwn Mushi/ Bokoni	Betwn Mushi/ Bokoni, Where terrestrial landscape changed to trees	Betwn Mushi/ Bokoni,by lowland forest	Bokoni	Bokoni
GPS Location (lat/long, in degrees)	3°1.74 S 16° 5.37E	3°1.74 S 16° 5.37E	3°1.74 S 16° 5.37E	3°1.74 S 16° 5.37E	3 °1.0 S 16°56.68E	3 ° 0.51S 16°58.44E	3 ° 3.81S 17°4.01E	3 ° 5.34S 17°6.87E	3 ° 09.46S 17°09.73E	
Depth at measured site (feet)	-	4.3	43	57.7	23	23.3	13.7	9.9	4	
Water Temp. at Surface (C)	27.6	27.8	27.6	27.7	27.5	27.8	28.7	28.8	30.3	
Current (qualitative)		Still	-	Medium	Fast	Medium	Medium	Medium	Fast	
pH		7.0	6.8	6.0	6.0	7.0	6.6	7.6	6.75	
Conductivity (iS)	20	20	30	10	30	20	20	30	30	
Secchi Disk (cm)	-	40.34	42.7	42.0	65.15	17.35	14.25	18.23	-	
Turbidity (FTU)	31	25	25	43	41	32	30	30	10	X = 25.5
Color	Black	Black	Black	Black	Black	Muddy	Muddy	Muddy	-	
True Color (Pt-Co units)	218	136	135	222	214	172	163	164	28	
General Hardness (ppm)		-	-	53.7	53.7	53.7	35.8	35.8	35.8	
Carbonate Hardness (ppm)		-	-	53.7	53.7	35.8	35.8	35.8	35.8	
Dissolved Oxygen		77%	84%		-	91.4%	90.1%	88.1%	86.2%	
Phosphate (PO_4) (mg/L)		0	.25	<.25	<.25	<.25	<.25	<<.25	<<.25	
Nitrate (NO_3) (mg/L)	3	-	5	5	<5	<5	<5	<5	<5	
Calcium (mg/L)	80	-	160	100	100	80	60	60	40	

Water quality: (- = no test; 0 = zero test value; empty cells indicate columns of additional samples for laboratory analysis).
Note: Exact dissolved oxygen values cannot be determined until we obtain maps that accurately provide altitude measures, for calibration.
A source has been found (CRES, 2000) for a Topographic and Climate Database for Africa, but a CD must be purchased.

Table 9b. Metals content in water samples from Bandundu
Values are in µg/L. Data analysed by ERGS.

Sites	Iron (Fe)	Cadmium (Cd)	Lead (Pb)	Manganese (Mn)	Copper (Cu)	Chromium (Cr VI)
Bandundu						
M_A	85	5	9	21	8	1
M_B	82	3	8	18	9	1
M_C	76	5	9	15	6	0.5
M_D	74	4	8	17	8	0.8
M_E	68	5	5	17	5	1
M_F	69	3	4	16	7	0.6
M_G	70	4	4	17	6	0.4
M_H	69	4	7	18	8	0.4
Bokoni	74	4	7	17	7	0.6
Average	**74.13**	**4.13**	**6.75**	**17.34**	**7.13**	**0.6**

8.5.3. Sampling Station Reports, Trip #1

Name: Bandundu to Mushi
Position: No position determined.

Date of visit: Sept. 15, 2002

Procedures: Only ecological observations were made, and water conductivity tested.

Ecological notes: The river Kwilu is brown, roughly one-half the width of the main Congo River channel, with sparse *Cyperus papyrus* and the grass *Panicum repens* along the banks. Water conductivity abruptly changed from 20 to 30 ìS at the convergence of the Kwilu and Fimi River.

Conservation/development notes: From Bokola to Mushi, the grass amounts decreased, as did the number of fishermen. This correlation indicates the importance of the grass habitats along the banks and islands to fish abundance.

Name: Mushi
Position: 3° 1.74 S; 16 ° 5.37 E

Date of visit: Sept. 15, 2002

Procedures: The land team surveyed vertebrates adjacent to the village, on the eastern side. Birds were caught with a mist net and released. Amphibians were recorded on tape. Plant samples were collected. Macroinvertebrates were caught primarily with a dip net. A drop net, Hester-Dendy sampler and kick net were also used. Fishes were collected by gill net in the wetland area on the river bank opposite Mushi, and obtained directly from fishermen.

Ecological notes: On the village side of the river, the terrain of the terrestrial landscape was sloped. The village is directly on the bank of the river; few trees remain in the village along the banks. Adjacent to the village, the habitat was primarily shrub savanna, with patches of grassy wetland and sand. Aquatic plants in the wetland areas across the river from the village and in front of the village included abundant amounts of *Panicum repens*, the invasive water spinach (aka swamp cabbage), *Ipomoea aquatica*, the invasive water hyacinth, *Eichornia crassipes*, and the invasive

giant salvinia, *Salvinia molesta*. Small larval fish of the family Eleotridae were observed in the wetlands. Adjacent to Mushi, the water was black. Very few insects were observed at the surface by plants; aquatic invertebrates were present, however. In the area sampled for macroinvertebrates, the river bottom ranged from sand to detritus. Fishes originating from the blackwaters of the Fimi River and the nearby Lake Mai-Ndombe have evolved darker coloration.

Water quality analyses were conducted at the following sites:
M_A: black water by the grassy wetland next to Mushi, on the Fimi River. Black water has a high concentration of dissolved organic carbon and humic compounds.
M_B: wetland across the river from Mushi village. The invasive floating *Eichornia crassipes* and *Salvinia molesta* fringed the wetland.
M_C: wetland, across the river from Mushi village west of site Mb, with floating *Eichornia, Panicum repens,* sand and mud bottom. This area had abundant amounts of dragonflies, and larval fish of the family Eleotridae (*Kribia nana*)
M_D: Middle of the Fimi River.
M_E: Black water, center of the channel of the Fimi River.

Conservation/development notes: Qualitatively, fish in the Mushi market are small to medium in size.

Name: Between Mushi and Bokoni (on pirogue)
Position: 3^o 0.51 S, 16^o56.68 E

Date of visit: Sept. 17, 2002

Procedures: Birds were noted en route. No other terrestrial animals were observed this time except for an aquatic snake. Water quality was tested at the confluence between the Fimi and Kasai River (sample $M_{F)}$ and by the bank where the biotope changed from grass to lowland (gallery) forest (sample M_G). At this site, there were many plants and a muddy bottom. Sample M_H was collected by a bank of lowland (gallery) forest.

Ecological notes: Several different habitats were observed during this one and a half-hour boat ride, including: sand, islands with Papyrus (*Cyperus papyrus*) and grasses along the banks (*Panicum repens*) (sand and grass were the predominant habitats), wetlands, patches of degraded lowland rainforest, and flooded wood savannah. These islands, along with floating littoral plants, provide key habitat for algae, invertebrates and fishes. Topographically, we encountered plains and sloping areas. Aquatic plants in grassy shore areas included abundant amounts of *Panicum repens* and *Alchornea cordifolia*. Soil was clay. Many insects were observed floating on the water surface.

Conservation/development notes: We observed fishermen fishing with cast nets.

Name: Bokoni
Position: 3^o 09.46 S, 17^o 09.73 E

Date of visit: Sept. 15, 2002

Procedures: Birds were caught with a mist net and released. Amphibians were recorded on tape. Fish were sampled at a wetland island (with 2 gill nets, a seine, and a cast net), at the fishing village of Lome (with seines and cast nets), and at Bokoni proper (with cast nets). Plant samples were collected.

Ecological notes: The forest around this small fishing village was sampled. Trees remain scattered throughout the village. The terrestrial landscape was a plain, with patches of field, secondary forest, and shrub savannah. The invasive Christmas bush (aka Siam weed), *Chromolaena odorata*, was present. Aquatic plants along the shore

included abundant amounts of *Panicum repens* and *Imperata cylindrica*. *Hyparrhenia diplandra* and *Panicum maximum* were also present.

Conservation/development notes: At one site, we saw fishermen use an illegal 1 cm. gill net, setting their gill nets parallel to the wetland, to catch medium-sized Distichotids. At another, we observed fishermen using legally-sized gill nets of 3 cm.; also 6 cm. The fishermen creatively use local material to make parts of the net, using flipflop material to make floats; cement for weights. We observed larvae in the wetlands; fishermen confirm that fish spawn in wetlands by the islands. These islands can be completely covered during the rainy season. They use fish traps in the flooded forest. By the Lome fishing village, they use 100 meter seines. Most fecund fish are thought to spawn twice a year.

While illegally-sized nets are used, overfishing is not yet a serious threat, deduced from the fact that many fish caught in this region are a large size. Evidence of overfishing can often be indicated by a biomass flip, where one sees a shift in the populations of many species, and larger fish become scarce.

The number of fishing encampments increases in the summer, when the children get out of school. At the time we were there, school was in session; however, many children in this village did not go to school.

8.6. Conservation and Management

I would rank this area as having moderate ecological integrity, given the number of invasive plants in the area, the extent of hunting, and the pressure of human populations. WWF (Thieme et al., 2003, in prep.) defines this category as follows: “Habitat is altered but potentially restorable. Human disturbance has extirpated many sensitive species, but some habitat remains suitable for most native species. Species composition and community structure are altered, but native species are likely to return with improved habitat and connections to source pools. Exotic species may potentially be managed. “

8.6.1. Threats and Development issues:

- Bushmeat hunting: The lack of large mammals, particularly hippos is cause for concern. Burgis and Symoens (1987, as cited in WWF, 2003, in prep.) note that the area is habitat for hippo and forest elephant (*Loxodanta africana*). Hippopotami are critical for maintaining the integrity of riverine systems, and their disappearance affects the species composition of riverine plants and animals alike (Naiman and Rogers, 1997; for further details, see Discussion section). For example, they maintain the health of fish stocks by stirring up rich water sediments and increasing water fertility with their feces (Meine and Archibald, 1996). Hippos are the main animals responsible for modifying the physical environment in this part of Africa, creating pools in the water which serve as habitats for crocodiles and larger fish, and channels to/from the river as they migrate nightly to their land feeding grounds (Naiman and Rogers, 1997). One hippo can eat up to 60 kg. of grass every night. The distribution of some flooplain tree species depends on animals such as hippos to eat the seeds, which enhances germination and aids dispersion (Feely, 1965).

Crocodiles: The decline of crocodiles may also affect the ecosystem. Crocodiles feed heavily upon catfish, which prey upon mormyrids and cichlids.

Germain Mankoto notes the disappearance of hippos, crocodiles, turtles, and snakes for the region in his trip report (Mankoto, 2002). WWF (2003, in prep.) corroborates that hunting pressure is very high for at least the Mai-Ndombe region.

- Logging and habitat conversion: The forest is disappearing along parts of the Kwilu and the Kisai, due in part to logging and in part to agricultural changes. This was noted by Germain Mankoto in his trip report

(Mankoto, 2002). WWF (2002) reports that valid logging concessions are present in the region, but currently inactive. We saw a Belgian timber operation by Bokala. Even though they started just in July, 2002 (Mankoto, personal communication), considerable logging has already taken place.

Overfishing. Fishermen fish in spawning areas and intensively fish during low water periods (Mankoto, 2002). Illegally-sized gill nets were observed on site at Bokoni, but the threat is a medium threat at this point.

- Mining: Diamond mining takes place much further downstream, in Tshikapa (Kasai Province). Mining increases the turbidity of the water, which can affect photosynthetic rates.

- Oil exploration and exploitation (future threat): The governor reported that oil is present underground, and he is pursuing exploitation of this resource.

- Malnutrition. The Governor reported a number of cases of malnutrition in Bokoni, primarily due to lack of vegetables.

8.6.2. Management:

To maintain the entire ecosystem will require awareness of the importance of maintaining viable populations of key animals for the riverine ecosystem, specifically, hippos, and terrestrial plants. For fisheries, the best option here would be 1) a net exchange program, swapping illegal nets for legal ones, 2) mapping of key spawning areas and fishing grounds, and 3) beginning monitoring of fishing effort. At Bokoni, it would be helpful to support an agriculture effort to reduce the malnutrition present.

8.6.3. Potential partner options:

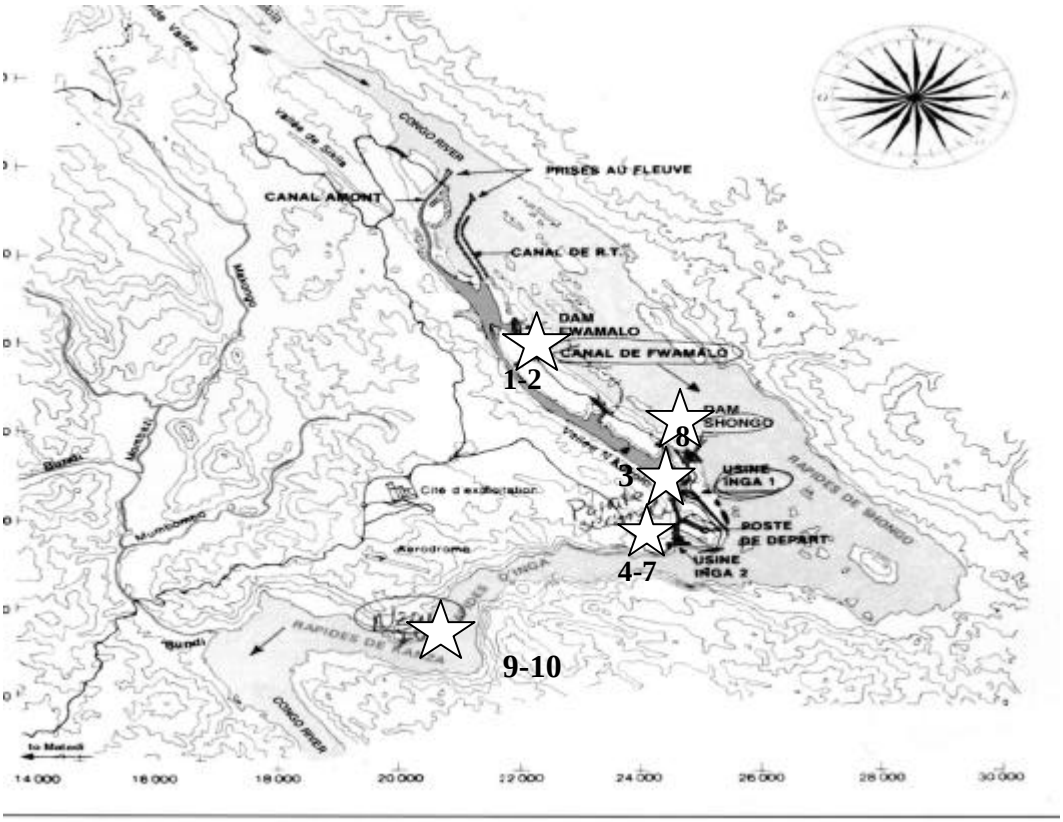
1) PERILAC (Bandundu) (President: Mr. Gryungo Nzambi Zenom). This NGO began two years ago. Its goal is to provide strategies for sustainable development.
2) SAQUA (Bandundu) This NGO is one year old. Its objective is to rejuvenate the pet trade and provide increased income for its members. However, the NGO currently has no connections for export, no representative in Kinshasa.Fish are caught with dip nets and a fine net made of clothes, catching fish at 1.5 meters.
3) COPADEM (Mushi) (President: Mr. Roger Iziza Pembe (aka Coco)). Newly formed NGO. Objective: sustainable development, including improved transportation for livestock and other goods.

Trip # 2: Bas-Congo Province: Inga

8.7. Summary

8.7.1. Map of Station Sites in Bas-Congo

Stars mark sampling sites; bold numbers indicate water quality stations. All species and water quality were sampled at all sites.



Map source: Société Nationale d'Electricité (2001)

8.7.2. Background

Our sampling sites are within the *Lower Congo Rapids* ecoregion (ecoregion # 60, Thieme et al., 2003, in prep.), in the Bas-Congo province. WWF considers this area of highest conservation importance. The rapids in this region are 300 km long. Currents are strong. The area by the rivers is wooded savannah, with pockets of gallery forest in parts. The rainy season here is Oct-Dec. and Jan. – April. According to Ifuta (personal communication), the region changed to savannah from tropical forest over the last century. Essentially, the savannah border moved further north. Pools abound. The last survey of the region was published in 1976 (Roberts and Stewart, 1976). These authors used the poison rotenone to sample the region. The region has exceptional species richness for fishes (129 species) and high endemism (34/129, or 26%), with many species specially adapted for life in the swift current — as evidenced by reduced eyes, coloration, and flattening of the body form. Other species fall into three other categories: 1) those poorly adapted (presence in rapids is atypical or accidental); 2) those moderately adapted (little or no morphological adaptation); and 3) those highly adapted to avoid rapids (e.g., hiding in caves and crevices, such as a blind lamprologine cichlid). Endemic fish species are found in the following families: Mormyridae, Characidae, Cyprinidae, Bagridae, Amphiliidae, Clariidae, Mochokidae, Cichlidae, and Mastacembelidae (Roberts and Stewart, 1976). Interestingly, the genera of these species are found widely throughout the Congo basin (Roberts and Stewart, 1976). The area is also thought to be important for molluscs, with at least 18 species (Bequaert and Clench: 1936, 1941).

8.8. Results

Aquatic habitats: Aquatic habitats included rapids with strong currents, a reservoir, and the main river and a river channel with rocky boulders, sand, and wetlands. We sampled at 5 sites: Inga #1, aka Tank (the reservoir), Nziya (the main river with rocky boulders and sand along the banks), Shongho (rapids), Point 50 (rapids) and Fwamalo (a river channel, with sand, boulders, and a wetland). The difficulty in sampling the aquatic habitat, particularly the rapids, and the difficulty in reaching these sites hindered our collection of fish. The prior survey by Roberts and Stewart (1976) used the fish poison rotenone. As the CREDP project has an environmental focus, with an effort to improve the sustainability of fish capture, we did not want to set a bad example by using poison. Therefore, our collection of fish by the rapids came from fishermen.

Terrestrial habitats: Wooded savannah in parts; gallery forest in others.

Species:

We identified 47 species of fish, comprising 16 families. Some of these species may be new, but this awaits confirmation from the AMNH. In the 1976 survey, Roberts and Stewart found 129 species from 17 families, the most speciose being Mormyridae and Cyprinidae, both at (15%); Cichlidae (13%); and Mochokidae (12%). We found the most speciose family to be Mormyridae (22%), followed by Characidae and Cichlidae, both at (12%), but Cyprinidae and Mochokidae were not as well represented in our sample. It is important to note that sampling was very different between the two surveys: Roberts and Steward used rotenone, while we primarily obtained fish from fishermen, as well as with dip nets, cast nets and seines.

Two species in our sample are considered highly adapted to currents: *Campylomormyrus muirus* and *Rheoglanus dendrophorus*. For the mormyrid, this is exemplified by its long snout, enabling it to eat insects among rock crevices, and small eyes. As almost all mormyrids have small eyes, Roberts and Stewart consider these fish to be 'preadapted' to a rapids habitat. For Rheoglanus, modifications include flattening of the body form, coloration, and small eyes.The following fish species found in our sample (in addition to potentially new species) were not reported by Roberts and Stewart during their extensive rotonene sampling: *Gnathonemus* sp.; *Campylomormyrus curvirostris*; *Phago* sp., *Ichthyoborus sp., Labeo coubie, Ctenopoma sp., Heterotus niloticus, Chariallobes* sp., *Cyprinodintidae* sp., and *Belonoglanis* sp.

With the help of the Fishing Association, we made considerable progress on a field guide to fishes in the local languages, Lingala and Kikonga.

We identified 23 species of birds, 6 species of amphibians, 2 species of reptiles, and 5 species of mammals, the latter all found as bushmeat. The straw-colored bat (*Eidelon helvum*) is a fruit bat involved in the seed dispersal and germination of a threatened West African hardwood, *Melicia excelsa* (www.for.nau.edu/research/pb1). The giant otter shrew (*Potamogale velox;* technically not a shrew but a tenrec), is considered endangered by IUCN. Found in streams and swamps, habitat quality is critical to this animal. It is not found where waters are muddy from erosion caused by deforestation. The giant otter shrew eats fish, crabs, frogs and aquatic molluscs. The Cercopithecus monkey (*Cercopithecus ascanius*) found is in the Guenon family. Guenons pollinate flowers and disperse seeds.

We found 21 species of aquatic macroinvertebrates, including 7 species of molluscs. Two invertebrate groups in particular, are of importance to fish as prey items: a freshwater shrimp (*Caridina africana*) and larvae of Libellulidae (dragonflies): *Libellula quadrimaculata* and *Palpopleura lucia*.

We noted 22 species of plants, 6 (27 %) of which are invasive. The highly aggressive invasive plant, *Mimosa pigra*, was present.

8.8.1. Systematic account of species for Bas-Congo province.

Table 1c. Provisional list of fishes recorded. Note: precise identification to species will take 6 months-1 year.
+ = recorded; sp. = unidentified single species, may not be the same across sites; spp. = unidentified multiple species; M = fish for consumption, either collected from fishermen or observed at the market.

		STATION					
FAMILY	**SPECIES**	**Inga** ***(Tank)***	**Nziya**	**Shongho**	**Fwamalo**	**Point 50**	**Mar-ket**
POLYPTERIDAE	*1.Polypterus sp.*						+M
CLUPEIDAE	*2.Clupeidae sp.*	+					
MORMYRIDAE	*3.Petrocephalus sp.*	+					
	4.Gnathonemus sp.				+		
	5.Mormyrops anguilloides	+					+M
	6.Marcusenius monteiri		+				
	7.Marcusenius sp.				+		+M
	8.Mormyrus caballus bombanus		+				+M
	9.Hippopotamyrus discorhynchus		+				
	10. Campylomormyrus mivris		+				
	11. Campylomormyrus urirrostrus		+				
	12. Campylomormyrus sp. 1						+M
	13.Campylomormyrus sp.2						+M
CHARACIDAE	*14. Hydrocynus goliath*						+M
	15. Small characid sp. 1		+				
	16. Small characid sp. 2		+				
	17. Small characid sp. 3		+				
	18. Small characid sp. 4		+				
	19. Small characid sp. 5		+				
DISTICHODONTIDAE	*20.Phago sp.*				+		
	21.Ichthyoborus afer				+		+M
	22.Distichodus sexfasciatus						+M
	23. Distichodus lusosso						
CYPRINIDAE	*24.Labeo velifer*		+		+		+M
	25.Labeo coubie		+			+	
	26.Labeo sp.(nasal protuberance)		+			+	
BAGRIDAE	*27.Chrysichthys sp. 1*		+				
	28.Chrysichthys sp. 2		+				
	29.Chrysichthys sp. 3		+				
	30.Bagrus sp.					+	
	31.Rheoglanis dendrophorus		+				+M
SCHILBEIDAE	*32.Schilbe mystis*						+M
ANABANTIDAE	*33. Ctenopoma sp.*				+		
OSTEOGLOSSIDAE	*34. Heterotus niloticus*		+				+M
MALAPTERURIDAE	*35. Malapterurus electricus*						+M
MOCHOKIDAE	*36. Synodontis sp. 1*		+				+M
	37. Synodontis sp. 2		+				
	38. Synodontis sp. 3		+				
	39. Synodontis sp. 4		+				
CLARIIDAE	*40. Chariallabes sp.*						+M
CICHLIDAE	*41. Tylochromis sp.*		+	+			
	42. Lamprologus sp.		+				
	43. Hemichromis sp.			+			
	44. Tilapia sp.						+M
	45.Steatocranus sp. 1			+			+M
	46.Steatocranus sp. 2			+			+M
CYPRINODONTIDAE	*47. Cyprinodontidae sp.*				+		
AMPHILIIDAE	*48. Belonoglanis sp.*				+		

Table 2c. Birds. For common names, see Table 2a.

		STATION				
FAMILY	**SPECIES**	**Inga (Tank)**	**Nziya**	**Shongho**	**Fwamalo**	**Pt. 50**
ACCIPITRIDAE	1.*Gypohierax angolensis*	+	+		+	
ALCEDINIDAE	2. *Halcyon senegalensis*	+				
ARDEIDAE	3. *Egretta alba*		+			+
	4. *Egretta ardesiaca*					
	5. *Egretta gularis*	+				
CAPITONIDAE	6.*Pogoniulus bilineatus*	+	+			
	7. *Pogoniulus sp*					+
COLUMBIDAE	8. *Streptopelia sp*					+
CORVIDAE	9. *Corvus albus*	+				
CUCULIDAE	10.*Centropus senegalensis*	+	+			
ESTRILDIDAE	11. *Lonchura cucullata*		+			+
	12.*Uraeginthus angolensis*		+			+
HIRUNDINIDAE	13.*Hirundo abyssinica*	+				
	14.*Hirundo rustica*				+	
	15.*Hirundo senegalensis*	+	+			+
	16.*Delichon ursica*				+	
MEROPIDAE	17. *Merops pusillus*					+
MOTACILLIDAE	18. *Motacilla agwimp*	+				
PASSERIDAE	19. *Passer griseus*					+
PHALACRO-CORACIDAE	20. *Phalacrocorax africanus*		+		+	+
PHASIANIDAE	21. *Francolinus sp.*	+				
PYCNONOTIDAE	22. *Pycnonotus barbatus*	+	+	+		
SYLVIIDAE	23. *Cisticola natalensis*				+	

Table 3c. Amphibians

		STATION				
FAMILY	**SPECIES**	**Inga (Tank)**	**Nziya**	**Shongho**	**Fwamalo**	**Pt. 50**
BUFONIDAE	*1. Bufo funereus*	+	+			
RANIDAE	*2. Rana fuscigula*	+				+
	3. Rana sp. 1		+			
	4. Rana sp. 2					+
	5. Hymenochirus curteines					+
	6. Rana mascariensis	+				
	Many larvae				+	+

Table 4c. Reptiles

		STATION				
FAMILY	**SPECIES**	Inga (Tank)	Nziya	Shongho	Fwamalo	Pt. 50
SCINCIDAE	*1. Mabuya maculilabris* (speckle-lipped skink)	+	+		+	+
AGAMIDAE	*2. Agama agama* (common agama)		+			+

Table 5c. Mammals

		STATION				
FAMILY	**SPECIES**	Inga (Tank)	Nziya	Shongho	Fwamalo	Pt. 50
BOVIDAE	*1. Tragelaphus spekei* (Sitatunga)		+			
	2.Cephalophus monticola (Blue duiker)	M				
PTEROPODIDAE	*3. Eidelon helvum* (Straw-colored bat)	+ M				
	4. Myonycteris torquata (flying fox)				+	
POTAMOGALIDAE	*5.Potamogale velox* (Giant otter shrew)	Fisherman				

Note: All species except for Potamogale were found as bushmeat. We did not directly observe Potamogale; its presence was noted by a fisherman.

Table 6c. Macroinvertebrates

			STATION				
ORDER	**FAMILY**	**SPECIES**	Inga (Tank)	Nziya	Shongho	Fwamalo	Pt. 50
CRUSTACEA	ATYIDAE	1. *Caridina africana*	+			+	+
		2.*Caridina sp1*	+			+	
		3.*Caridina sp2*	+			+	
		4. *Caridina sp. 3*					
	POTAMONIDAE	5. *Potamonautes dybowkin*	+			+	+
COLEOPTERA	DYSTICIDAE	6. *Cybister tripunctatus*					

HETEROPTERA	GERRIDAE	7.*Gerris sp. 1*	+				
		8. *Gerris sp. 2*					
HEMIPTERA	NEPIDAE	9.*Ranatra grandicollis*	+				
	BELOSTOMATIDAE	10. *Belostoma niloticum*					
ODONOTA	COEANAGRIONIDAE	11. *Megaloprepus caerulatus*	+			+	
	LIBELLULIDAE	12.*Palpopleura lucia*					
		13. *Libellula quadrimaculata*	+				+
	AESHNIDAE	14. *Aeshnid sp.*					
MOLLUSCA	HYDROBIIDAE	15.*Hydrobia plena*				+	
	MELANIIDAE	16. *Melaniid sp.*					
	ASSIMINEIDAE	17. *Assimi oreidae*				+	
		18. *Pseudogibula duponti*					
		19. *Pseudogibula pallidior*					
	SIBULINIDAE	20. *Pseudoglossoria bessei*				+	
	AMPULLARIIDAE	21. *Aetheria elliptica*					

Table 7c. Plants.

FAMILY	**Species (common name, where available)**	**Comments**
POACEAE	1.*Panicum repens L.* (Australia torpedo grass)	Invasive grass
	2.*Panicum maximum (guinea grass; colonial grass)*	Medicinal value
	3.*Oryza barthii* (species of wild rice)	Valuable for agricultural diversity
	4.*Echinochloa pyramidalis* (antelope grass)	Nutritious fodder for dry-season grazing
	5. *Imperata sp.*	Grass
	6. *Hyparrhenia diplandra*	Dominant grass species of flooded wood savannah regions
CYPERACEAE	7. *Cyperus sp.*	Grass
CONVOLVULACAE	8. *Ipomoea aquatica* Forsk (water spinach; aka swamp cabbage)	Invasive species; floating vine; *Medicinal value*
SALVINIEACEAE	9. *Salvinia nymphellula*	Floating plant
PONTEDERIACEAE	10. *Eichornia crassipes* (water hyacinth)	Invasive floating plant
POLYGONACAE	11.*Polygonum acuminatum* H.B. and K. (knotweed)	Freshwater plant; medicinal value
MYRTACAE	12. *Eugenia congolensis*	Tree found in flooded forest
EUPHORBIACEAE	13. *Hymenocardia acida*	Medicinal value
IRVINGIACAE	14. *Irvingia smithii* Hook. F.	Tree in gallery forest
THELIPTERIDACAE	15.*Cyclosorus dentatus* (Forsk) (lynyolo)	Medicinal value
MORACEAE	16. *Ficus mucosa* (fig tree)	Medicinal value; documented to be used by chimps for same reason; timber species
RUBIACAE	17.*Nauclea latifolia* Smith (Pin cushion tree; aka African peach)	Small tree; medicinal value
ANACARDIACAE	18.*Lannea antiscorbutica* (Hiern) Engl. (pink lannea)	Found in riverine forests with sandy soil
BOMBACEAE	19. *Ceiba pentandra* (kapok tree)	Invasive tree
	20. *Andansonia digitata* (African baobob)	Native tree; medicinal value; pollinated by bats
FABACEAE	21. *Mimosa pigra* (catclaw mimosa; aka giant sensitive plant)	Invasive, highly destructive; forms dense monocultures and suppresses other vegetation as well as impacts on fish life.
ASTERACEAE	22. *Chromolaena odorata*	Invasive perennial shrub

8.8.2. Water Quality Analysis

Inga is particularly poor in organics, compared to Bandundu (at Bokoni and Mushi sites). Productivity, as measured by PO4 and NO3 was extremely low. This means that the aquatic food chain critically depends on food sources from the land: specifically, terrestrial plant matter and insects.

The water was consistently clear and brown-tinged, with the coloring humic substances orginating from the Cuvette Centrale (Roberts and Stewart, 1976). Transparency, as measured by the Sechi disk, was consistent throughout the sampling sites (48-50 cm); Robert and Stewart reported transparency levels of less than 100 cm. Mean total turbidity was 32 (FTU); mean true color was 172.4 (Pt-Co units). The pH was close to neutral, ranging from 6.5 to 7. Roberts and Stewart reported pH values between 7-7.5. Conductivity was constant throughout the sampling sites (33 –36 ìS). Carbonate hardness (aka alkalinity) was particularly low at the rapids of Point 50 and the stiller waters of Nziya. Roberts and Stewart noted the very low alkalinity levels for the rapids. By the rapids of Shongho and Point 50, dissolved oxygen levels were super-saturated, as previously reported by Roberts and Stewart (1976). The faster the current (and the mixing), the greater the level of dissolved oxygen. Water temperatures are more than four degree higher than those reported by Roberts and Stewart for August, 1973. They reported water temperatures of 24.7-34.8 ^{o}C for their two Inga sampling sites, with air temperatures of 23.3-30^{o} C; we found water temperatures from 28-30^{o} C, with air temperatures ranging from 28-32.6^{o}C; mean: 29.97^{o}C) for this September survey.

Results of chemical analysis for metals showed that the Inga sites are significantly polluted in heavy metals, especially in lead (Pb), and Cadmium (Cd). The heavy metal pollution poses a danger for human health, if the water is used for drinking, may pose a problem for the consumption of certain fish, particularly benthic feeders such as catfish (see paragraph below), and may pose a threat to the health of other species. Relatively high levels are also found for iron (Fe) and copper (Cu), but they do not pose a health hazard. The mean lead level of 163.82 ug/L is a real concern if the water is used as drinking water. The EPA considers a lead level of 40 ug/L "imminent and substantial endangerment, based on toxicological studies on young children," (www.epa.gov/safewater), and *the lead level found is 4 times greater than this.* Health effects for infants and children include "delays in physical or mental development, slight deficits in attention span, and learning abilities." For adults, high lead levels cause kidney problems, liver and thyroid function,and high blood pressure. Lead is also cancer-causing. Lead primarily enters water via corrosion of plumbing systems and erosion of natural deposits, but industrial processes could also play a role.

According to Eisler, 1988, "lead has been shown to have adverse effects in amphibians, including loss of sodium, reduced learning capability, and developmental problems (Horne and Dunson 1995; Freda 1991). Fish exposed to high levels of lead exhibit a wide-range of effects including muscular and neurological degeneration and destruction, growth inhibition, mortality, reproductive problems, and paralysis (Eisler 1988b; EPA 1976). At elevated levels lead can cause reduced growth, photosynthesis, mitosis, and water absorption (Eisler 1988b). Birds and mammals suffer effects from lead poisoning such as damage to the nervous system, kidneys, liver, sterility, growth inhibition, developmental retardation, and detrimental effects in blood (Eisler 1988b; Amdur et al. 1991). Lead partitions primarily to sediments, but becomes more bioavailable under low pH, hardness and organic matter content (among other factors). *Lead bioaccumulates in algae, macrophytes and benthic organisms*, but the inorganic forms do not biomagnify. Lead poisoning in higher organisms has been associated with lead shot and organolead compounds, but not with food chain exposure to inorganic lead (other than lead shot, sinkers or paint). There are complex interactions with other contaminants and diet. *Lead adversely affects algal growth, invertebrate reproduction and fish survival. ...* The main potential ecological impacts…result from direct exposure of algae, benthic invertebrates, and embryos and fingerlings of freshwater fish and amphibians to lead. Potential endpoints include growth reductions and impaired survival."

The samples were also more than three times higher than the safe level for cadmium (5 ug/L). High levels of cadmium cause kidney damage. Cadmium enters the water system through corrosion of galvanized pipes, discharge

for metal refineries, runoff from waste batteries and paints, and erosion of natural deposits. Further investigation of both water quality and bioaccumulation of heavy metals in ecosystems will allow us to identify mitigative solutions that should reduce the threats to people and other species.

Table 8c. Summary of water quality data for Bas-Congo province.

	STATION NUMBER										
	1	2	3	4	5	6	7	11	8	9	10
Site Description	Fwamalo H1	Fwamalo H2	Inga Center H1	Point 50 Bank	Point 50 Center A1	Point 50 Center A2	Point 50 Center A3	Point 50 Center A4	Shongho A1	Nziya 1	Nziya H2
GPS Location (lat/long, in degrees)	5°28.13S 13°35.01E	5°28.13S 13°35.01E	5°31.01S 13°37.17E	5°31.69S 13°36.47E	5°31.69S 13°36.47E	5°31.69S 13°36.47E	5°31.69S 13°36.47E	5°31.69S 13°36.47E	5°31.43S 13°37.76E	5°32.25S 13°33.61`E	
Depth at measured site (feet)	Center: 67		Center: 69	-					24.7	Center: 22.3	
Water Temp. at Surface (C)	27.9			29.2					30.0	30.1	
Current (qualitative)	Medium			Fast					Fast	Slow	
pH	6.73		6.8	6.6					6.99	6.54	
Conductivity (iS)	34.3		35.5	36.1					33.5	33.4	
Secchi Disk (cm)	50			48					50	50	
Turbidity (FTU)	32	32	31	33	33	34	31	32	31	32	32
Color	Clear, Brown-tinged			Clear, Brown-tinged					Clear, Brown-tinged	Clear, Brown-tinged	
True Color (Pt-Co units)	160	178	169	180	173	180	175	179	178	179	162
General Hardness (ppm)	53.7		35.8	35.8					35.8	53.7	
Carbonate Hardness (ppm)	53.7		35.8	17.9					35.8	17.9	
Dissolved Oxygen (Percent; B = before calibration; C = Calibrated) See note	91.3% B: 96.8 C: 98			103.9% B:103.9 C: 99					103% B: 97.2 C: 99	-	
Phosphate (PO4) (mg/L)	<<0.25		<<0.25	0					0	0	
Nitrate (NO3) (mg/L)	-			-					-	<<5	
Calcium (mg/L)	20			60					20	20	

Water quality: (- = no test; 0 = zero test value; empty cells indicate columns of additional samples for laboratory analysis).

Note: Exact oxygen values cannot be determined until we obtain maps that accurately provide altitude measures for calibration. A source has been found (CRES, 2000) for a Topographic and Climate Database for Africa, but the CD must be purchased.

Table 9c. Metals content in water samples.
Values are in µg/L. Data analysed by ERGS.

Sites	Iron (Fe)	Cadmium (Cd)	Lead (Pb)	Manganese (Mn)	Copper (Cu)	Chromium (Cr VI)
Inga, H1 Center	94	17	169	11	45	3
Nziya H_1	91	18	159	8	39	4
Nziya H_2	89	18	160	8	52	5
Shongo A_1	99	19	177	7	48	5
Fwamelo H_1	97	18	159	8	45	4
Fwamelo H2	95	14	132	13	48	3
Point 50	89	23	165	8	53	3
Point 50, A_2, Center	88	18	166	8	45	4
Point 50,A_2,Center	93	17	169	8	44	5
Point 50, Center II	94	16	177	9	53	5
DG, Center	90	19	169	7	46	4
Average	**92.64**	**17.91**	**163.82**	**8.73**	**47.09**	**4.09**

8.8.3. Sampling Station Reports, Trip #2

Name: Inga #1 (Tank)
Position: 5° 31.01 S, 13° 37.17 E

Date of visit: Sept. 24, 2002
Returned the evening Sept. 25, 2002 to record fishermens' catch.

Procedures: Birds and amphibians were observed and tape recorded. Reptiles and mammals were noted. Plant samples were collected. Macroinvertebrates were caught with a dip net. As we had no access to a pirogue at this site, fish were obtained from fishermen.

Ecological notes: This water body was a large reservoir 500 meters wide, 3 km long, created by the blockade of water from the dam at Inga #1. The surrounding landscape was mountainous wooded savannah habitat. Soil was clay. Aquatic plants included wild rice (*Oryza barthii)*, *Salvinia nymphellula,* and the invasive species of *Eichornia crassipes*, *Ipomea aquatica*, and *Mimosa pigra. Panicum maximim* and *Imperata cylindrica* were also present. The wooded savannah included the following trees: *Ficus mucosa* and *Hymenocardia acida*; the dominant savannah grass, *Hyparrhenia diplandra*; and the invasive shrub, *Chromolaena odorata*. The reservoir bottom was mud.

Conservation/development notes: The reservoir is not of much conservation interest. The aquatic habitat has been completely altered by the creation of the reservoir due to the dam at Inga 1. However, it remains an easy site for fishing, and is therefore of developmental interest.

Name: Nziya
Position: 5 º 32.25 S, 13 º 33.61 E

Date of visit: Sept. 24, 2002
Sept. 27, 2002

Procedures: Birds were observed and tape recorded. Amphibians, reptiles and mammals were noted. Plant samples were collected. Cast nets and seines were used to capture fish. A dip net was used to capture aquatic invertebrates.

Ecological notes: This very steep cliff was covered with wooded savannah habitat. Soil was clay. Abundant plants in the wooded savannah included the grass, *Hyparrhenia diplandra,* and various grasses in the family Poaceae. At the bottom of the mountainous cliff, diverse aquatic habitats in this main part of the river included sand, rocky boulders, and grassy shore areas with a muddy bottom. The river was approximately 700 meters wide at this point. Currents were slow near the bank. The biting blackfly was ubiquitous.

Conservation/development notes: An animal trap was observed on the trail. An abundant small crustacean is caught for food.

Name: Shongho
Position: 5 º 31.43 S, 13 º 37.76 E

Date of visit: Sept. 25, 2002

Procedures: Birds, reptiles and mammals were observed. No amphibians were found during this rapid survey. Macroinvertebrates were captured with a dip net. We tried to use a dip net to catch fish, but were unsuccessful. Fish were obtained from local fishermen, who used a gill net and hook and line.

Ecological notes: The cliff was covered with wooded savannah habitat. The river width was approximately 1 km. The aquatic habitat comprised rapids, with bedrock and large boulder bottom. Currents were very strong. Large boulders were along the banks. The shore had bushy plants.

Conservation /development notes: We observed a fish net used as a mist net to catch birds.

Name: Fwamalo
Position: 5 º 28.13, 13 º 35.01 E

Date of visit: Sept. 25, 2002

Procedures: Birds, reptiles and mammals were observed. Seines and dip nets were used to capture fish.

Ecological notes: This site was the canal. Chanel width was roughly 100 meters. The channel river bottom was large rocky boulders and sand. A grassy wetland was present further upstream. The banks were covered with grass.

Conservation/development notes: As with the reservoir, this site is not of much conservation interest due to the change of aquatic habitat caused by the dam.

Name: Point 50
Position: 5 º 31.69 S, 13 º 36.47 E

Date of visit: Sept. 26, 2002

Procedures: Birds and amphibians were observed and tape recorded. Plant samples were collected. A dip net was used to collect macroinvertebrates and to attempt to capture fish. Cast nets were also employed along sandy stretches for fish. On the way down to the rapids, we sampled a small forest stream.

Ecological notes: The terrestrial landscape was a very steep cliff, with wooded savannah habitat and new and old fallow. Soil was clay. At the bottom of the mountainous cliff, aquatic habitats were rapids, with bedrock, large boulders, and sand in parts. Plants in the wooded savannah habitat included the African baobob (*Andasonia digitata),* the invasive kapok tree (*Ceiba pentandra),* the dominant grass, *Hyparrhenia diplandra,* the invasive shrub, *Chromolaena odorata,*and unidentified plants called locally Mutumbilo.The width of the river was roughly 750 meters at this station. The blackfly was ubiquitous.

Conservation/development notes: Fishermen use innertubes and handlines to fish the rapids (a technique invented by a local fisherman in the 1960s), along with gill nets. Given the treacherous nature of fishing rapids, as well as the difficulties in reaching the site, overexploitation is likely not an issue.

8.9. Conservation and management

WWF (2003, in prep.) considers the Lower Congo Rapids to be among the highest priority for conservation. It has the highest category of biological distinctiveness, high integrity, moderate threats, but a low level of scientific understanding.

8.9.1. Threats and Development Issues:

Over the last century, the ecosystem in this area has changed from lowland forest to wooded savannah (Ifuta, personal communication). Essentially, the savannah border moved further north. This no doubt has had an effect on the hydrology of the river, the local climate, and on the species composition of insects and plant food from allocthanous (land-based) sources.

Current threats include:

- Water pollution, including sewage, industrial chemicals from Brazzaville and Kinshasa, mining south of these two cities, and sedimentation.

- Future damming of the entire river: The greatest future threat to the extraordinary biodiversity of the region is the proposed Gran Inga dam. Inga 1 and 2 have only blocked a river channel; not the main river. However, the Gran Inga dam would block the entire river (SNEL, 2002).

8.9.2. Management:

Fisheries: Without assessing abundance, having knowledge of the number of fishermen, or the number of fishing trips, we conclude that the fishing appears sustainable, given the large size of fish caught, the tremendous difficulty in reaching the fishing sites, and the difficulty in fishing, particularly the rapids. At the rapids of Shongo, fishermen used hook and line, baited with worms. The size of the hooks was the legal size of #8,#12, #16, and #18. They also used large mesh-sized gill nets stretched across the slower part of the rapids.

Recommendation: From a conservation standpoint, the best option would be 1) a net exchange program, swapping illegal nets for legal ones, 2) mapping of key spawning areas and fishing grounds, and 3) beginning monitoring of fishing effort. Note that Roberts and Stewart sampled in June-Sept.. Half of their sample were

young fishes of 3 cm or less, and 1/5 of their sample was 2 cm or less, including species in the families Mormyridae, Distichodontidae, Bagridae, Cichlidae, and Cyprinidae, meaning spawning occured just prior to this period. The authors suggest that spawning here is less seasonal than the larger part of the river.

From a development standpoint, we encourage a small grant proposal from the local Fishing Association. Their goals are to increase production and to develop the fishermen. They are seeking: a cold room, a store to sell fishing supplies, nets, life jackets, and mosquito repellant. Black flies (which cause river blindness, or onchocerciasis) are extremely abundant here, with one study documenting that fishermen could receive up to 8000 bites a day! Blackflies have aquatic larvae.

Pollution: Lead levels are a major concern, particularly for the health of young children in the area.

Recommendation: Additional water quality surveys should be conducted to explore the seasonality of the lead input, and to identify the source of the lead. We need to know if this water is used as drinking water. In addition, it is essential to know whether the lead is accumulating in the benthic or predatory fish caught for consumption.

Dam: The future dam of the entire river is the greatest concern. While the landscape has already been changed, the aquatic ecosystem still harbors extraordinary richness of fish.

Recommendation: Given the length of time to secure funding for the Grand Dam, we hope that discussions can take place over the next several years among a qualified hydrologist and the government to determine ways to build or modify the dam to best protect the region's flooding cycle and maintain some of the rapids areas.

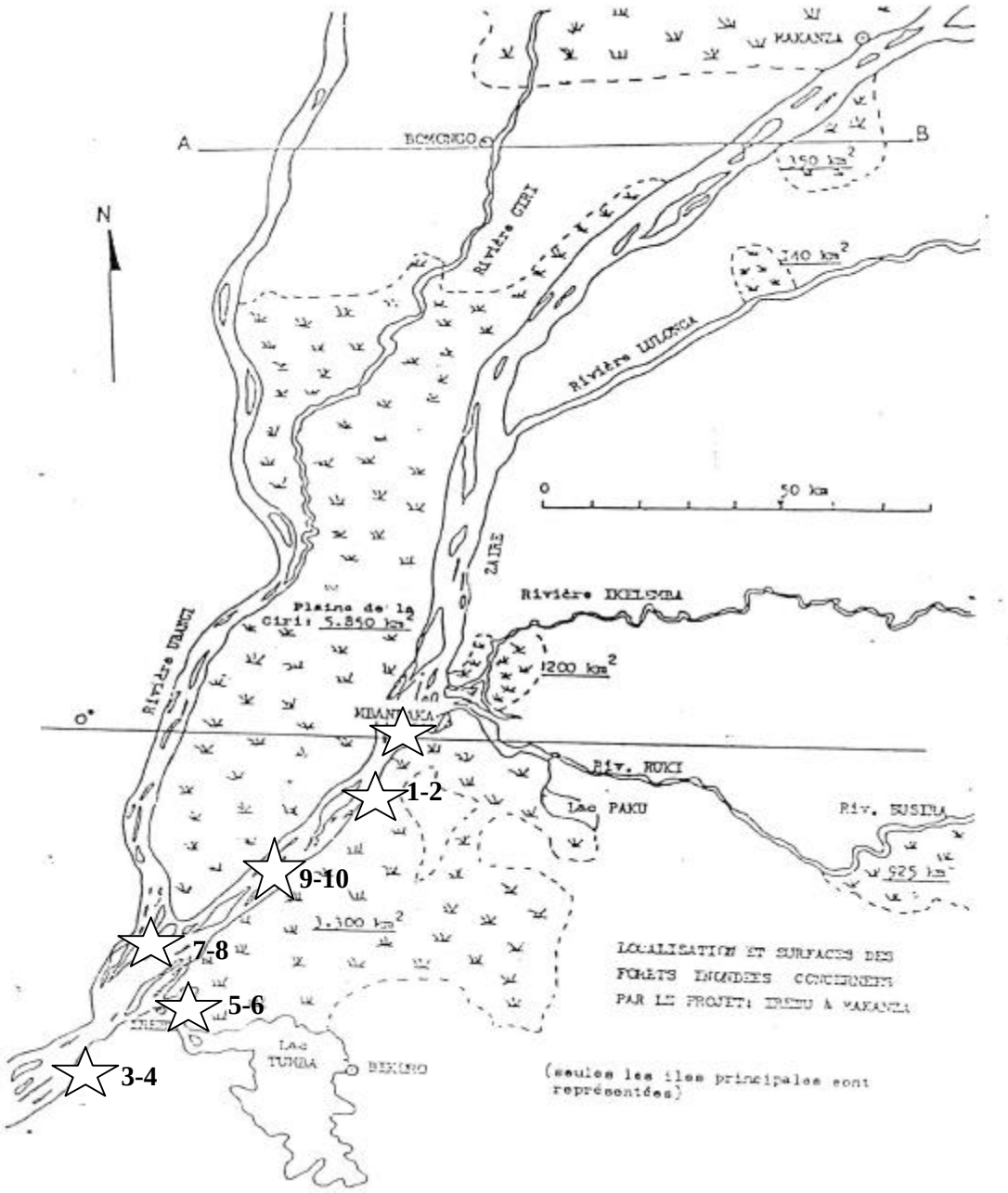
Restoration of the landscape: Over the longer term, it would be useful to make efforts to restore the landscape back to forest, if the concern over the dam could be addressed.

TRIP # 3: EQUATEUR PROVINCE: MBANDAKA TO GOMBE

8.10. Summary

8.10.1. Map of Station Sites in Equateur

Stars mark sampling sites; bold numbers indicate water quality stations. All species and water quality were sampled at Bodjia (stations 1-2), Gombe (stations 3-4), and near the confluence of Ubangi river (stations 7-8). Fish, macroinvertebrates, and water quality were sampled at Irebu (stations 5-6). Water quality was sampled midway between Mbandaka and Gombe (stations 9-10). Fish only were sampled at the markets in Mbandaka and Maita (near station 9-10).



Map source: COOPEQUA (2002)

8.10.2. Background

Our sampling sites encompass 4 ecoregions. One of our sampling sites (Irebu) lies within the *Lake Tumba ecoregion* (ecoregion # 13, Thieme et al., 2003, in prep.); the confluence of the Ubangi and Congo River site is the transition zone between two ecoregions, the *Sudanic Congo (Oubangui) ecoregion* (# 30) and the *Lake Tumba ecoregion* (#13; two sampling sites, Bodjia and Mbandaka, fall within the *Cuvette Central* ecoregion (#18), and Gombe lies just within the *Sangha ecoregion (#27),* but may be considered in a transition zone between *Sangha* and two other ecoregions, *Lake Tumba* and the *Sudanic Congo*. WWF (2003, in prep.) considers the Cuvette Centrale to be of highest conservation importace; the Lake Tumba ecoregion to be of high conservation importance due to its intact habitas and rich invertebrate and fish faunas; the other ecoregions bioregionally outstanding. IUCN considers both the Lake Tumba region and the swamp forest of Giri to be critical sites for forest conservation.

The flooded forest region in the confluence of the Ubangi and Congo river covers nearly 38,000 km2, depending on season. This is the most extensive zone of swamp forest and inundated forest on the African continent (WWF, 2003, in prep.). The flooded zones receive decomposed organic materials from forest plants, rendering the water acidic.

Due to the biannual forest flooding, a number of fauna are uniquely adapted to this flooded habitat. Some fish species found predominantly in the flooded forest areas include: Polypterus, Protopterus, Clarias, Ophicephalus, Channidae. As such, the presence of these species could potentially provide an indicator for this type of habitat. Many endemic plant species have been recorded here. WWF notes that one key primate in the region is Allen's swamp monkey (*Allenopithecus nigroviridis*), of evolutionary interest due to the fact that it is believed to be a holdback from the swamp-dwelling ancestor of modern arboreal monkeys.

The Giri swamp forest (aka Bangala swamp) is to the west of the Congo river, between the Congo and Ubangi Rivers. WCMC (as cited in WWF, 2003, in prep.) notes that mammal species in the region include hippopotamus (*Hippopotamus amphibius*), buffalo (*Syncerus caffer*), Allen's swamp monkey (*Allenopithecus nigroviridis*), and possibly red colobus (*Procolobus badius*). The area is also important for birds. WWF notes that "this is a large and relatively intact area, with high potential for research and conservation."

The Cuvette Centrale (site of Bodjia and Mbandaka) contains the largest block of rainforest in Africa (WWF, 2003). It is considered to be rich in fish species, with many endemics.According to WWF (2002), this low-lying depression is also thought to provide key habitat for Allen's swamp monkey and the threatened Hartlaub's duck (*Pteronetta hartlaubii*). Known aquatic mammals in the region include giant otter shrew (*Potamogale velox*), Congo clawless otter (*Aonyx congica*), sitatunga (*Tragelaphus spekei*) and chevrotain (*Hyemoschus aquaticus*).

8.11. Results

Aquatic habitats: Aquatic habitats in this region included: islands, flooded swamp forest, floating grass islands, sand banks, and swamp grasslands. We rapidly sampled 5 sites: Bodjia, Gombe, Irebu, the confluence of the Ubangi and Congo Rivers, midway between Gombe and Mbandaka (at the Maita market, the river center and bank) and Mbandaka (market only). Note: Immigration and logistical travel difficulties considerably reduced the amount of time available for the survey in this province.

Terrestrial habitats: Terrestrial habitats included cropland, lowland swamp forest, islands, swamp grassland, and pockets of dryland forest.

Species: We found 51 species of fish, comprising 16 families. Dominant families include Mormyridae (comprising 35% of the species), Characidae, Bargidae, Mochokidae, and Cyprinidae, all at 8%, and Distichodontidae and Claridae (6%). All of these families have been reported to be frequently captured in Equateur, with the exception of Claridae and Characidae (COOPEQUA, 2002). Other families reported to be frequently captured, but not present in our sample include Phractolaemidae, Malapteruridae, Ophiocephalidae, Hepsetidae, Centropomidae, Tetraodontidae,

Mastacembelidae, Amphiliidae,and Pantolidae. While some of these species may possibly be new, this awaits confirmation from the AMNH.

Given the limited time available for our survey of sites in this province, we found 32 species of birds; 8 species of amphibians; 3 species of reptiles; and 19 species of aquatic macroinvertebrates from 8 families. The African soft-shelled river turtle, Trionyx triunguis, eats fish. As with the other provinces, we recorded 3 species of mammals, but none were found alive; all were observed as bushmeat. We identified 13 species of plants, 3 of which are invasive (23%).

Management: With the help of experienced fishermen, we completed the compilation of names for the field guide to fishes in the local languages, Lingala and Kikonga.

8.11.1. Systematic account of all species for Equateur province.

Table 1d. Provisional list of fishes recorded. Note: Identification to species will take 6 mos-1 yr.
+ = recorded; sp. = unidentified single species, may not be the same across sites; spp. = unidentified multiple species; M = marketed fish.

		STATION					
FAMILY	**SPECIES**	**Bodjia**	**Maita**	**Gombe**	**Confl.Ubangi/ Congo**	**Irebu**	**Mbandaka**
PROTOPTERUS	*1. Protopterus dolloi*		+ M				
POLYPTERIDAE	*2.Polypterus sp.*		+ M				
CLUPEIDAE	*3.Clupeidae sp.*	+ sp.				+ sp.	
MORMYRIDAE	*4. Campylomormyrus tamandua.*						
	5 Campylomormyrus sp.					+ sp.	
	6.Marcusenius greshoffi						
	7.Marcusenius sp. 1						
	8. Marcusenius sp. 2						
	9.Marcusenius monteiri						
	10.Hippopotamyrus discorhynchus					+ sp.	
	11. Hippopotamyrus plagiostoma			+			
	12. Hippopotamyrus sp.			+			+M
	13.Mormyrops anguilloides						+M
	14.Mormyrops nigricans						
	15.Petrocephalus sauvagii						+ M
	16. Petrocephalus sp. 1					+ sp.	
	17.Petrocephalus sp.2						
	18.Mormyrus caballus bombanus						
	19.Mormyrus proboscirostris						
	20.Mormyrus ovis						
	21.Gnathonemus sp.						
CHARACIDAE	*22. Hydrocynus goliath*		+ M			+	+ sp.
	23. Alestes sp.						
	24. Characid sp.	+ sp.				+ sp.	
	25. Brycinus sp.						
	26. Bryconaethiops sp.						
DISTICHODONTIDAE	*27. Ichthyoborus afer*					+	
	28. Distichodus lusosso						
	29. Distichodus sp.		+ sp. M				+ M
	30. Phago sp.						+M
CITHARINIDAE	*31.Citharinus gibbosus*						
CYPRINIDAE	*32.Labeo sp.1*		+ sp. M				
	33.Labeo sp. 2						
	34.Labeo sp. 3 (mouton allonge)						
	35.Leptocyrus sp.						
BAGRIDAE	*36.Bagrus ubangensis*						+ M
	37.Chrysichthys sp. 1		+ M			+ sp.	+ sp. M
	38.Chrysichthys sp. 2						
	39.Auchinoglannis occidentalis		+ M				+ M
SCHILBEIDAE	*40.Schilbe mystus*					+ sp.	+ sp.
ANABANTIDAE	*41. Ctenopoma sp.*		+ M				M
OSTEOGLOSSIDAE	*42. Heterotus niloticus*						
MOCHOKIDAE	*43. Synodontis sp. 1*						
	44. Synodontis sp. 2						
	45. Synodontis sp. 3						
	46. Synodontis acanthomias						
CLARIIDAE	*47.Heterobranchus longifilis*		+ M				
	48.Clarias sp. 1		+ M				+ M
	49.Clarias sp. 2						
CICHLIDAE	*50.Tylochromis sp.*					+	

	51. Hemichromis sp.	+					
	52. Tilapia nilotica						
NOTOPTERIDAE	*53. Xenomystus sp.*						+M
CHANNIDAE	*54.Parachanna obscura*						+ M

Table 2d. Birds. For common names, see Table 2a.

		STATION		
FAMILY	**SPECIES**	**Bodjia**	**Gombe**	**Confluence Ubangi/Congo**
JACANIDAE	*1.Actophilornis africanus*		+	
ARDEIDAE	*2. Egretta alba*		+	
	3. Egretta ardesiaca			
	4. Bubulcus ibis			+
ANHINGIDAE	*5. Anhinga rufa*		+	
MEROPIDAE	*6. Merops pusillus*		+	
PASSERIDAE	*7. Passer griseus*		+	
COLUMBIDAE	*8. Turtur afer*		+	
BUCEROTIDAE	*9. Tochus fasciatus*			
PSITTACIDAE	*10. Psittacus erythacus*			
PLOCEIDAE	*11. Ploceus cucullatus*		+	
	12.Ploceus pelzelni		+	
	13. Ploceus melanocephalus		+	
	14. Ceryle rudis		+	
	15. Quelea quelea		+	
	16. Brachycope anomala		+	
RALLIDAE	*17. Porphyrio alleni*		+	
PYCNONOTIDAE	*18. Pycnonotus barboratus*		+	
	19. Pycnonotus sp.	+		
ESTRILDIDAE	*20. Estrilda sp.*			
CORVIDAE	*21. Corvus albus*			
VIDUIDAE	*22. Vidua macruora*			
TURPIDIDAE	*23. Saxicola saxicola torquata*		+	
APODIDAE	*24. Raphidura sabini*		+	
NECTARINIDAE	*25. Anthrepes collaris*	+		
ACCIPITRIDAE	*26. Milvus migrans*		+	
	27. Gypohierax angolensis		+	
ALCEDINIDAE	*28.Halcyon senegalensis*	+	+	
	29. Halcyon leucocephala		+	
CAPRIMULGIDAE	*30. Macrodypteryx vexillarius*			+
CUCULIDAE	*31. Centropus senegalensis*			+
COLUMBIDAE	*32.Streptopelia semitorquata*		+	+

Table 3d. Amphibians

		STATION		
FAMILY	**SPECIES**	**Bodjia**	**Gombe**	**Confluence Ubangi/Congo**
BUFONIDAE	*1. Bufo regularis*	+	+	
	2. Bufo funerius	+		
RANIDAE	*3. Rana mascariensis*	+	+	
	4. Discroglossus occipitalis	+	+	
	5. Rana fuscigula nutti		+	
	6. Rana fuscigula angolensis	+	+	
	7. Rana sp.		+	

Table 4d. Reptiles

		STATION		
FAMILY	**SPECIES**	**Bodjia**	**Gombe**	**Confluence Ubangi/Congo**
TRIONICHYDAE	1.*Trionyx triunguis* (African soft-shelled turtle)		+	
	2.*Cycloderma aluryi* (Aubrey's flapshell turtle)		+	
SCINCIDAE	3. *Mabuya sp.* (skink)	+	+	

Table 5d. Mammals.

		STATION		
FAMILY	**SPECIES**	**Bodjia**	**Gombe**	**Confluence Ubangi/Congo**
CERCOPITHECIDAE	*1. Cercopithecus mitis* (blue monkey)		+	
	2. Cercopithecus ascarius (red-tailed monkey)			
	3. Papio anubis (anubis or olive baboon)		+	

Table 6d. Macroinvertebrates.

			STATION		
ORDER	**FAMILY**	**SPECIES**	**Bodjia**	**Irebu**	**Confluence Ubangi/Congo**
DECAPODA	ATYIDAE	1. *Caridina africana*		+	+
		2. *Caridina sp.*		+	+
	PALAEMONIDAE	3. *Palaemon dux congoensis*			
	THERIDIIDAE	4. *Theridiid sp.*			
HETEROPTEA	HYDROMETIDAE	5. *Hydrometra sp.*		+	+
	NEPIDAE	6. *Ranatra grandicollis*		+	+
	GERRIDAE	7. *Gerris sp.*1		+	
ODONATA	COENAGRIONIDAE	8. *Megaloprepus caerulatus*		+	
	LIBELLULIDAE	9. *Palpopleura lucia*		+	
		10. *Libellulula quadrimaculata*			
COLEOPTERA	DYSTICIDAE	11. *Cybister tripunctatus*		+	
HEMIPTERA	NOTONECTIDAE	12. *Anisops varia*			
	BELASTOMATIDAE	13. *Belostoma niloticum*		+	
		14. *Belastoma sp.*		+	
SIGMURETHRA	ACHATINIDAE	15. *Achatina schweinfurthi*		+	
	.	16. *Achatina zebriolata*		+	
		17. *Achatina greyi*			
CAENOGASTROPODA	AMPULARIIDAE	18. *Aetheria elliptica*			
ARANAE LABIDOGNATHA suborder	ARACHNIDAE	19. *Unknown sp.*		+	

Table 7d. Plants

FAMILY	Species (common name, where available)	Comments
POACEAE	1.*Panicum repens L.* (Australia torpedo grass)	Invasive grass
	2.*Panicum maximum* (guinea grass; colonial grass)	Medicinal value
	3.*Oryza barthii* (species of wild rice)	Valuable for agricultural diversity
	4.*Imperata cylindrica* (cogon grass or speargrass)	Invasive, one of the ten worst weeds in the world
	5. *Hyparrhenia diplandra*	Dominant grass species of flooded wood savannah regions
PONTEDERIACEAE	6. *Eichornia crassipes* (water hyacinth)	Invasive floating plant
FLACOURTIACAE	7.*Coloncoba glauca (P.Beauv.) Gilg.*	Tree; seeds used to destroy rats; oil used to treat leprosy
PALMAE	8. *Elaeis guinensis* (African oil palm)	
ARECACEAE	9. *Raphia sp.* (palm)	
EUPHORBIACAE	10..*Alchornea cordifolia*	Shrub; medicinal value
CAESALPINIACAE	11.*Griffonia tessmannii* (De Wild) Compere	Shrub; medicinal value
MORACEAE	12. *Ficus mucosa* (fig tree)	Medicinal value; documented to be used by chimps for same reason; timber species
	13. *Ficus sp.*	

8.11.2. Water quality Analysis

As with the other two provinces, all stations showed poor productivity due to low nutrient content (phosphates < 0.25 mg; nitrates < 5 mg/l), routinely acid waters (pH = 6) and limited transparency. The acidity of the water is due to the decomposition of organic material over the flooded forest, ending up in the river. (Note, though, that transparency measures were 1.4-1.7 times greater than at the other two provinces. The most transparent waters were found at the Irebu site.) Mean total turbidity was 84.5 (FTU); mean true color was 181.7 (Pt-Co units). Thus, the beginning of the food chain in the river originates from the land: specifically, (allocthanous) terrestrial plant matter and insects. These natural characteristics mean that destruction of the terrestrial ecosystems along the river can significantly affect the riverine food web.

The lowest dissolved oxygen measures were for Bodjia: 43% (3.25 mg/L) and 58% (4.51 mg/L), possibly indicating sewage input at this site. These levels were the lowest found for all 3 provinces, and are in the range where aquatic animals would exhibit stress. Conductivity was also lowest at the Bodjia site (10 ìS). Interestingly, water temperatures dropped 5-6^{o}C at the confluence of the Ubangi and Congo river (station numbers 7-8) , even with air temperatures as high as 33.7^{o}C. Such a change in temperature may influence the faunal composition at this site. These water temperatures are the lowest recorded for all provinces.

Table 8d. Summary of water quality data for Equateur province.

	STATION NUMBER									
	1	2	3	4	5	6	7	8	9	10
Site Description	Iyonde Bank (Bodjia)	Iyonde Center	Gombe Bank	Gombe Center	Irebu Bank	Irebu Center	Ubangi Confluence Bank[1]	Ubangi Center	Bank – midway between Gombe/Mbandaka	Center -midway between Gombe/Mbandaka
GPS Location (lat/long, in degrees)	0°2. 34S 18° 10.94E	0°2.34S 18° 10.94E			0° 35.84 S 17°46.96E	0° 35.84 S 17°46.96E	0°30.75S 17°43.16E	0°30.75S 17°43.16E	0°16.84S 17°59.03E	0°16.84S 17°59.03E
Depth at measured Site (feet)	1.6	36.6	12.2	78	25.9	30.3	31.4	12.2	11.5	25.6
Water Temp. at Surface (°C)	27.3	25.2	27.2	27.8	27.2	27.6	21.7	19.8	21.4	25.6
Current (qualitative)	Slow	Slow	Fast	Fast	Fast	Fast	Medium	-	Medium	Medium
pH	6.0	6.62	<6.0	6.0	<6.0	< 6.0	6.0	6.6	6.1	6.0
Conductivity (ìS)	10	10	20	30	26	20	20	20	20	30
Secchi Disk (cm)	Too shallow to record	70.5	75	72	120	102	72	71	57.3	100
Turbidity (FTU)	57	64	87	105	63	64	98	104	100	103
Color	Black	Black	Black	Black	Black	Black	Clear, Brown-tinged	Clear, Brown-tinged	Clear, Brown-tinged	Clear, Brown-tinged
True Color (Pt-Co Units)	137	140	203	236	132	132	210	215	203	209
General Hardness (ppm)	35.8	17.9	53.7	35.8	35.8	35.8	17.9	35.8	35.8	35.81
Carbonate Hardness (ppm)	17.9	17.9	35.8	35.8	17.9	17.9	17.9	17.9	35.8	17.9
Dissolved Oxygen (Percentage) B= before calibration; C = after calibration, see note	42.9% B: 93.4 C: 99	57.5%	87.6 %	86.1 %	75.4% B: 99.8 C: 99	78.5% B:100.5 C: 99	69.3	85.6%	67%	72%
Phosphate (PO_4) (mg/L)	<<0.25	<<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	0.25
Nitrate (NO_3) (mg/L)	<5	<5	<5	<5	<5	<5	<5	< 5	<5	<5
Calcium (mg/liter)	40	20	60	40	40	60	20	20	40	40

Water quality: (- = no test; 0 = zero test value; empty cells indicate columns of additional samples for laboratory analysis).Note: Exact oxygen values cannot be determined until we obtain maps that accurately provide altitude measures for calibration. A source has been found (CRES, 2000) for a Topographic and Climate Database for Africa, but the CD must be purchased.[1]This GPS reading is to the east of water quality test, which was done on the Ubangi side of the confluence.

8.11.3. Sampling station reports.

Name: Iyonde (Bodjia village)
Position: 0^{o} 2.34 S; 18^{o} 10.94 E

Date of Visit: Oct. 6, 2002

Procedures: Birds and amphibians were observed and tape recorded. Reptiles and mammals were noted. Plant samples were collected. Macroinvertebrates were caught with a dip net. Fish were sampled with cast nets.

Ecological notes: The terrestrial landscape by this small fishing village, 25 km south of Mbandaka, was a plain, with cropland (new or old fallow). Abundant plants included: aquatic grasses of the Poacae family, *Alchornia cordifolia, Eichornia crassipes, Raphia spp., Elaeis guinensis, and Ficus sp.*. In the center of the river, a few drifting *Eichornia crassipes* islands passed by.

Name: Gombe
Position: Not recorded.

Date of Visit: Oct. 8, 2002

Procedures: Amphibians and birds were observed and recorded on tape. Birds were also caught with a mist net. Reptiles, mammals, and plants were noted. Macroinvertebrates were collected with a dip net.

Ecological notes: The terrestrial landscape by this large village was a plain, with cropland (new or old fallow). Abundant plants included: the shrub, *Alchornia cordifolia*, fig tree, *Ficus mucosa,* and the grass, *Hyparrhenia diplandra.* Other plants included the grass, *Panicum maximum*, and the invasive grass, *Imperata cylindrica*.

Conservation/development notes: Numerous pirogues line the banks.

Name: Irebu
Position: 0^{o} 35.84 S; 17^{o} 46.96 E

Date of Visit: Oct. 9, 2002

Procedures: Macroinvertebrates were collected with a dip net. Fish were collected near a grassy wetland and near a tree root with the use of a cast net. Fish were collected in the middle of the river with an artisinal gill net method (200 m gill net rotated by two pirogues with 4 fishers).Water quality samples were collected.

Ecological notes: Swamp grasslands along banks, with hanging tree roots nearby. Abundant floating and emergent water plants included *Oriza bartilli* and *Eichornia crassipes.* Macroinvertebrates were collected over a muddy river bottom. The village of Irebu was roughly one hundred meters downstream.

Conservation/development notes: One of the two gill nets used by the fishers was an illegally-sized 2.5 cm mesh net.

Name: Ubangi Confluence
Position: 0^{o} 30.75 S; 17^{o} 43.16 E

Date of Visit: Oct. 9, 2002

Procedures: Fish were collected with a cast net and dip nets. Amphibians, reptiles, and birds were observed. Macroinvertebrates were collected with a dip net over a sandy bottom. Water quality samples were obtained.

Ecological notes: Abundant floating and emergent water plants included *Oryza barthii* and *Eichornia crassipes.* The terrestrial habitat was flooded forest. Water temperatures were much lower than the other sites.

Name: Midway between Mbandaka and Gombe
Position: 0^{o} 16.84 S; 17^{o} 59.03 E

Date of Visit: Oct. 10, 2002

Procedures: Only water quality samples were taken at this site. Nearby, we recorded fish at the fish market in Maita.

Ecological notes: Littoral plants predominantly consisted of the shrub, *Alchornea cordifolia*, along with some *Eichornia crassipes*.

Conservation/development notes: At Maita, we were surprised by the absence of mormyrids, cichlids, and carps in the market. We noted the presence of the African soft-shelled turtle (*Trionyx triunguis*) at the market.

Name: Mbandaka
Position: not recorded.

Date of Visit: Oct. 6, Oct. 12, 2002

Procedures: Fish were purchased at the fish market.

Ecological notes: Densely populated city.

Conservation/development notes. Malaria is rampant in this city. We met a former pet-trader, Jean Kongolo. He was transferred to Mbandaka in 1993 for the pet trade, but trade collapsed in 1997 due to the war, and has not yet resumed. Large fish are caught in the middle of the river. Fish are sold both in Mbandaka and on the Congo-Brazzaville side.

8.12. Conservation and Management

WWF (2003, in prep.) considers the Cuvette Central to be among the highest priority for conservation. It has the highest category of biological distinctiveness, highest integrity, low threats, but a low level of scientific understanding. It considers Tumba to be among a high priority for conservation, having high biological distinctiveness, high integrity and moderate threats.
The seasonally flooded forest regions are considered by WWF to be a globally rare ecosystem (WWF, 2003, in prep.)

8.12.1. Threats and Development Issues:

The two most immediate threats for the region included in the project are bushmeat hunting and overfishing.

- Bushmeat hunting: As in the other two provinces, all of the mammals observed were dead bushmeat, of potential concern. An important caveat to our results is that we had limited time, did not survey at night, and did not record presence of mammal dung (feces). However, WWF (2003, in prep.) corroborates that there is

considerable hunting pressure in the south of the Ubangi ecoregion. The area is thought to be habitat for hippos, but none were observed. As noted in the section on Bandundu, hippopotami are critical for maintaining the integrity of riverine systems, and their disappearance affects the species composition of riverine plants and animals alike (Naiman and Rogers, 1997).

- Overfishing: The area has high levels of fishing and trade, due to the proximity of Mbandaka. High value fresh fish at the market include: *Chrysichthys chrysichthus* (Libonu), *Auchenoglanis occidentalis* (mpoka), and *Labeo Velifer* (Momgaza) (COOPEQUA, 2002). Fishermen use gill nets (both stationary and moving. The latter technique requires two pirogues and 4 fishers.), seine nets, cast nets, handlines, and nonmotorized canoes (FAO).
  Environmentally unsound fishing methods include: defoliating the banks, using poisons and herbicides, and using nets smaller than 3 cm. We directly observed the use of illegally-sized gill nets (2.5 cm) at Irebu. 3 cm is legal. We also saw the use of illegally-sized cast nets (1.5 cm) to catch small distichotids (6 inches or less). Large chrysichthids (3-4 ft.) are caught with hooks on handlines. COOPEQUA (2002) notes that there has been a reduction in abundance of Chrysichthyes along the river. At Maita, the absence of mormyrids, cichlids, carps in the market was noted. Given the preponderance of mormyrids at other stations in this province, the absence of mormyrids may indicate overfishing, or it could indicate market preference for other fish!.

  Potential annual fisheries yield estimates for the region range from 100,000-120,000 t, but fishing is dispersed and the true yield is unknown. (COOPEQUA, 2002). In 1986, fish production in Equateur was estimated at 30,000 tonnes for 20,000 fishers, In 1997, it was estimated at 36, 492 tonnes, an increase of nearly 22% (Source: Plans d'action provinciaux de la biodiversite, Juin, 1999). Estimated potential (kg/ha) is 25.

  Fishing closely follows the water cycle. The best period for fishing is July to middle of September, corresponding to the period of water decline. During this period, the fish move from the forest towards the river. Production is estimated at 20-30kg/unit of fishing, with 20 days fished/month (COOPEQUA, 2002). Monthly production is estimated at 400-600 kg/unit of fishing.

  The second best period is Jan-March and October, during the period of water rise, when the fish make the reverse move. Production is estimated at 10-30kg/unit of fishing, with 15 days fished/month (COOPEQUA, 2002). Monthly production is estimated at 150-225 kg/unit of fishing.

  The worst period for fishing occurs during the highest water period (April – June; Nov.-Dec.), when the fish are in the forest proper, reproducing in the inundated areas or along the banks. Production is estimated at 2-8 kg/unit of fishing, with 10 days fished/month (COOPEQUA, 2002). Monthly production is estimated at 20-80 kg/unit of fishing.

- Logging (future threat for lowland rainforest, not swamp forest): The province of Equateur had an estimated 99.7% forest coverage in 1990 (WWF, 2003, in prep.). In the late 1980s, it also had the greatest volume of veneer and sawmill production. While the war in this province has considerably slowed or even stopped logging efforts, given the extent of forest in this region, this is likely to rapidly become a threat when peace resumes throughout the region. However, given the difficulties in harvesting a swamp forest, the region within this project is much less likely to be threatened.

- Pollution (Bodjia and Mbandaka): A localized threat is the low level of dissolved oxygen by Bodjia. Given the size of Mbandaka, sewage is likely to be a problem here as well.

8.12.2. Management:

Recommendation:

1. Survey birds, mammals, and fish more intensively. This region is of both high conservation importance and scientific importance. The area has a virtually intact flooded forest (with the exception of large mammals). The project could greatly contribute to international understanding of this unique ecosystem by conducting a more thorough bird and mammal survey in the region, as well as to resample the fish seasonally. This would set the stage for monitoring the impact of the health of the flooded forest regions, an important first step in improving forest management.

2. Promote awareness of the importance of maintaining viable populations of key animals for the riverine ecosystem, specifically, hippos and terrestrial plants. Both are important for maintaining the extraordinary diversity of fishes in the region.

Bushmeat hunting:

Recommendation: The mammal survey would also help us determine how much of a threat bushmeat hunting is in the area. In addition, support a sociological study to better understand the nature of the threat of bushmeat hunting, as suggested by WWF (2003, in prep.).

Overfishing:

According to COOPEQUA (2002), fishing closely follows the seasonality of the water cycle. The best period for fishing is July to middle of September, corresponding to the period of water decline. At this time, the fish move from the forest towards the river. Production is estimated at 20-30kg/unit of fishing, with 20 days fished/month. Monthly production is estimated at 400-600 kg/unit of fishing.

The second best period is Jan-March and October, during the period of water rise, when the fish make the reverse move. Production is estimated at 10-30kg/unit of fishing, with 15 days fished/month (COOPEQUA, 2002). Monthly production is estimated at 150-225 kg/unit of fishing.

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Recommendation: Support 1) a net exchange program, swapping illegal nets for legal ones, 2) mapping of key spawning areas and fishing grounds, and 3) beginning monitoring of fishing effort. From a development standpoint, we encourage a small grant proposal from the local Fishing Association to improve their fishing materials, contingent on their agreement to undertake monitoring.

Pollution:

Recommendation: If Bodjia is to become part of the project, it would be useful to 1) retest the oxygen levels at another time of the year; and 2) determine the cause of the low oxygen levels. It would also be useful to conduct water quality analysis in Mbandaka.

8.12.3. Potential partner options:

1. Action Contre la Faim (Mbandaka)
2. Fishing Association (Bodjia)
3. Fishing Association (Gombe)